ASSESSMENT OF GENERAL AVIATION AIRPORT PAVEMENT CONDITIONS IN KANSAS

by

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Abstract

The objective of this research project was to assess the condition of general aviation airport pavements in Kansas. The study was also intended to form the basis for a pavement management system (PMS). A total of 137 runways from 107 airports across the state were surveyed. MicroPAVER, a PMS system developed by the U.S. Army Corps of Engineers, was selected as the platform for the PMS. An inventory database was developed for all runways in the network. Information about the construction and maintenance history was entered into the MicroPAVER database. On-site surveys were conducted between the months of May and July of 2008 to assess pavement conditions in terms of the Pavement Condition Index (PCI), following the methodology outlined by ASTM D 5340-04 and adopted by the Federal Aviation Administration (FAA).

Approximately 68% of the sections surveyed were in "good" to "satisfactory" condition. Almost one-third of the network can be rated as "good." About 21% of the sections studied were in "fair" condition. Overall, the condition of the network can be rated as "satisfactory." A condition prediction curve was developed for each of the two different types of surfaces. From the prediction curves created using MicroPAVER, it was estimated that the number of branches rated as "good" could decrease by 50% by 2010. As much as 44% of the network could have a rating of "fair" by 2013 if the sections receive only routine maintenance. Two budget scenario comparison reports developed show that the 108 runways of the 78 general aviation airports eligible for FAA funding in Kansas could be brought to a "satisfactory" rating or above (i.e. average PCI $\geq$ 70) by spending approximately $15 million on average per year for the next five years.

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CHAPTER 1

INTRODUCTION

1.1 OVERVIEW

The major objective in the design and construction of airport pavement is to provide adequate load-carrying capacity and good ride quality, permitting safe operation of aircraft under all conditions. However, immediately upon completion of construction, airport pavement begins to undergo a gradual deterioration which can be attributed to several factors. This situation leaves airport agencies with limited fiscal resources to address an often-growing backlog of pavement rehabilitation needs. This is especially true as funding levels become more restrictive and the competition for pavement rehabilitation project funding heightens. Airports and state aviation agencies are better able to address these issues if they have a systematic maintenance program at their disposal to help them in the decision-making process. If a systematic maintenance program is developed on a two or three-year cycle, then a time schedule and listing of equipment and supplies required can be developed. The repairs can then be made systematically each year to the extent necessary. While deterioration of the pavement due to use and environment can not be completely prevented, timely and effective maintenance is the greatest deterrent to pavement deterioration. However, it should be noted that maintenance, no matter how effectively carried out, cannot overcome or compensate for a major design or construction inadequacy. However, maintenance inspection can reveal, at an early stage, where a problem exists and thus provide the warning and time needed to permit corrective action. Postponement of minor maintenance can develop into major and costly pavement repair problems.

1.2 PROBLEM STATEMENT

The aviation community has a large investment in airport pavements. Immediately upon completion of construction, airport pavement begins a gradual deterioration which can be attributed to several factors. Normal distresses in the pavement structure result from surface weathering, fatigue effects, poor drainage, and differential movement in the underlying layers over a period of years. In addition, faulty construction techniques, substandard materials, or poor workmanship can accelerate the pavement deterioration process. Consequently, there is a continual necessity to perform routine maintenance, rehabilitation, and upgrading of existing airport pavements. In operating and maintaining an airport, managers and maintenance personnel are continually faced with the problem of identifying and properly treating pavement distresses and deterioration.

Kansas has 143 general aviation (GA) airports, 109 have paved runways, and 79 of these are eligible for funding from the Federal Aviation Administration (FAA). A 1995 survey of 16 paved runways in Kansas showed that approximately 26% GA airport runway sections were in poor to failed condition (Hossain and Uddin, 2001). The Comprehensive Transportation Plan authorized by the Kansas Legislature allocated $30 million towards GA airport improvement. However, a study is needed to quantify the present “condition” and predict future needs of GA airports in Kansas. Information on various pavement distresses, together with recommended corrective actions are also necessary to assist KDOT’s Division of Aviation in developing a strategy for preventive and remedial maintenance.

1.3 RESEARCH OBJECTIVES

The major objective of this research project was to assess the condition of general aviation airport pavements in Kansas and to prepare a program for state participation. The study would better demonstrate the needs of Kansas to the FAA, and would also help in preparing a state program for preservation of airport pavements. The specific objectives were as follows:

1. To assess the present condition of all paved GA airport runways in Kansas in terms of the Pavement Condition Index (PCI) based on the U.S. Army Corps of Engineer's PAVER (Shahin and Kohn, 1981) methodology as adopted by the FAA and standardized by ASTM (ASTM, 1995);
2. To develop an inventory database for all GA airports in Kansas; and
3. To form the basis for a PAVER-based pavement management system (PMS) for GA airports in Kansas.

1.4 RESEARCH ACCOMPLISHED

This research was initiated with the intention of assessing the condition of runway pavements at general aviation airports in Kansas and developing a pavement management system (PMS) for state participation. During this study, pavement conditions of runways of 107 airports were surveyed. Wichita Mid-Continent airport and Beech Factory airport were not included in the report as per KDOT's request. Airports surveyed in this study are shown Figure 1.1 and listed in Table 1.1. MicroPAVER was used as the platform for the intended PMS. The tasks accomplished were as follows:

1. Development of the framework for a PMS
2. Generation of an inventory report for the network
3. Preparation of a construction and maintenance history report

4. Evaluation of pavement conditions of the entire network
5. Development of deterioration prediction models
6. Generation of PCI prediction reports for the next five years
7. Generation of network maintenance and repair costs and policies.

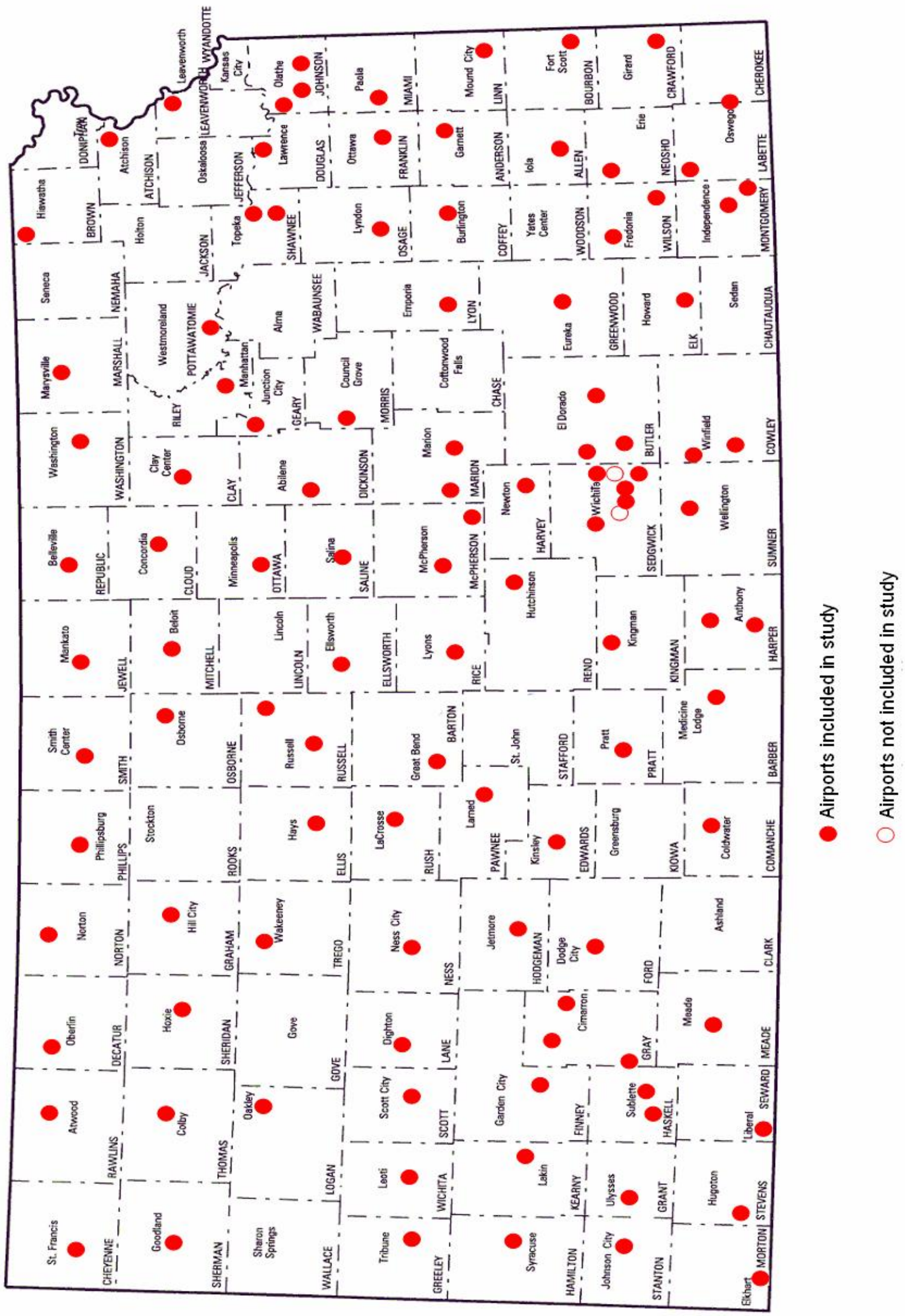

Figure 1.1: Location of Airports with Paved Runways in Kansas

Table 1.1: Kansas General Aviation Airports Studied

Nearest City	Name	ID
Abilene	Abilene Municipal Airport	K78
Anthony	Anthony Municipal Airport	ANY
Atchison	Amelia Earhart Airport	K59
Atwood	Atwood - Rawlins Co. Airport	ADT
Augusta	Augusta Municipal Airport	3AU
Belleville	Belleville Municipal Airport	RPB
Beloit	Moritz Memorial Airport	K61
Benton	Lloyd Stearman Field	1K1
Burlington	Coffey County Airport	UKL
Chanute	Martin Johnson Airport	CNU
Cimarron	Cimarron Municipal Airport	8K8
Clay Center	Clay Center Municipal Airport	CYW
Coffeyville	Coffeyville Municipal Airport	CFV
Colby	Shaltz Field	CBK
Coldwater	Comanche County Airport	3K8
Concordia	Blosser Municipal Airport	CNK
Dighton	Dighton Airport	K65
Dodge City	Dodge City Regional Airport	DDC
El Dorado	Captain Jack Thomas Airport	EQA
Elkhart	Elkhart - Morton County Airport	EHA
Ellsworth	Ellsworth Municipal Airport	9K7
Emporia	Emporia Municipal Airport	EMP
Eureka	Eureka Municipal Airport	13K
Fredonia	Fredonia Airport	1K7
Ft. Leavenworth	Sherman AAF	FLV
Ft. Scott	Ft. Scott Municipal Airport	FSK
Garden City	Garden City Regional Airport	GCK
Gardner	Gardner Municipal Airport	K34
Garnett	Garnett Municipal Airport	K68
Goodland	Renner Field	GLD

Table 1.1: Kansas General Aviation Airports Studied (continued)

Nearest City	Name	ID
Great Bend	Great Bend Municipal Airport	GBD
Harper	Harper Municipal Airport	8K2
Hays	Hays Regional Airport	HYS
Herington	Herington Regional Airport	HRU
Hill City	Hill City Municipal Airport	HLC
Hillsboro	Hillsboro Municipal Airport	M66
Hoxie	Hoxie - Sheridan County Airport	1F5
Hugoton	Hugoton Municipal Airport	HQG
Hutchinson	Hutchinson Municipal Airport	HUT
Independence	Independence Municipal Airport	IDP
Ingalls	Ingalls Municipal Airport	30K
Iola	Allen County Airport	K88
Jetmore	Jetmore Municipal Airport	K79
Johnson	Stanton County Municipal Airport	2K3
Junction City	Freeman Field	3JC
Kingman	Kingman Municipal Airport	9K8
Kinsley	Kinsley Municipal Airport	33K
La Crosse	Rush County Airport	K94
Lakin	Lakin Airport	36K
Larned	Larned - Pawnee County Airport	LQR
Lawrence	Lawrence Municipal Airport	LWC
Leoti	Mark Howard Memorial Airport	3K7
Liberal	Mid-America Regional Airport	LBL
Lucas	Lucas Airport	38K
Lyons	Lyons - Rice County Airport	LYO
Manhattan	Manhattan Regional Airport	MHK
Mankato	Mankato Airport	TKO
Marion	Marion Municipal Airport	43K
Marysville	Marysville Municipal Airport	MYZ
McPherson	McPherson Airport	MPR
Meade	Meade Municipal Airport	MEJ

Table 1.1: Kansas General Aviation Airports Studied (continued)

Nearest City	Name	ID
Medicine Lodge	Medicine Lodge Airport	K51
Minneapolis	Minneapolis City/County Airport	45K
Moline	Elk County Airport	2K6
Moundridge	Moundridge Municipal Airport	47K
Neodesha	Neodesha Municipal Airport	2K7
Ness City	Ness City Municipal Airport	48K
Newton	Newton City-County Airport	EWK
Norton	Norton Municipal Airport	NRN
Oakley	Oakley Municipal Airport	OEL
Oberlin	Oberlin Municipal Airport	OIN
Olathe	Johnson County Executive Airport	OJC
Olathe	New Century Aircenter	IXD
Osage	Osage City Municipal Airport	53K
Osborne	Osborne Municipal Airport	K75
Oswego	Oswego Municipal Airport	K67
Ottawa	Ottawa Municipal Airport	OWI
Oxford	Oxford Municipal Airport	55K
Paola	Miami County Airport	K81
Parsons	Tri-City Airport	PPF
Phillipsburg	Phillipsburg Municipal Airport	PHG
Pittsburg	Atkinson Municipal Airport	PTS
Pleasanton	Gilmore Airport	57K
Pratt	Pratt Industrial Airport	PTT
Rose Hill	Cook Airfield	K50
Russell	Russell Municipal Airport	RSL
Sabetha	Sabetha Municipal Airport	K83
Saint Francis	Cheyenne County Municipal Airport	SYF
Salina	Salina Municipal Airport	SLN
Satanta	Satanta Municipal Airport	1K9
Scott City	Scott City Municipal Airport	TQK

Table 1.1: Kansas General Aviation Airports Studied (continued)

Nearest City	Name	ID
Smith Center	Smith Center Municipal Airport	K82
Sublette	Sublette Flying Club Airport	19S
Syracuse	Syracuse - Hamilton County Municipal Airport	3K3
Topeka	Billard Municipal Airport	TOP
Topeka	Forbes Field	FOE
Tribune	Tribune Municipal Airport	5K2
Ulysses	Ulysses Airport	ULS
WaKeeney	Trego County - WaKeeney Airport	0H1
Wamego	Wamego Municipal Airport	69K
Washington	Washington County Memorial Airport	K38
Wellington	Wellington Municipal	EGT
Wichita	Cessna Aircraft	CEA
Wichita	Jabara Airport	AAO
Wichita	Riverside Airport	K32
Wichita	Westport Airport	71K
Winfield	Strother Field Airport	WLD

1.5 SYNOPSIS

This thesis is divided into seven chapters. Chapter one is an introduction to the problem. Chapter two is a literature review on airport pavement management systems. Chapter three identifies the projects and describes the methodology used in the study. Chapter four is an analysis of the data gathered. Chapter five develops condition prediction models. Chapter six presents several reports developed with MicroPAVER. Deterioration prediction models, maintenance policies, and budget reports are presented in this chapter. Finally, chapter seven offers conclusions and recommendations.

CHAPTER 2

LITERATURE REVIEW

2.1 HISTORY OF PAVEMENT MANAGEMENT SYSTEMS

The modern concept of pavement management systems can be attributed to the developments from three different research projects. In 1968, researchers at the University of Texas began developing a systems approach to design pavements using available data from the AASHO Road Test. Concurrently, Hutchinson and Wilkins conducted independent studies to structure the overall pavement design and management problem in Canada (Haas et al., 1994). Also, the Texas Transportation Institute of Texas A&M University was making strides in this area as part of their work for the Texas Highway Department. The term "pavement management system" began to be used by these groups of researchers in the late 1960s and early 1970s to describe the entire range of activities required in providing and preserving pavements (Haas et al., 1994).

One of the first "working" pavement management systems was Project 123, a joint research effort conducted by the Texas Highway Department, Texas A&M University, and the University of Texas (Hudson, 1970). A series of reports and manuals as well as many of the modern innovations in pavement analysis were a direct result of this. In the late 1970's Haas compiled two books summarizing early developments in pavement management. In the following years, the focus shifted to the development of component technology for pavement management, and to the implementation at the state and local levels (Haas et al., 1994).

Nowadays pavement management systems are used in three key components of the transportation system: highway, air and rail. Obviously, pavements are a major component of highway systems. Air travel requires pavements in the form of runways, taxiways, and aprons. Railroads travel under a “pavement” made up of rails, ties, and ballast, which is not all too different from a highway pavement design. While the function of the pavement varies through the different types of systems its purpose remains the same: to serve traffic safely, comfortably and, efficiently, at a reasonable cost. The goal of any pavement management system is to improve the efficiency of the decision making process by providing timely feedback, and ultimately, to provide cost-effective solutions to maintain pavements (Haas et al., 1994).

2.2 PAVEMENT MANAGEMENT SYSTEM BASICS

Pavement management involves all the activities related to providing and managing the pavement portion of a public or private works program, regardless of its size. The objective of the management system is to use reliable information and decision criteria in an organized framework to produce a cost-effective pavement program (Haas et al. 1994). A pavement management system (PMS) is a set of tools that assist decision makers in finding optimum strategies for providing and maintaining pavements in a serviceable condition over a given period of time. In order to accomplish this, any PMS must meet the following requirements (Haas et al. 1994):

- Capable of being easily updated and/or modified as new information becomes available
- Capable of considering alternative strategies
- Capable of identifying the optimum alternative

- Capable of basing decisions on rational procedures with quantified attributes, criteria, and constraints
- Capable of using feedback information regarding the consequences of decisions

In order to perform those essential requirements a PMS typically consists of three distinct components: database, network-level management, and project-level management.

2.2.1 Database:

Pavement management systems rely on data to predict future pavement conditions and support the decision-making process. A database is the cornerstone upon which the entire PMS is built. It literally serves as the building block of a PMS and servers as the repository of the information required to support all decisions concerning maintenance and rehabilitation. The quality of the database is very important because it determines the quality of outputs of the PMS. The major following categories of input data are essential for PMS (Haas et al. 1994):

- Inventory
- Information relative to pavement condition
- Construction, maintenance and rehabilitation history
- Costs
- Other (traffic, design material, geometrics, etc.)

2.2.2 Network-Level Management

As the name suggests, network-level management considers the needs of the entire network. In order to minimize cost, the network is inspected in lesser details and more quickly. In general, network-level management considers the agency's short- and long-term-range budget needs, present and future overall network conditions, and identification and prioritization of potential projects. The primary purpose of the network-level management is to develop a priority program and a schedule of work within overall budget constraints. When a pavement section is selected as a potential project, project-level management comes into play.

Developing a priority program and schedule of work is the main goal of network-level management. In order to achieve that goal network-level management must perform the following (Uddin, 1998):

1. Collect and maintain data about the network inventory and cost of labor and materials;
2. Divide the network into homogenous sections;
3. Develop deterioration prediction models for different road categories;
4. Perform condition surveys to determine the present condition of the network. Condition survey at network level is much less detailed that the condition survey at project level;
5. Determine performance standards based on a condition index;
6. Identify "now" and "future" needs. Now needs are determined based on condition survey results and performance standards. Future needs are identified with deterioration or performance prediction models;
7. Develop alternative maintenance and repair (M&R) policies and their associated costs;
8. Determine current and future budget requirements by using the maintenance and repair policies of the agency; and
9. Determine annual and long range work plans by using the priority programming technique of the agency. Prioritization compares the investment alternatives based on a life-cycle cost analysis.

2.2.3 Project-Level Management

Selecting the best maintenance and rehabilitation alternative for each project is done in the project-level management. A detailed condition survey and evaluation is conducted for each project, and the most feasible alternative is selected. Little or no consideration is given to the resource requirements of other pavements in the network. In the past, most pavement engineers have been trained to work at the project level. This is acceptable as long as the money is abundant, which is rarely the case. Top management is now demanding budget projections that consider the agency's entire network for each fiscal year. Activities performed at the project level include the following (Uddin, 1998):

1. Detailed data collection about construction history, traffic, pavement condition, drainage, etc;
2. Pavement evaluation, based on collected data, to determine overall pavement condition, and the contribution of different factors in deterioration of pavements;
3. Selection of feasible M&R alternatives based on pavement evaluation;
4. Life cycle cost analysis to determine the most cost-effective alternative;
5. Physical implementation of the project; and
6. Performing routine maintenance action.
7.

2.3 DETERMINING MAINTENANCE AND REHABILITATION NEEDS

This section will discuss four different approaches to estimate maintenance and rehabilitation (M & R) needs: Ad hoc approach, structured approach, optimum approach and fuzzy logic approach. The first three approaches are well known, time tested, and used by many different agencies (especially the optimum approach). The fuzzy logic approach is relatively new and uses a complex mathematical method to make decisions.

2.3.1 Ad hoc Approach

This approach uses the opinion, judgment and experience of a staff member to determine the M&R needs. No life-cycle cost analysis is considered in this method. This approach results in the application of a few selected alternatives to solve most problems (Kher and Cook, 1985).

2.3.2 Structured Approach

The structured approach evaluates pavement in terms of a condition indicator to select M&R requirements. Even though this method addresses specific distresses found on the pavement, it might not provide a cost-effective solution because no life-cycle cost analysis is conducted to compare other alternatives (Kher and Cook, 1985).

2.3.3 Optimum Approach

Life cycle cost analysis determines the selection of M&R strategies in this approach. An accurate method to predict future pavement condition is indispensable in this method. There are various optimization methods currently used by different agencies. True optimization techniques seen to be the most successful in terms of the net amount of monetary savings created for the users. The Arizona Department of Transportation (ADOT), Kansas Department of Transportation (KDOT), and the Ohio Department of Transportation (ODOT) have developed some of the most revolutionary optimization methods.

ADOT has been a pioneer of PMS since the early 1980s. For the last three decades, ADOT used a Markovian chain-based PMS to support its pavement design, construction, and preservation activities. With the use of the Markov process-based PMS, ADOT personnel have obtained the most cost-efficient budgets to meet pavement performance standards. This National Management Science Achievement award winner PMS was a great success and has influenced the development of similar PMS all over the world. Since its original implementation the system has been updated periodically, but the core methodology has remained the same (Li et al., 2006). However, the nature of the Markovian chain model means that the model lacks the flexibility to consider different conditions associated with individual pavement projects. After five years of research, ADOT unveiled its new PMS in 2006. The new PMS uses a completely different method to predict pavement needs. Instead of characterizing the condition changes of a group of pavements as a whole set, as Markovian chains do, it strives to capture the unique performance pattern for each individual pavement. This approach combines the use of site-specific prediction with default performance class-based models that are used when there is not sufficient data for site-specific models. The site-specific modeling approach is based on the analysis of historical performance data stored in database to develop model coefficients for the individual pavement section. For each individual section, available historical performance data since last rehabilitation or construction is analyzed to determine the model that matches the observed performance of the section and predict future needs (Li et al, 2006).

KDOT uses a Markov decision process as the basis for their PMS. KDOT's PMS consists of three distinctive systems: a Network Optimization System (NOS), a Project Optimization System (POS) and a Pavement Management Information System (PMIS). NOS is designed to identify pavement rehabilitation and maintenance policies that minimize total costs subject to meeting performance standards, or maximize performance standards for a fixed budget. The annual NOS report produces an annual minimum rehabilitation budget, locations of candidate rehabilitation projects, minimum performance requirements for a fixed budget, and optimal rehabilitation projects. POS is designed to deal with engineering and technical decisions and it identifies optimal rehabilitation actions or initial design for each project in group of candidate projects. POS identifies optimal maintenance solutions using site specific actions, costs, and engineering data for major projects identified using NOS. The objective of the POS model is to maximize user benefits subject to meeting target budget and performance levels. The third component, PMIS, provides the necessary information for NOS and POS models to operate (Kulkarni, 1983).

The Ohio Department of Transportation (ODOT) uses a network level PMS to prescribe maintenance and rehabilitation actions and predict required budget for each roadway segment for each year of a six-year planning period. The PMS, called PMS-III, forecasts future network conditions, M&R needs, and associated budget by maximizing preservation of pavement investment for a given annual budget or by minimizing the cost of maintaining the network condition at a given performance level. The system consists of six different modules. The pavement condition module evaluates pavements based on pavement condition rating, present serviceability, and skid resistance. The M & R module determines the most feasible M & R strategies based on information from the previous module. The cost module estimates the cost of a given M & R strategy. The performance-prediction module predicts future pavement condition using a damage function. The damage function was developed from historical data and can be updated to reflect new trends; the function is dependent on traffic, pavement structure, and soil characteristics. The optimization module uses a linear programming package to analyze various 6-year plans. Two methods of optimization are available: performance maximization and cost minimization. The optimal solution identifies a policy and a budget to be allocated to a project

(Majidzadeh et al, 1992). In recent years ODOT has used a fuzzy-logic based system to determine M&R needs (Wee and Kim, 2006). Fuzzy logic is explained in detail in the next section.

2.3.4 Fuzzy Logic Approach

Fuzzy logic is a form of multi-valued logic derived from fuzzy set theory used to deal with reasoning that is approximate rather than precise. In pavement maintenance, fuzzy-logic can be used to provide a pavement condition rating score for each distress, and to provide a basis for maintenance needs assessment in terms of various user-defined severity terms. The user-defined severity levels are a key input to programming and scheduling maintenance activities using this approach. The fuzzy logic approach was created to accommodate the uncertainties involved in subjective pavement assessments, and variations among the subjective assessment of experts. Fuzzy logic can receive different opinions (expressed in term of maintenance needs) from different sources, and arrive at an aggregated decision. This eliminates subjectivity by using a consistent analytical procedure to address the differences in maintenance needs assessments. The opinion on maintenance needs from difference sources, together with the aggregated membership functions of a distress can be converted into a numerical score useful to categorize pavement needs (Fwa et al., 2003).

2.4 DEVELOPMENT OF A PAVEMENT DETERIORATION PREDICTION MODEL

Pavement deterioration prediction models are an essential component of network-and project-level management. Prediction models are used at the network level for budget optimization by performing life-cycle cost analysis, and to determine data collection needs to assess the present condition of the network. At the project level, prediction models are used to design pavements, perform life-cycle cost analysis, determine the best time to perform maintenance, and select optimal maintenance or rehabilitation measure. The following are the major requirements for any prediction model (Darter, 1980):

1. An adequate database
2. Inclusion of all significant variables affecting deterioration
3. Careful selection of the fundamental form of the model
4. Criteria to assess the precision of the model

Deterioration prediction models can classified in two basic classes of models, namely, deterministic and probabilistic. Deterministic models are based on the primary response, structural performance, functional performance, and damage of the pavements in service. Examples of deterministic prediction models include straight line extrapolation, regression analysis, and constrained least squares. Probabilistic models take into account certain uncertainties associated with pavement performance under all traffic and weather conditions. Examples of probabilistic models include survivor curves and Markov models (Lytton, 1987).

2.4.1 Straight Line Extrapolation

Straight line extrapolation is a simple model based on data gathered during a one-time condition survey. It can be used to develop a pavement deterioration model if a large database with enough pavement condition data is not available. However, if sufficient data is available, a more accurate model should be adopted.

2.4.2 Regression Analysis

This method relates a dependent variable to one or more independent variables. For pavement prediction models, the measured structural or functional deterioration (dependent variable) can be associated with subgrade strength, axle load applications, pavement layer thickness, and environmental factors (independent variables). This method needs a long-term database and each model is only applicable to specific situations.

2.4.3 Constrained Least Squares

The constrained least squares model fits a polynomial curve to the data that minimizes the squared differences between predicted and actual data. Also, the technique applies a constraint that does not allow the curve to have a positive slope. This means that pavement condition is not allowed to increase with age. MicroPAVER, a pavement management system developed by the U.S. Corps of Engineers, uses this method to create prediction models.

2.4.4 Survivor Curve

Survivor curves use a plot of probability versus time to indicate the percentage of pavement that remains in service at a particular time requiring major maintenance or rehabilitation.

2.4.5 Markov Model

The Markov model is a special case of dynamic programming. The objective of the model is to choose the actions at the successive points in time in such a way that maximizes the total expected reward over an infinite time horizon. Markov models are used to select a set of actions that will give the biggest reward in the long run or to determine the total reward that can be expected if a certain set of actions are taken. The Markov decision processes can be solved using an algorithm, linear programming, or approximated by standard dynamic programming (Van Nunen, 1976).

As mentioned in previous sections, the Markov model has been successfully implemented in the pavement management system of several states. In general, a Markovian prediction model for use in pavement management can be developed using the following step-by-step procedure (Uddin, 1998):

1. Divide the highway network into uniform road segments
2. Define road categories
3. Define stress states and condition states for each road category
4. Identify alternative maintenance actions
5. Estimate transition probabilities
6. Determine optimum maintenance polices.

The main disadvantage of the Markov models is that it requires a large amount of computations, or a large-scale linear programming software package (Van Nunen, 1976). Also, because of the probabilistic nature of Markov models, they require statistical analysis of a large number of samples. In order to obtain enough samples for meaningful statistical analysis many different pavement sections have to be grouped into a limited number of roughly homogenous categories based on certain data. More categories could be generated, but a larger number of categories would mean a fewer sample pavements in each category, which would compromise the reliability and validity of the process (Li et al., 2006).

2.5 USE OF PAVEMENT MANAGEMENT SYSTEMS IN GA AIRPORTS IN THE UNITED STATES

The most effective means of preserving airport pavement areas is the implementation of a comprehensive maintenance program. Such a program is a coordinated, budgeted, and systematic approach to both preventive and remedial maintenance. Also, it is an indispensable part of a pavement management system (PMS). Since 1985, the number of airport agencies using a PMS to manage their pavements has grown considerably. In fact, 84% of state aviation agencies in the United States use a PMS (Broten et al., 2004). This is a direct effect of the passage of Public Law 103-305 in 1995, which states that for an airport agency to be eligible for federal funding, it must be able to show that it has an effective pavement maintenance management system (FAA, 2003). A few states, namely Arizona, Texas, North Carolina and Virginia, have successfully used and applied a PMS to general aviation airports over the last two decades.

2.5.1 Arizona Department of Transportation

In 1992, the Arizona Department of Transportation (ADOT) developed a network-level pavement management system for 56 general aviation airports throughout the state. The system used to evaluate pavement condition was the Arizona Pavement Rating system; also, it provided the necessary tools to produce prediction of pavement service life, rehabilitation requirements, and prioritization of airport pavement projects. The system was based on experiences gained from pavement evaluations that used PCI procedures, but the system was not as labor-intensive and did not produce as much quantitative information as the MicroPAVER methodology (Holt, 1994).

With the goal of promoting and improving its aviation pavement infrastructure, ADOT revamped its airport management system in 2000. Nowadays, the Arizona Airport Pavement Management System uses MicroPAVER as the basis for generating a five-year airport pavement preservation program (APPP). As part of APPP, every three years the MicroPAVER-based database is completely updated. Individual airport reports from the update are shared with all participating system airports. ADOT's aeronautic division ensures that the PMS database is kept current and in compliance with the FAA requirements. The aeronautic division was recognized with a "Showcase in Excellence" award by the Arizona State Quality Award Program for its pavement management system.

2.5.2 Texas Department of Transportation

In the early 1990s, the division of aviation of the Texas Department of Transportation (TxDOT) implemented a MicroPAVER-based PMS for the airfields in the state. By the end of 1993, data for 141 airports had been entered into the MicroPAVER database. Based on pavement conditions and relevant maintenance cost information, MicroPAVER was used to prepare budgets suitable for maintenance actions. The system had all the capabilities of a MicroPAVER-based PMS including report generation (Freeman and Dresser, 1993).

Starting in 2000, in addition to being required to have a PMS in order to be eligible for federal funding, airports in the state of Texas were required to participate in a program initiated by TxDOT's division of aviation called RAMP (routine airport maintenance program) in order to be eligible for state funds. RAMP will use TxDOT resources, and existing maintenance contracts or new contracts, to assist local governments in providing needed airport maintenance.

RAMP is designed to promote a well-managed maintenance program that will enhance the safety, serviceability, and useful life of airport pavements in Texas. The data collected during pavement inspections can be used to develop the scope of RAMP work needed. In other words, the pavement management program can identify work to be done, and RAMP can execute that work, at a significantly reduced cost (Texas Department of Transportation, 2000).

2.5.3 North Carolina Department of Transportation

The division of aviation of the North Carolina Department of Transportation (NCDOT) started implementing a pavement maintenance management system (PMMS) in 1994. The first inspection and report for the PMMS were completed that year and were funded by a System Planning Grant from FAA. By 1996, NCDOT had completely updated the system, including re-inspections (Walston, 1993).

In September 2006, the division of aviation began a biennial process for updating the PMS for each publicly owned and operated general aviation airport in North Carolina. The update was performed in large part by the NCDOT division of highways area pavement coordinators using the PCI methodology. The division of aviation is expecting to analyze and budget for the maintenance needs of each individual airport in an objective manner through use of the PCI evaluation and the expertise of the pavement coordinators. NCDOT expected to complete the data collection by the end of 2006, with the data entry and analysis completed by March 2007. A report with the PMS results was expected to be submitted to all airports in the state by the end of spring 2007 (North Carolina Department of Transportation, 2008).

2.5.4 Virginia Department of Transportation

The Virginia Department of Transportation (VDOT) implemented three integrated management programs to enable the Division of Aviation to supervise existing pavement deficiencies and maximize the use of their budget. The three integrated systems are: runway approach identification, airport information management, and pavement management. The MicroPAVER-based pavement management system consists of a network of 56 general aviation airports. The implementation of the system included the following steps:

1. Training of airport inspectors
2. Obtaining historical data base for each airport
3. Rating the current condition of each runway pavement
4. Developing feasible maintenance policies
5. Estimating cost of implementing maintenance polices.

Several condition and projected future condition reports were developed with the use of the MicroPAVER system. Also, reports estimating total rehabilitation costs for each airport were created with the computer software (Broten and McNeely, 1993).

2.6 CURRENT STATE OF AVIATION INFRASTRUCTURE IN THE UNITED STATES

Every four years the American Society of Civil Engineers reports on the state of the country's infrastructure. The *2009 Report Card for America's Infrastructure* qualifies the overall condition of the nation's aviation infrastructure as "poor" (equivalent to a D letter grade). According to the National Plan of Integrated Airport System (NPIAS), there are 3,356 publicly owned, public-use airports in the United States. The Federal Aviation Administration (FAA) aims to have no less than 93% of the runways under NPIAS in good or fair maintenance condition. In 2007, 78% of runways under NPIAS were rated good and 18% were rated fair, exceeding the proposed goal. However, the number of runway incursions increased by 12% from 2006 to 2007. A runway incursion is an incident involving the incorrect presence of an aircraft, vehicle, person or object on the ground that creates a collision hazard for an aircraft taking off, indenting to take off, landing or indenting to land. The number of runways incursions is expected to keep increasing in the next few years due to FAA's stringent new definition (ASCE, 2009).

The ASCE report estimates a need of $87 billion to cover the total airport capital development cost for the next five years. Estimated spending on improvement projects during that period of time is $46.3 billion, creating a $40.6 billion projected shortfall. Four sources of funding are generally used to fund airport improvements: airport cash flow, revenue and general obligation bonds, federal/state/local grants, and passenger facility charges. One of the most common ways to finance improvement plans is through the Airport Improvement Program (AIP). However, congressional authorization for AIP expired in 2007, making it difficult to create any sort of long-term development plan (ASCE, 2009).

Finally, the report suggests actions needed to “raise the grade” of the current aviation infrastructure. The development of federal, regional, and state infrastructure plans that both complement the national vision and center on system wide outputs should be a priority. The plans must present a better defined set of roles for all parties involved and focus founding to solve the most pressing problems. Special attention should be paid to the life cycle costs and ongoing maintenance. This measure will result in sustainable and durable systems that meet the needs of future users. Increased investment and commitment from all stakeholders is needed; more specifically, Airport and Airway Trust Fund balances should be used for air traffic and airport infrastructure and improvement projects only, and the gap on annual funding shortfalls could be closed by increasing funding guarantees in the reauthorization.

CHAPTER 3

FRAMEWORK FOR A PAVER-BASED PAVEMENT MANAGEMENT SYSTEM FOR GA AIRPORT RUNWAYS IN KANSAS

3.1 PAVEMENT MANAGEMENT SYSTEMS

A common saying goes, "A stitch in time saves nine." This could not be truer for pavement management, to the point that the industry revolves around the policy of "Pay now, or pay much more later." Airport agencies are realizing that it is more costly to rehabilitate badly deteriorated pavement. To effectively use funds available, pavements should be managed not only maintained. A pavement management system (PMS) provides a systematic and consistent method for selecting maintenance and rehabilitation procedures, determining priorities, choosing cost-effective alternatives and determining optimal times for repair.

Figure 3.1 shows a general deterioration model for pavements and how the cost of rehabilitation changes at various times throughout its life. Several studies have shown that maintaining a pavement in good condition instead of rehabilitating a pavement in poor condition is about five times less expensive. Also, it can be observed from Figure 3.1 that the best time to perform a major rehabilitation is just as the pavement's rate of deterioration starts to increase. Unfortunately, pavements do not exhibit clear signs when they reach this point. However, a pavement management system can help identify when it is best to rehabilitate and help decision makers use available resources more effectively.

Because of its many capabilities and popularity among pavement management agencies, MicroPAVER was chosen to serve as the pavement management system for this research.

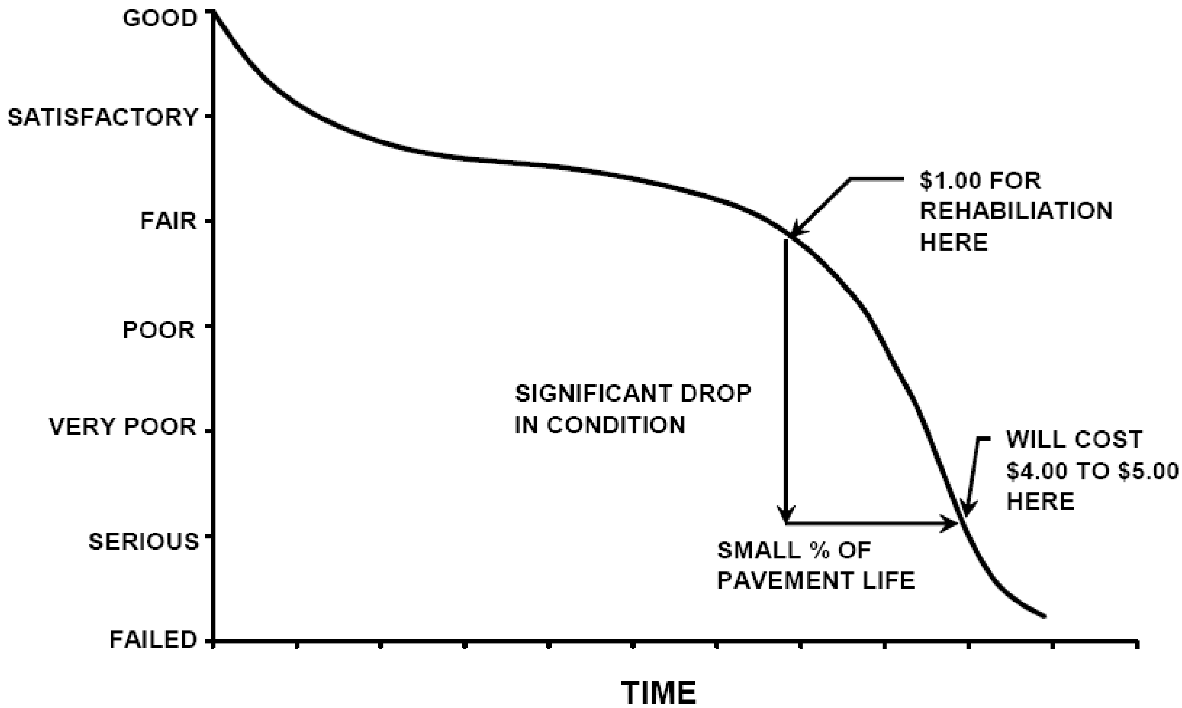

Figure 3.1: Typical Pavement Condition Life Cycle (Shahin, 1994)

3.2 INTRODUCTION TO MICROPAVER

MicroPAVER is a pavement management system originally developed in the late 1970s by the U.S. Army Corps of Engineers to help the Department of Defense manage maintenance and rehabilitation needs of pavements in military bases (Corps of Engineers, 2008). In 1979, the American Public Works Association (APWA) adopted the original PAVER for use in microcomputers and the system was re-titled MicroPAVER (APWA, 2008).

MicroPAVER uses field inspection data and a Pavement Condition Index (PCI) to describe a pavement's present condition and to predict future maintenance and rehabilitation needs. PCI values can then be used as the basis for a practical decision-making procedure for identifying cost-effective maintenance and repairs on airfield pavements, roads, streets, and parking lots. PCI values are an ASTM standard to measure pavement conditions of roads, parking lots, and airports (ASTM D6433-99 and ASTM D5340-04, respectively). MicroPAVER is the only pavement rating methodology that has an ASTM standard designation. This makes MicroPAVER the premier software to describe the current condition of all types of pavements

Nowadays, MicroPAVER is the state-of-art technology for pavement management. It is currently being used by more than 600 entities, including cities, counties, airports, and, private consulting firms. MicroPAVER is also the pavement management system still used by the U.S. Army, U.S. Navy, U.S. Air Force, Air National Guard, and the Federal Aviation Administration. MicroPAVER has many attractive features, as follows:

- Data storage and retrieval
- Database administration
- Inspection scheduling
- Pavement network definition
- Pavement condition rating
- Determination of M & R needs
- Determination of present and future condition
- Performance of economic analysis
- Budget planning

User support and feedback play a key role in development of any pavement management software. One of the many strengths of MicroPAVER "lies in the long-term durability of Corps of Engineers and APWA involvement in supporting user software, information, and training needs" (APWA, 2008).

3.3 THE PAVEMENT MANAGEMENT PROCESS

The following are the main tasks necessary for the creation of a pavement management process:

1. Pavement network definition
2. Pavement branch definition
3. Pavement section definition
4. Pavement condition measurement
5. Pavement condition prediction
6. Network-level management
7. Project-level management.

3.3.1 Pavement Network Definition

Network identification and definition is the first step in establishing a PMS. By definition, a network should consist of a logical grouping of pavements for M&R management. Some factors to consider when identifying different networks are use, funding source, minimum operational standards, and purpose of the PMS. In a MicroPAVER PMS, before any type of data can be entered into the database, the pavement network must be defined. In most cases, an agency (manager) may be responsible for management of roads, parking lots, airfields, sidewalks, and other type vehicular facilities. The agency should make a decision as to which of these facilities will be identified as separate networks. For example, a regional airport in Kansas might decide to identify its pavements as two separate networks; one for airfields (runways, taxiways, aprons, etc) and one for roads and parking lots. Separate networks can be stored in a single computerized PMS environment, which allows the capability of sharing data as needed. A major advantage of smaller networks is efficient data entry and report generation.

3.3.2 Pavement Branch Definition

A branch is a readily identifiable part of the pavement network and has a distinct function. For example, the regional airport mentioned in the section above could consider a taxiway or a runway each as a separate branch of their network. In MicroPAVER, each branch is identified in two ways: (1) by an alphanumeric descriptive name, which can be up to 35 characters long, called the "branch name" and (2) by an alphanumeric code of 10 characters or less called the "branch ID." Typically, existing street names are used as branch names. The branch code is a unique code used to help store, identify, and retrieve data from the database. Before selecting a code, it is recommended to review existing codes at the agency to ensure compatibility.

3.3.3 Pavement Section Definition

A branch does not always have consistent characteristics throughout its entire area or length. For this reason, branches are divided into smaller components called "sections" for managerial purposes. A section should be viewed as the smallest management unit when considering application and selection of major maintenance and repair treatments. A section must be of the same surface type throughout its entire length. Each branch consists of at least one section, but may consist of more if pavement characteristics vary within the branch. The decision to classify sections further by other factors can be made at the agency's discretion. For example, MicroPAVER gives the option of classifying sections by "zones," which can be used to group geographic portions of a network based on characteristics common to a subset. Several factors must be considered when dividing branches into sections, among them are pavement structure, construction history, traffic, pavement functional classification, drainage facilities, and condition. Each of these factors will be discussed below. Above all, judgment and consistency must be the driving factors when designating sections. In MicroPAVER, a section is represented by an alphanumerical code. This code is referred to as the “section ID” and is used for storage and retrieval of all section information stored in the database. MicroPAVER also offers the option of “marking” the beginning and ending points of each section.

3.3.3.1 Pavement Structure

The structural characteristics (thickness and materials) should be consistent throughout the entire section. Construction records should be consulted if enough information about the pavement structure is not readily available. If there is a suspicion about inaccurate construction records, then a limited number of cores should be taken to obtain information about the pavement structure.

3.3.3.2 Construction History

Construction history should be consistent within a given section. Pavement constructed at different times, or by different contractors, or with different materials should be treated as separate sections. Also, areas that have received significant major repairs that are not common anywhere else in the section should be divided into a separate section.

3.3.3.3 Traffic

Traffic on runways usually transits within the central 50 to 75 ft. For this reason, runways might have to be divided into different sections to account for the excess traffic in the middle area; this is especially true for larger airports.

3.3.3.4 Pavement Functional Classification

A section division should be made if the functional classification changes along the section length (i.e. the runway changes from a primary runway to a secondary runway at some point).

3.3.3.5 Drainage Facilities

Drainage facilities should be consistent throughout a section and should not affect pavement performance.

3.3.3.6 Condition

Pavement condition can be used to divide sections if, after an initial inspection, it is noted that there is considerable variation in condition. Changes in distress types, quantities, or causes can serve as the basis to create a new section.

3.3.3.7 Other Considerations

As mentioned before, judgment and consistency should be the driving factors when analyzing if a new section needs to be created. Each situation must be approached as a unique situation, as no two agencies have the same implementation and economic conditions. Remember that a section is the smallest management unit; therefore, sections can not be too small to schedule productive individual M&R work.

3.4 PAVEMENT CONDITION MEASUREMENT

An essential feature of a PMS is its ability to determine the current condition of the pavement network and to predict the future condition. To predict conditions reliably, an objective, repeatable rating system for identifying the pavement's condition must be used. The pavement distress condition rating procedure used in this study is the Pavement Condition Index (PCI) developed by the U.S Army Corps of Engineers (Shahin, 1994).

The PCI is a numerical index with values ranging from zero (failed) to 100 (excellent). Calculation of the PCI is based on the results of a visual condition survey in which distress type, severity, and quality are identified. Figure 3.2 shows the inputs MicroPAVER requires to calculate PCI and a standard PCI rating scale, which was also used in this study to qualify pavement conditions.

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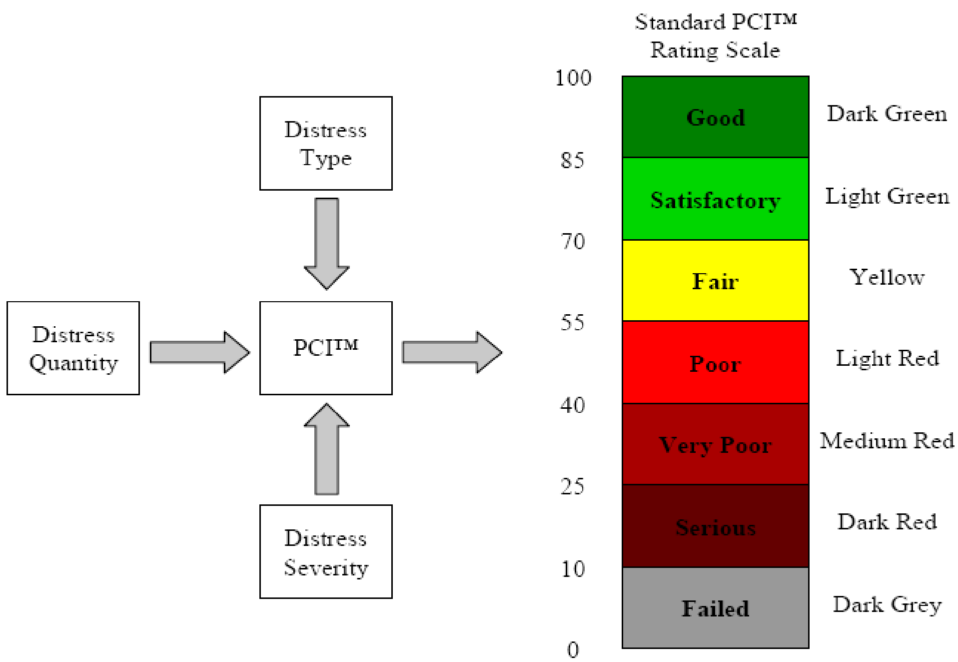


Figure 3.2: Pavement Condition Index (PCI) Inputs and Rating Scale (APWA, 2007)

The PCI was developed to provide an index of the pavement's structural integrity and surface operational condition. The distress information obtained as part of the PCI condition survey provides insight into the cause of distress, and whether it is related to load or climate. The degree of pavement deterioration is a function of distress type, distress severity, and density of distress. Because of the large number of conditions possible, producing one index that would take into account all three factors was considered a problem. To overcome it, "deduct values" were introduced as weighing factors to indicate the degree of effect that each combination of distress type, severity level, and distress density has on pavement condition. The deduct values were estimated using in-depth knowledge of pavement behavior, input from many experienced pavement engineers, field testing, and evaluation of the procedure. Use of PCI for airfield pavement, roads, and parking lots is widely accepted and has been formally adopted as a standard procedure by many agencies worldwide.

Before conducting the visual survey to determine the PCI, a section must be first divided into sample units. Then, some of the sample units will be selected to be surveyed. Only after those two steps are completed can the condition survey be carried out.

3.4.1 Dividing a Section into Sample Units

A sample unit is a conveniently defined portion of a pavement section designed only for the purpose of pavement inspection. For asphalt-surfaced roads (including asphalt over concrete), a sample unit is defined as an area of 2,500 ± 1,000 sq. ft. For asphalt-surfaced airfields, each sample unit area is defined as 5,000 ± 2,000 sq. ft. MicroPAVER suggests using sample unit sizes close to the recommended mean for accuracy. For concrete roads and airfields with joints spaced less than or equal to 25 ft., the recommended sample size is 20 ± 8 slabs. For slabs with joints spaced greater that 25 ft., imaginary joints, less than or equal to 25 ft. apart, should be assumed. For example, if a road has slabs with joints every 60 ft, imaginary joints are assumed at 20 ft. Thus, each slab would be counted as three slabs for the purpose of pavement inspection. An important consideration in dividing a pavement section is convenience. For example, an asphalt road pavement section 22 ft wide by 4,720 ft long can be divided into sample units 22 ft wide by 100 ft long, resulting in a sample unit size of 2,200 sq. ft. Due to the section's length, some sample units may have to be a different length than others. Not all sample units are required to be of the same size, but they do have to fit within the guidelines for recommended unit size to ensure an accurate PCI. For each pavement section being inspected, it is highly recommended to keep sketches showing size, location, and orientation of sample units. These sketches can be used to relocate sample units for future inspections (Texas Department of Transportation, 2000).

3.4.2 Choosing Samples Units To Be Surveyed

Inspection of every sample unit in a pavement section requires considerable effort and time, especially for larger sections. Creation of a sampling plan, which minimizes the amount of resources needed without compromising the accuracy of the PCI estimation, is necessary (Shahin, 1994). The required degree of sampling depends on use of the pavement and whether the survey is conducted at the network or project level. For a network-level analysis, a limited number of samples are inspected. MicroPAVER, for example, requires a minimum of five samples. Table 3.1 shows a typical network-level sampling criteria used by some agencies.

Table 3.1: Network-Level Sampling Criteria (Shahin, 1994)

Number of sample units in the section	Minimum number of units to be inspected
1 – 5	1
6 – 10	2
11 - 15	3
16 - 40	4
Over 40	10% (rounded up the next whole sample unit)

For project-level analysis, more accurate data is needed to make informed decisions. Therefore, more samples units are inspected than in a network-level survey. The minimum number of sample units (n) that must be surveyed to obtain an adequate estimate of the section's PCI can be calculated using the following formula (Shahin, 1994):

$$n = \frac{N * s^2}{\left(\frac{e^2}{4}\right) * (N-1) + s^2} \qquad (3.1)$$

where

N = total number of sample units in the section

e = allowable error in the estimate of the section PCI; usually, e = ± 5 PCI points; and

s = standard deviation of the PCI between sample units in the section. When performing an initial inspection or if no other data is available, the standard deviation is assumed to be 10 for asphalt pavements and 15 for Portland cement concrete pavements.

Once the number of sample units to be surveyed has been determined, the next step is to compute the spacing interval of the units. It is recommended to space the units using a systematic random sampling method, where the samples are equally spaced throughout the section and the first sample is selected at random. The sampling interval (i) is determined by the following formula rounded off to the smaller whole number:

$$i = \frac{N}{n} \qquad (3.2)$$

where

N = total number of sample units; and

n = number of sample units to be surveyed.

Additional sample units should be inspected when non-representative or unusual distresses are encountered. These "unusual" sample units should be considered as additional units, rather than as random or representative units (Shahin, 1994).

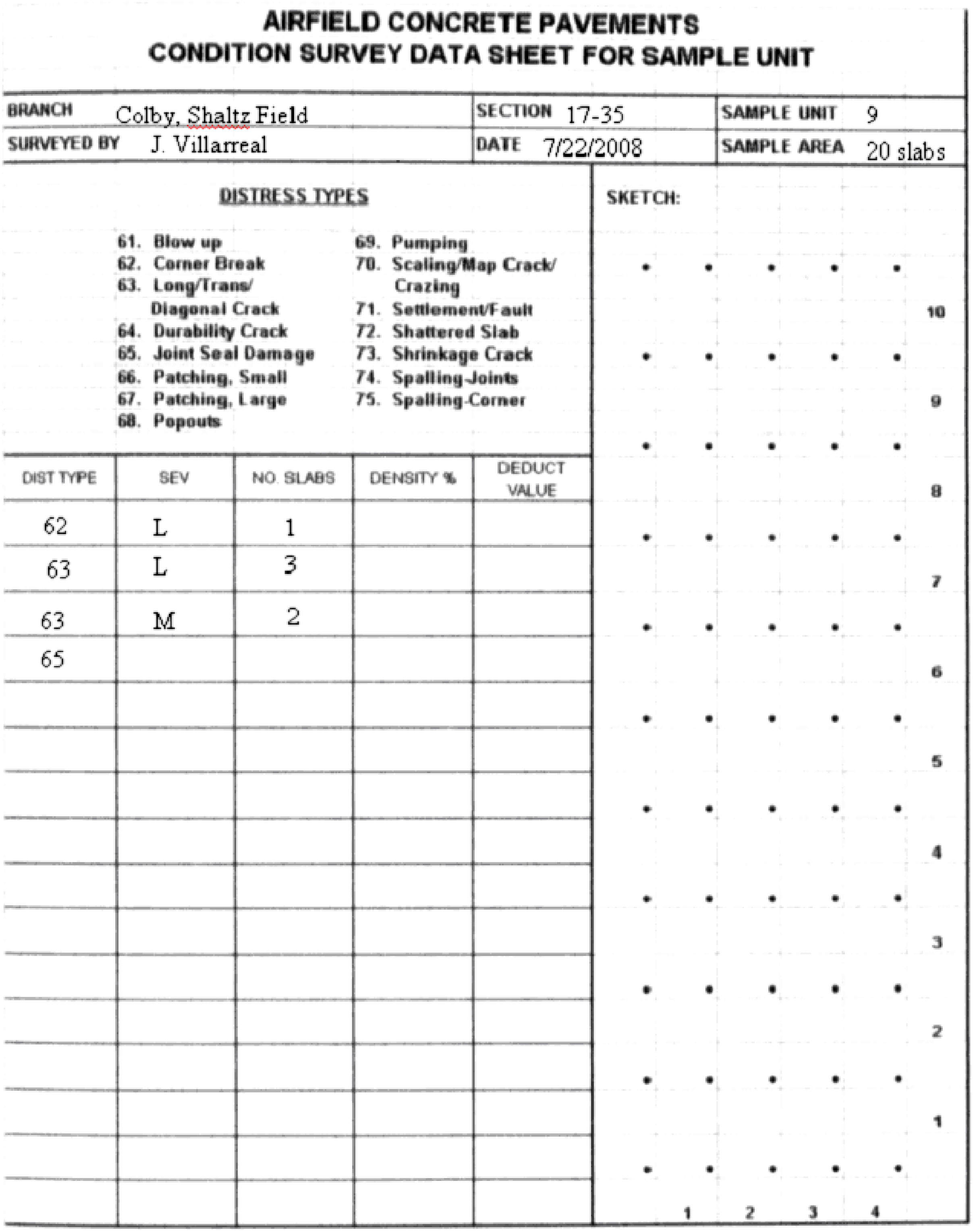
Equation 3.1 was used throughout this study to determine the number of sample units to be surveyed for the majority of airports. The only runway where network sampling criteria was used was Runway 15-35 of Salina Municipal Airport. Both network- and project-level criteria were assessed for all airports, and the method that yielded the largest number of sample units to be surveyed was selected. This was done to ensure that the calculated PCI reflected as accurately as possible the actual condition of every runway.

3.4.3 Performing the Condition Survey

After the pavement sections are divided into sample units and the sample units to be inspected are determined, the visual inspection survey can be carried out by identifying the type and severity of distresses present in each selected sample unit. The distresses measured during the visual survey will be entered in MicroPAVER to obtain the pavement condition index (PCI) for all the section in the network. Distress definitions for asphalt and concrete are quite different. Therefore, the procedure used to perform a PCI condition survey will vary depending on the surface type being inspected. Shahin, 1994 and ASTM, 1995 provide specific details of the inspection procedures for asphalt and concrete, as well as the distress definitions. Distress definitions must be followed closely to generate an accurate PCI for each section. This survey will generate the PCI for all sections in the network. Sample condition survey data sheets for concrete and asphalt airfield pavements are shown in Figures 3.3 and 3.4, respectively. MicroPAVER automatically calculates the density of the distress and deduct values shown in Figures 3.3 and 3.4.

3.4.4 Calculation of PCI

Once the condition survey is completed, the PCI value for each inspected unit is calculated. Only after the PCI for each surveyed unit has been calculated, the PCI for the entire pavement section can be computed. The PCI calculation is based on the deduct values, which are weighing factors from 0 to 100 that indicate the impact each distress has on pavement condition. A deduct value of 0 indicates that the distress has no effect on pavement performance, while a value of 100 represents an extremely serious distress. The PCI can be calculated using several methods: manually, using a computerized spreadsheet, or using MicroPAVER. The MicroPAVER software automatically calculates the PCI for every single unit inspected on a section from the distress data entered. A report for every sample unit surveyed, or for every section in the network, can be generated using MicroPAVER.



AIRFIELD CONCRETE PAVEMENTS
CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT

BRANCH	Colby, Shaltz Field	SECTION	17-35	SAMPLE UNIT	9
SURVEYED BY	J. Villarreal	DATE	7/22/2008	SAMPLE AREA	20 slabs

DISTRESS TYPES

61. Blow up
62. Corner Break
63. Long/Trans/ Diagonal Crack
64. Durability Crack
65. Joint Seal Damage
66. Patching, Small
67. Patching, Large
68. Popouts
69. Pumping
70. Scaling/Map Crack/ Crazing
71. Settlement/Fault
72. Shattered Slab
73. Shrinkage Crack
74. Spalling-Joints
75. Spalling-Corner

DIST TYPE	SEV	NO. SLABS	DENSITY %	DEDUCT VALUE
62	L	1		
63	L	3		
63	M	2		
65				

SKETCH:

Figure 3.3: Sample Concrete Pavement Condition Survey Data Sheet

AIRFIELD ASPHALT PAVEMENT CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT

SKETCH:

BRANCH	Wamego Municipal Airport	DATE	5/23/2008
SURVEYED BY	M. Hossain, J. Villarreal	SAMPLE UNIT	2
SECTION	17-35	SAMPLE AREA	45 ft x 1000 ft

41. Alligator Cracking Sq Ft
42. Bleeding Sq Ft
43. Block Cracking Sq Ft
44. Corrugation Sq Ft
45. Depression Sq Ft
46. Jet Blast Sq Ft
47. Jt. Reflection (PCC) Ft
48. Long. & Trans. Cracking Ft
49. Oil Spillage Sq Ft
50. Patching Sq Ft
51. Polished Aggregate Sq Ft
52. Raveling/Weathering Sq Ft
53. Rutting Sq Ft
54. Shoving from PCC Sq Ft
55. Slippage Cracking Sq Ft
56. Swell Sq Ft

DISTRESS SEVERITY	QUANTITY								TOTAL	DENSITY %
43L	45 x 45								2025 sq. ft	
48L	19	54	91						164 ft	
52L	46 x 3								138 sq. ft.	
48M	20								20 ft	
50L	3 x 45								135 sq. ft	

Figure 3.4: Sample Asphalt Pavement Condition Survey Data Sheet

3.5 PREDICTION OF FUTURE PAVEMENT CONDITIONS

An important feature of a PMS is its capability of predicting the future conditions of pavements in the network. Therefore, prediction models are essential for a complete PMS. Many methods are available for developing models for pavement condition deterioration. Some of the methods are purely mechanistic, mechanistic-empirical, regression, and subjective. The purely mechanistic method is under development and is based on some primary pavement response or behavior parameter such as stress, strain, or deflection. A mechanistic-empirical method relates a measured structural or functional deterioration to a response parameter through regression equations. Regressions are the most common method for creating pavement condition models; they relate a dependent variable (a measured or observed structural or functional deterioration) to one or more independent variables like load applications, pavement layer thickness, age, and environmental factors and their interactions. However, development of good models for predicting performance, in terms of PCI versus age or accumulated axle-load applications, has been a major challenge for pavement engineers. Past experiences are used in subjective methods to guess a deterioration model. The degree of accuracy required of a prediction model is a function of its intended use. Models for project-level analysis need to be more accurate than those for network-level analysis.

Using prediction models allows an estimation of funding required in the future based on the predicted condition of the pavement network. Such models also forecast the condition of the pavement if no maintenance or rehabilitation treatments are applied to the network. MicroPAVER uses a prediction modeling technique called “family method” which will be discussed in Chapter 5.

CHAPTER 4

PAVEMENT CONDITIONS OF GENERAL AVIATION AIRPORTS IN KANSAS

4.1 FIELD SURVEY

Before surveying conditions, the runways of Kansas general aviation airports were divided into sample units sections, based on the surface and the width of each runway. Asphalt runways were divided into sample units following the guidelines given in Table 4.1. This was done to create sections with an area of approximately 5,000 sq. ft. and to facilitate the surveying process.

Table 4.1: Asphalt Runway Sample Unit Guidelines

Width of Airfield (ft)	Center section (ft)	Edge sections (ft)
30	30 x 175	-
35	35 x 150	-
40	40 x 125	-
50	50 x 100	-
60	30 x 150	15 x 300
75	38 x 150	18.5 x 300
100	50 x 100	25 x 200
150	50 x 100	50 x 100

Portland cement concrete (PCC) runways were divided into sections based on the number of slabs in the width direction. The aim was to create sections of 20 slabs in such a way that would allow a two-man survey crew to constantly walk forward. Guidelines used to divide PCC runways are presented in Table 4.2.

Table 4.2: Portland Cement Concrete Runway Sample Unit Guidelines

Number of slabs in the width direction	Center section (slabs)	Edge sections (slabs)
4	2 x 5	-
6	2 x 10	2 x 10
7	3 x 7	2 x 10
8	4 x 5	2 x 10

During the summer of 2008, about 20 to 30 percent of the sample units of 137 runways across Kansas were inspected using the ASTM 5340-04 procedure. Since the survey was performed at the network level, the sample size was more than adequate. However, a higher sample size should be used when performing project-level surveys. A layout showing the sample units that were surveyed in sample airports is included in Appendix B.

4.2 PAVEMENT CONDITION SUMMARY

After completion of the condition survey, the distress data were entered into the MicroPAVER database. Using the reported distress data, MicroPAVER automatically calculated the Pavement Condition Index (PCI) value for each of the 137 sections. A PCI report, containing individual PCI values for each of the sections in the study, is included in Appendix B. As shown previously, the qualitative rating of a pavement section based on PCI values is as follows:

PCI Range	Rating
0 – 10	Failed
11 – 25	Serious
26 – 40	Very Poor
41 – 55	Poor
56 – 70	Fair
71 – 85	Satisfactory
86 – 100	Good

Figures 4.1 and 4.2 summarize results obtained from the PCI calculation. Results show that as of August 2008, about 68% of the GA runways in Kansas are in “good” to “satisfactory” conditions. On the other hand, only one runway (0.7% of the network) was in “failed” condition. Gilmore Airport, located in Pleasanton, Kansas was in clear state of abandonment and had a PCI of 7. The arithmetic average PCI for the network is 76. Also, using the area of each runway as a weight, a weighted average PCI was calculated. The weighted average PCI also came out to be 76. So, overall, the condition of the entire network can be rated as “satisfactory.

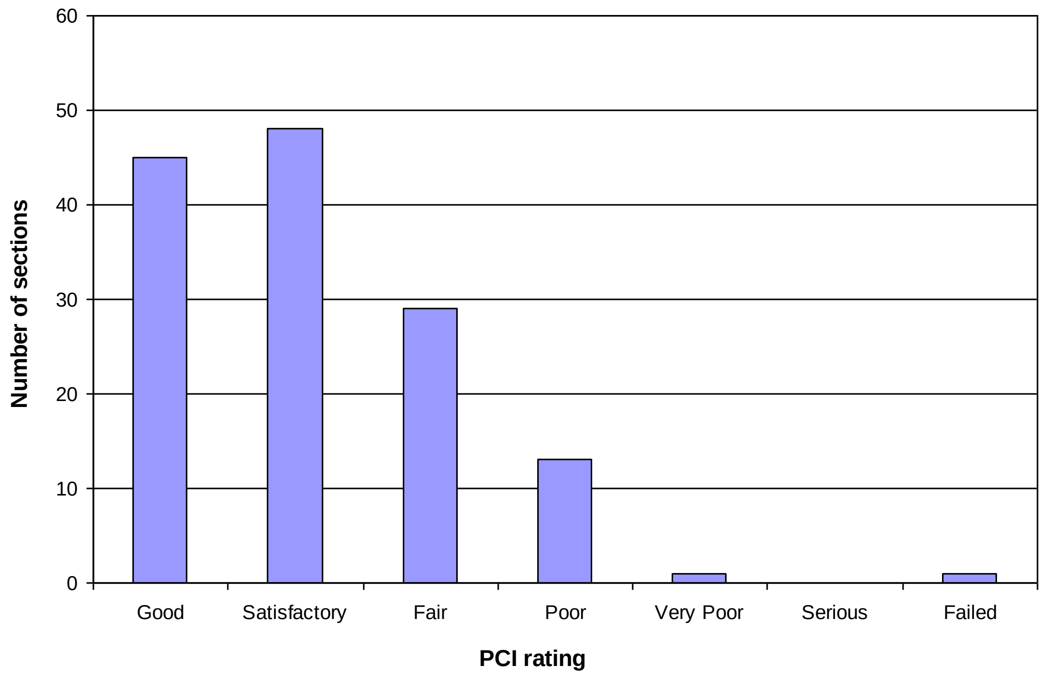


Figure 4.1: Number of Sections by PCI (surveyed summer 2008)

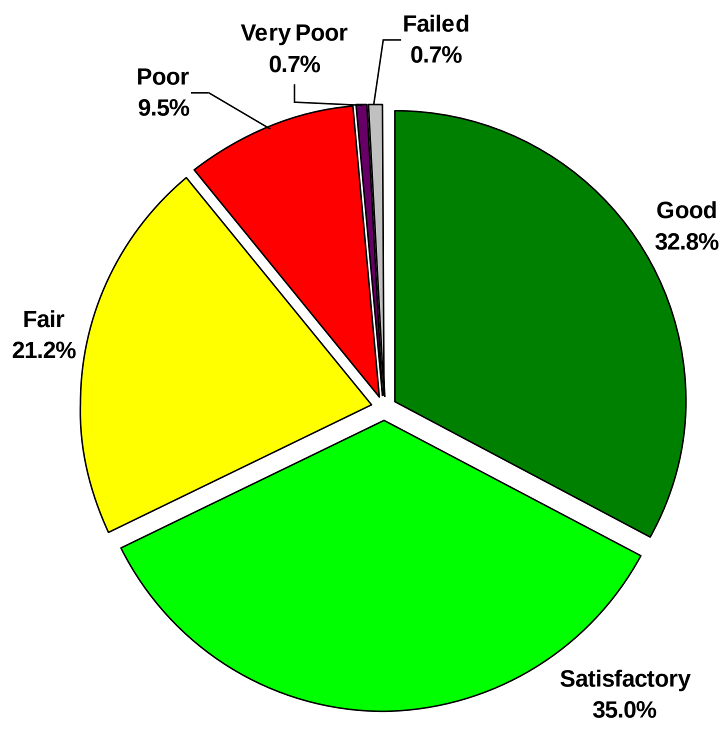


Figure 4.2: Pavement Condition Summary (as of August 2008)

Figure 4.3 shows a comparison of the PCI values for the airports surveyed in 1995. The graph clearly shows that nine runways (Herington, Junction City, Kingman, Larned, Oberlin, Paola, Russell, and runway 12-30 of Ulysses) have received major rehabilitation. On the other hand, Anthony, Clay Center, Eureka, Oakley, Phillipsburg, Scott City, and runway 17-35 of Ulysses seem to have not received little to no maintenance during that period of time.

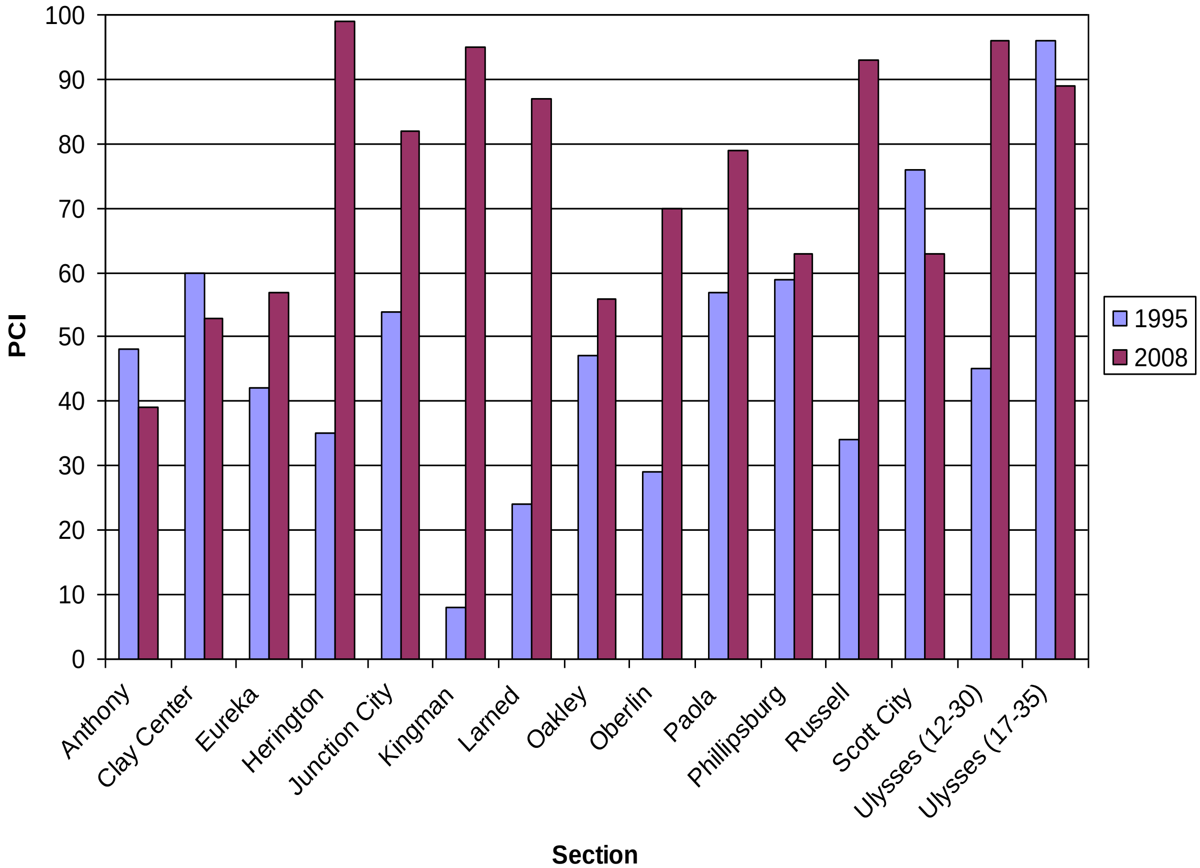


Figure 4.3: Comparison of PCI Values for Runways Surveyed in 1995

CHAPTER 5

DEVELOPMENT OF DETERIORATION PREDICTION MODELS

Pavement condition prediction models are vital to have a complete pavement management system. Prediction models allow making informed decisions to determine maintenance and rehabilitation requirements at the network and project level of management. At the network level, prediction models can be helpful in condition forecasting, budget planning, inspection scheduling, and work planning. Usually, the main concern when using prediction models at the network level is to determine the level of maintenance and rehabilitation needed. Project-level management uses prediction model conditions to select specific rehabilitation alternatives to meet expected traffic and climatic conditions. Many different techniques are available to develop pavement condition models. For the purpose of this project, the prediction method used by MicroPAVER, the “family method,” will be used to create a suitable model for the network.

The “family method” was created following an extensive research program on pavement deterioration modeling conducted by the U.S. Army (Shahin, 1994). The method provides the user an excellent capability of analyzing groups of data, and consists of the following steps:

1. Pavement family definition
2. Data filtering
3. Data outlier analysis
4. Family model development
5. Pavement model development

Initially, the method was designed for use with MicroPAVER to predict PCI as a function of time. However, the concept can be extended to predict other condition measures. The following sections describe the steps mentioned above as used in MicroPAVER.

5.1 PAVEMENT FAMILY DEFINITION

A pavement family is defined as a group of pavement sections with similar deterioration characteristics. MicroPAVER allows the user to define a family based on several factors including use, rank, surface type, zone, section category, last construction date, and PCI. The user may define as many families as required for accurate condition prediction. Data availability may impose a limitation on appropriate family definition. For each family defined, MicroPAVER automatically creates a file containing pavement section identification, age, and PCI. For this study, surface type and climatic zones were the factors considered as possible factors to define a family. Climatic zones are defined in section 6.1.7.

The statistical analysis software SAS was used to perform the analysis of variance of the factors under study. Also, SAS was used to perform an F-test to determine if the variance measuring the differences between the factors is large when compared to the variance measuring the differences within a specific factor. If the difference is large it indicates that there are real differences between the groups. In other words, it would suggest that the factor should be used to define a family. As shown in Figure 5.1, the average PCI for all the asphalt sections, 72, is significantly different than the average PCI for all the concrete sections, 87 at a level of significance (α)of 0.05 (see Appendix C). Hence, a different prediction model was developed for each surface type. The average PCI for each type of surface in the four different climatic zones present in Kansas, as defined by FHWA, was also calculated. Besides the expected difference of

PCI based on surface type, no other significant difference at an α-level of 0.05 was found between the climatic zones (see Figure 5.2 and Appendix C). Therefore, surface type was the only factor used to create pavement families. Climatic zones are explained in detail in the following chapter.

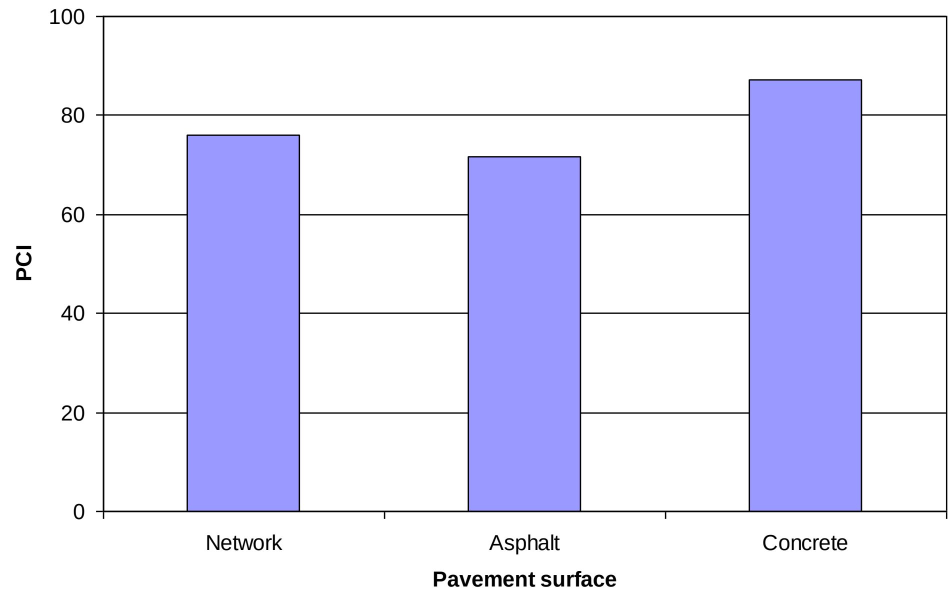


Figure 5.1: Average PCI Based on Surface Type

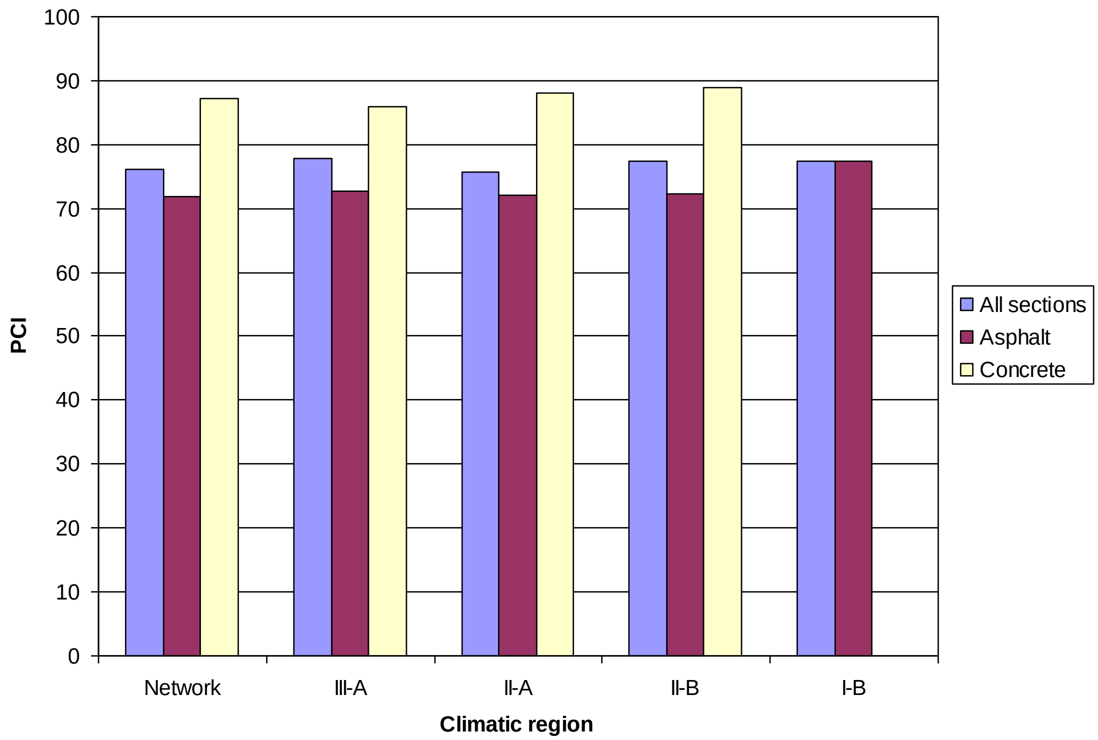


Figure 5.2: Effect of Climatic Zone on PCI

5.2 DATA FILTERING

In this step, MicroPAVER allows the user to filter out suspicious data points. Data are first sorted by pavement section identification number, age, and PCI. When the same section is listed more than once, sequential cases of the same section are compared. If the PCI increases with age, and the increment is greater than 20 points, the case with the higher PCI is moved to an "error" file. This action indicates that either an error is present in one of the records or major rehabilitation has been performed between condition surveys, which would place this section in a different family of pavements. If two pavement sections of the same age are listed more than once and the PCI are the same, only one pavement section is retained. If the PCI are different for sections of similar age, all cases are moved to the "error" file. A further check on suspicious data is done using a set of boundaries defined by a "maximum and minimum" envelope developed by reviewing many databases; however, these values can be easily modified by the user. If a record falls outside the envelope boundaries, the record is moved to the "error" file

(Shahin, 1994). Finally, in order to produce an accurate model, sections which did not have a verifiable "last construction date" were not included in the model. A total of 92 sections were used to create the prediction models.

5.3 DATA OUTLIERS ANALYSIS

The data-filtering procedure is used to remove obvious errors in the data as described above. Further examination of the data for statistical removal of extreme points is performed in the outlier analysis. This step is important because pavements with unusual performance can have a significant impact on the way family behavior is modeled. MicroPAVER calculates the prediction residuals, which are the differences between the observed and predicted PCI values using a fourth-degree polynomial least-error curve. The residuals were found to have a normal frequency distribution, which allowed a confidence interval to be set. For example, an interval of three standard deviations in both directions contains 99.8% of the observed PCI. MicroPAVER allows the user to specify the confidence interval. For this study, an interval of 1.96 standard deviations was used, which corresponds to a 95% confidence interval. Sections that are detected as outliers based on this confidence interval are identified and placed in the outlier "error" file.

5.4 FAMILY MODEL DEVELOPMENT

A fourth-degree polynomial, constrained least-squared error model is developed using data after processing through the filtering and outlier analysis. This polynomial is constrained in that it is not allowed to have a positive slope because the PCI cannot increase with age. An unconstrained best fit can be viewed if a positive PCI vs. age slope is detected. This is a useful feature because it may imply a non-homogeneous family. It also helps the user view where the problem is occurring. This best-fit curve for the family analysis extends only as far as the available data. To predict future conditions, the curve is extrapolated by extending a tangent of the same slope as that of the curve at the last few years. For this study, the extrapolation period was left at the default value of three years.

5.5 PAVEMENT SECTION CONDITION PREDICTION

The pavement family prediction model is used to predict the PCI at the section level. The prediction function for a pavement function for a pavement family represents the average behavior of all sections in that family. The prediction for each section is done by defining its position relative to the family prediction curve. It is assumed that deterioration of all pavement sections in a family is similar and is a function of their present condition, regardless of age. A section prediction curve is drawn through the latest PCI/age point for the pavement section being investigated, parallel to the family prediction curve. Comparing the section deterioration to the family deterioration provides invaluable feedback on the effects of maintenance, traffic, drainage, and other factors on the pavement behavior. This type of feedback is invaluable as a guide for revising pavement-thickness design procedures. The family method was developed so that as more and more data is incorporated into the database, the deterioration model is continuously updated.

Using the methodology described above, two family curves were developed. Figure 5.3 shows the graph created by MicroPAVER for the family curve for concrete runways. The family curve for asphalt runways pavements can be seen in Figure 5.4. Comparing the two models, it is evident that the PCI for asphalt runways decreases faster during the first five years than that of concrete sections.

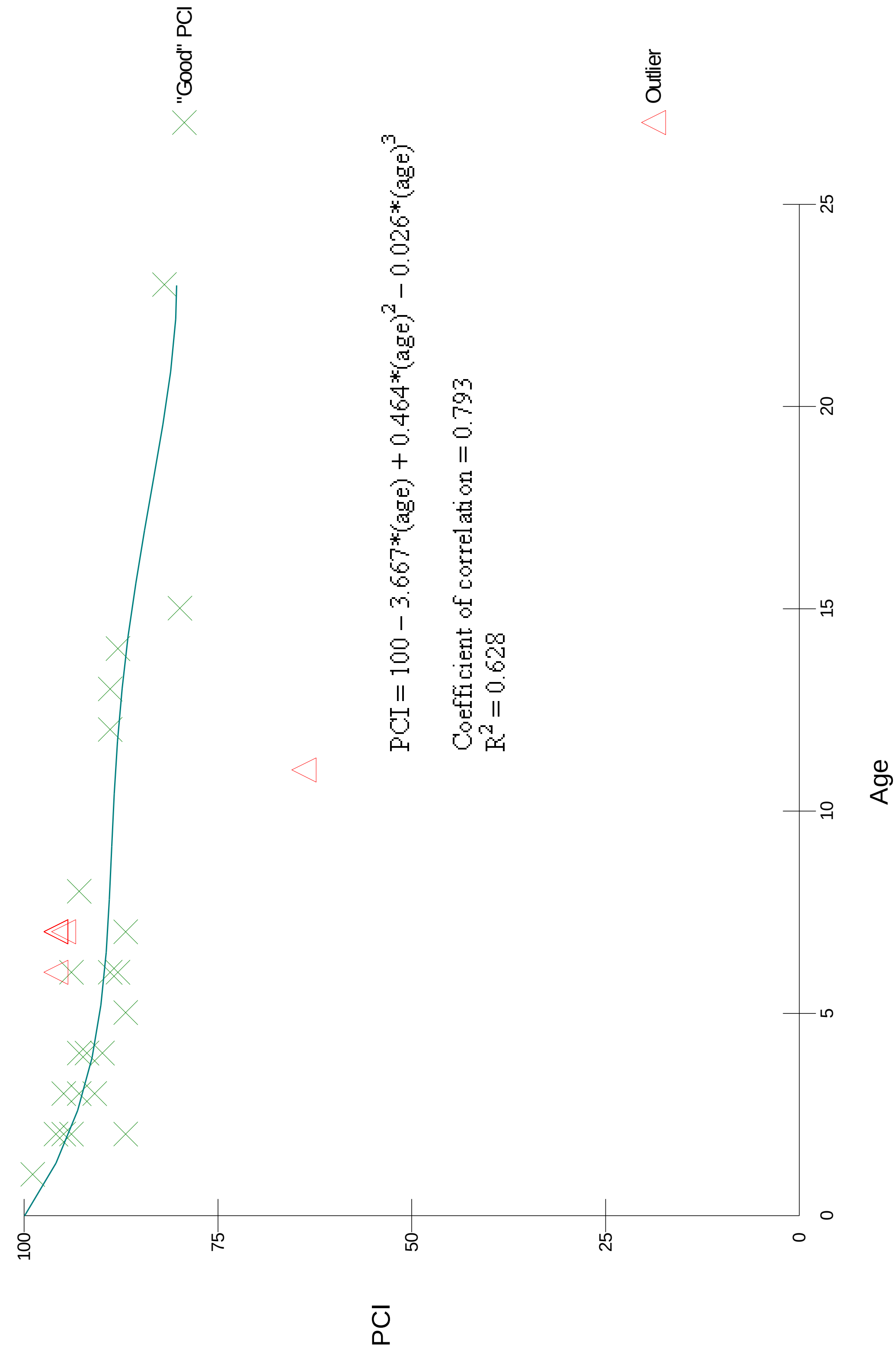


Figure 5.3: Family Curve for PCC Runways

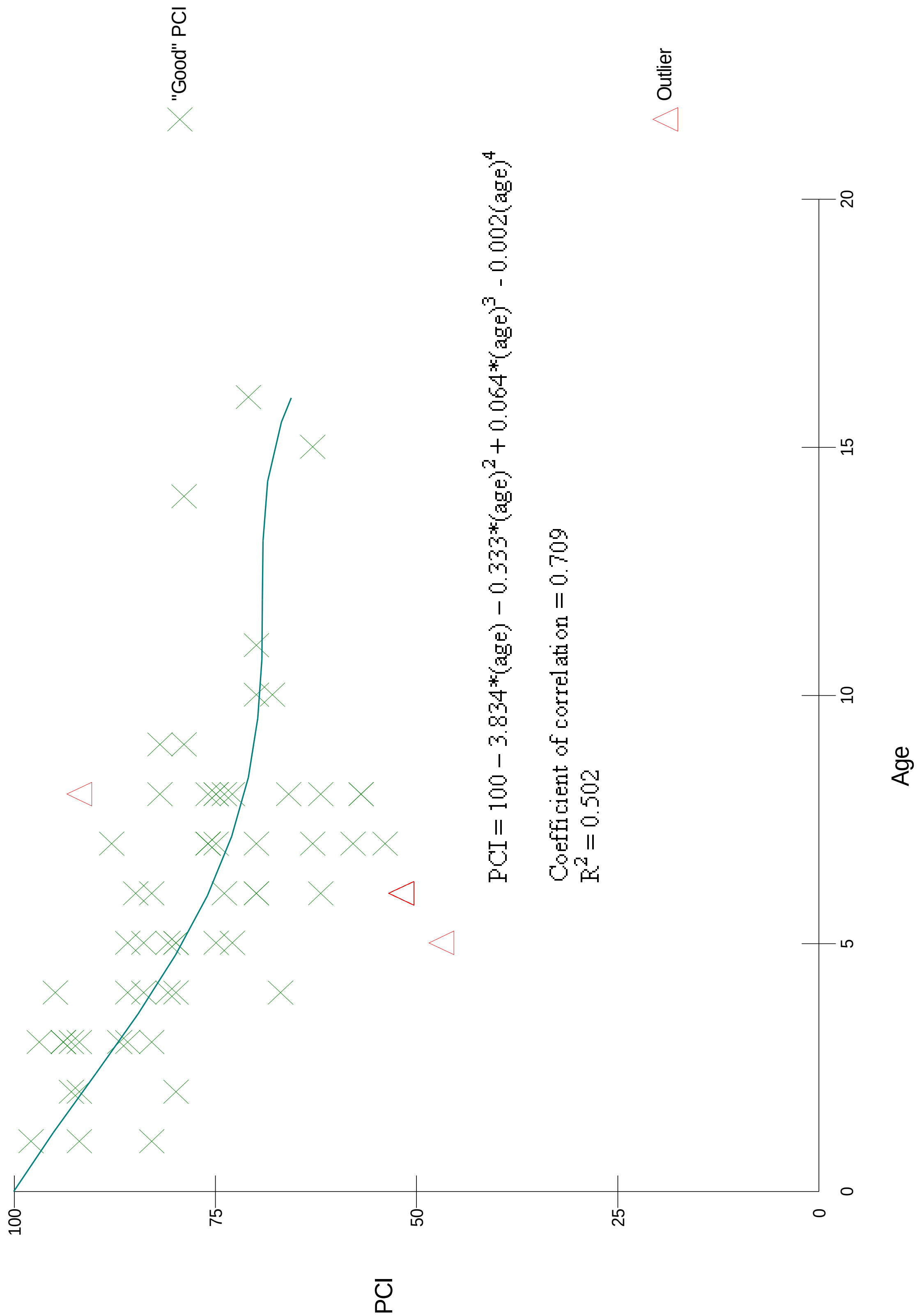


Figure 5.4: Family Curve for AC Runways

CHAPTER 6

GENERATION OF PAVEMENT MANAGEMENT REPORTS USING MICROPAVER

One of the many functions of MicroPAVER is that it can produce several types of reports depending upon the needs of the user. Inventory reports provide summarized or detailed information about the network. Future pavement conditions can be predicted by assigning prediction curves to the network. Different budget conditions can be compared to determine the best maintenance and repair policy. This chapter describes in detail the three reports generated using data gathered during this study.

6.1 INVENTORY REPORT FOR GENERAL AVIATION AIRPORTS IN KANSAS

The inventory information for 137 runways of 107 general aviation airports in Kansas was entered into the MicroPAVER database and an inventory report was generated. MicroPAVER gives the option of generating inventory reports with many different items. A sample inventory report, with a few important items, is attached in Appendix D. Some key items included in the inventory report are discussed below.

6.1.1 Network

As mentioned before, network identification and definition is the first step in establishing a PMS. Usually, the pavement manager or engineer is responsible to make the decision as to which facilities will be identified as a separate network. For this study, only one network was identified containing all the data on the runways of all 107 airports surveyed.

6.1.2 Name

Airports were named using the official name given in the 2008 – 2009 Kansas Airport Directory. The name of the city closest to the airport, followed by the official name of the airport, was used to name airports whose name did not already include the name of a city. For example, Shaltz Field was given the name "Colby Shaltz Field." This was done to facilitate identification and sorting.

6.1.3 Branch ID

The unique three-digit code assigned to each of the general aviation airports by the 2008 – 2009 Airport Directory was used as the branch id. This is a very useful sorting criterion and is reported on almost all MicroPAVER reports. All runways in a specific airport have the same branch id but differ on section name.

6.1.4 Section

In this study, each runway was treated as a separate section, with the runway number serving as the section ID. The sections were named listing the end of the runway with the lower number first, followed by the end with the higher number. The "To" and "From" options were used to indicate the direction in which the runway was surveyed. For example, Hays Regional Airport has two sections, "4-22" and "16-34" representing its two runways; and section "4-22" is marked to start at “22” and end at “4,” meaning that the condition survey was carried out in that direction.

6.1.5 Surface

A surface type was entered for each section. Surface type is another major sorting criterion used by MicroPAVER for most reports. For this project, two surface types were identified:

AC – asphalt concrete

PCC – Portland cement concrete

6.1.6 Section Rank

Rank is a very useful tool that can be used to rate or assign priority to any section. For this study, all sections were left with the default “A” rank. But future studies can choose to rank sections based on certain user-defined criteria. For example, sections can by ranked according to their function, designating runways as “P” for primary; taxiways would be cataloged with an “S” for secondary; and aprons could get a “T” for tertiary. The ranking system can also be used to prioritize runways based on their size and/or number of operations.

6.1.7 Zone

Zone is a user-defined sorting criterion. For this study, the zone has been defined as FHWA climatic regions. This was done based on the assumption that different climatic situations would affect the deterioration pattern of the airport pavement. By using this sorting criterion, all airports in a certain zone can be analyzed as a group. This could be helpful in predicting future conditions. FHWA uses Thornthwaite's definitions to divide the U.S. into nine climatic zones (I-A, I-B, I-C, II-A, II-B, II-C, III-A, III-B, and III-C). Based on this classification, Kansas has four different climatic regions, as shown on Figure 6.1 and explained below (FHWA, 2000):

1. Dry, Freeze (III-A): This zone experiences long winters with the temperature below freezing for extended periods. Potential for a slowly advancing freezing front into the sub grade is extremely high. Frost damage is to be expected, accompanied by other low-temperature problems. In this zone, annual moisture state is dry. Load-related performance is good for all materials. Seasonal concentrations of moisture will be responsible for producing slightly lower performance in one area versus another where the moisture is not concentrated in one time period.
2. Wet/Dry, Freeze (II-A): This zone experiences long winters with the temperature below freezing for extended periods. Potential for a slowly advancing freezing front into the sub grade is extremely high. Frost damage is to be expected, accompanied by other low temperature problems. State of moisture in the sub grade will vary during the year. This zone produces a moisture state that produces load-related performance in a transitional portion between good and poor. Seasonal concentration of moisture will be important in determining which level of performance would be present.
3. Wet/Dry, Freeze – Thaw (II-B): This zone experiences winters with more fluctuation of temperatures near the freezing point. Freeze-thaw cycling into the base course is to be expected. Some thermal fatigue problems could be expected,

with hot summers being a problem in the west due to radiation. State of moisture in the sub grade will vary during the year. This zone produces a moisture state that produces load-related performance in a transitional portion between good and poor. Seasonal concentration of moisture will be important in determining which level of performance would be present.

4. Wet, Freeze – Thaw Cycling (I-B): This zone experiences winters with more fluctuation of temperatures near the freezing point. Freeze-thaw cycling into the base course is to be expected. Some thermal fatigue problems could be expected, with hot summers being a problem in the west due to radiation. Due to climatic influences, the sub grade will remain wet for the majority of the year and very little moisture variation will occur. Performance relationships indicate that the zone will maintain a moisture level that will produce low load-related performance.

An entry of "zne1" under the zone category means that the airport is in the II-A zone; "zne2," "zne3," and "zne4" are associated with regions II-A, II-B, and I-B, respectively. For example, McPherson Airport is in climatic region II-A and therefore, the entry for this airport under Zone is "zne2."

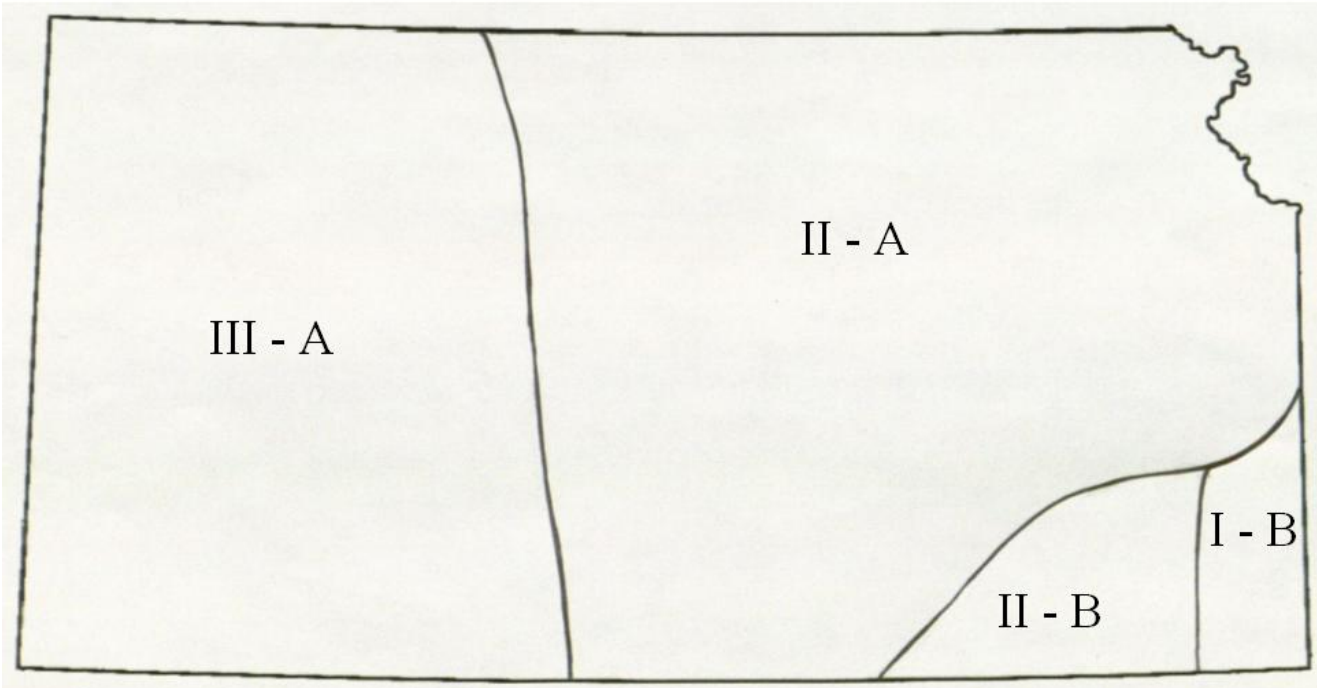


Figure 6.1: Climatic Zones in Kansas as Defined by FHWA

6.1.8 Last Construction Date

This entry shows the month and year that last major maintenance, rehabilitation, or construction was performed for each section. This date is significant because MicroPAVER assumes that the section had a PCI of 100 at this point. This information is very valuable to create a pavement condition prediction model. The dates were gathered using information provided by airport managers and/or KDOT. Sections for which data could not be obtained show a blank entry.

6.2 PCI PREDICTION REPORT

The family deterioration curves were developed using only data from runways for which a last construction date was available. Once the family curves were created they were assigned to all runways based on their respective surface types. MicroPAVER can predict pavement conditions in terms of PCI for all sections in the network, at any point in time specified by the user, using the family deterioration curve. The PCI prediction report assumes that no major maintenance activities will be applied on the pavement except for routine maintenance until the specific time of prediction.

MicroPAVER can produce a detailed condition prediction report for each of the 137 sections in the network for any number of years. However, in order to produce a concise and useful report, the average PCI for the branches during the next five years was studied. A sample PCI condition prediction report for the next five years, for all the branches in this study, is shown in Appendix E. Table 6.1 summarizes the predictions obtained for 2010 and 2013; and Figure 6.2 illustrates the estimated pavement conditions for 2010 and 2013. The results show that the average PCI for the network will decrease from 76 in 2008 to 72 and 69 in 2010 and 2013, respectively, if no major maintenance actions are applied. This means that by 2013, the entire network could be rated as "fair," instead of its current "satisfactory" rating.

The number of branches rated as "good" could decrease by 50% by 2010 if no maintenance actions are done between 2008 and 2010. Therefore, in order to sustain the network's rating, it is vital to keep sections with a good PCI well maintained. Also, it is important to notice that the number of branches with a "fair" condition almost doubles from 2010 to 2013. Many agencies consider that once a section's PCI gets lower than 70, immediate actions are required (Andrew Maysent, personal communication, December 2, 2008); in other words, when a section's rating goes from “satisfactory” to “fair” it is imperative to apply some maintenance activities in order to avoid higher costs in the future.

Table 6.1: Branch Pavement Condition Summary (2010 and 2013)

PCI Rating	**Year**		
	2008 (%)	2010 (%)	2013 (%)
Failed	1	1	1
Serious	0	0	0
Very Poor	1	2	2
Poor	7	10	13
Fair	22	24	44
Satisfactory	38	47	27
Good	30	16	13
AVERAGE RATING FOR NETWORK	**Satisfactory (76)**	**Satisfactory (72)**	**Fair (69)**

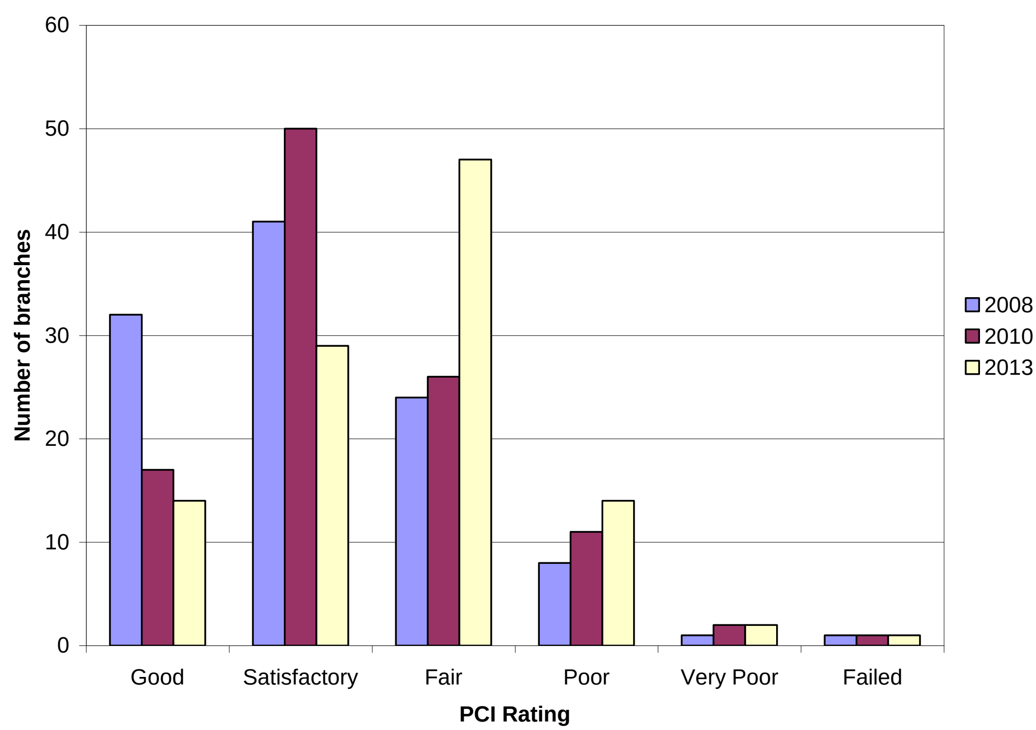


Figure 6.2: Branch Pavement Condition Prediction Summary (2010 and 2013)

6.3 DEVELOPMENT OF A BUDGET REPORT

A few steps are needed before executing a budget report. MicroPAVER requires the costs of maintenance and repair actions as well as a set of rules to establish actions should be taken at any period of time.

6.3.1 Maintenance and Repair Costs and Policies

Maintenance and repair costs were estimated based on information provided by Mr. George Laliberte, Aviation Program Manager for KDOT, and figures from available literature. Cost figures obtained are meant to serve as a guideline to help estimate budget requirements using MicroPAVER for a network-level analysis. For a project-level analysis, these cost figures might need to be changed. Tables 6.2 and 6.3 show the cost of a few selected maintenance items for asphalt and concrete, respectively. The unit cost of the items (\$/ft or \$/ft^2) was selected to facilitate their entry into MicroPAVER.

Table 6.2: Cost of Maintenance Items for AC Runways

Maintenance Action	Cost
Crack sealing	1.70 \$/ft
Patching (full depth)	1.50 \$/ft^2
Slurry sleal	0.19 \$/ft^2
2" Overlay	1.40 \$/ft^2
Cold mill 3" and Hot recycling 6"	2.02 \$/ft^2
5" Overlay	2.15 \$/ft^2

Table 6.3: Cost of Maintenance Items for PCC Runways

Maintenance Action	Cost
Joint sealing – silicon	4.50 $/ft
Crack sealing	0.75 $/ft
Patch (full depth)	10.56 $/ft^2
Slab replacement	8.33 $/ft^2
5” Overlay	2.61 $/ft^2

Table 6.4 presents a set of maintenace policy guideliness for runways based on surface type. The maintenance policies were developed with the objective of keeping the overall PCI rating of the network as high as possilbe. Maintenance policies might need to be adjusted, depending on indiviual project needs and budget constraints.

Table 6.4: Suggested Maintenance Actions Based on PCI of Section

PCI Range	Surface Type	
	Asphalt Concrete (AC)	**Portland Cement Concrete (PCC)**
100 – 90	Do nothing	Do nothing (check joint sealant)
90 – 80	Crack repair	Joint sealant and crack repair
80 – 70	Crack repair and patching	Joint sealant, crack repair and patching
70 – 50	Crack repair and extensive patching or slurry seal or overlay	Extensive patching and joint sealant
50 – 30	Crack repair and overlay	Slab replacement or overlay
<30	Cold mill 3” and hot recycling 6”, thick overlay or reconstruct	Overlay or reconstruct

6.3.2 Budget Report

Budget forecasting is an important tool that can be used to guide management, establish goals, and facilitate planning. MicroPAVER's Maintenance and Repair (M&R) Plan feature allows to schedule, budget, and analyze pavement maintenance and repair activities. The M&R Plan uses inventory data, inspection values, maintenance policies, maintenance costs, and pavement condition predictions to determine future maintenance requirements or develop specific pavement management practices based on available funds.

Several different budget requirement plans can be developed using MicroPAVER's M&R Plan. However, a 5-year M&R plan based on minimum pavement condition with a consequential unlimited budget was selected for this study. As its name indicate, a plan based on minimum pavement condition allows the user to set the lowest PCI that is allowed per year to produce a maintenance strategy. Selecting a budget consequence optimizes M&R activity against a specific budget. An unlimited budget was chosen to determine the total needs of the network.

In an effort to better demostrate the needs of Kansas airports to FAA, the budget forecasting report was developed using 78 of the 79 general aviation airports in Kansas that are eligible for FAA funding. Wichita Mid-Continent airport was not included because no data was collected for this airport. Runways were divided according to their surface type. Then, budget requirements were calculated for asphalt and concrete runways. Costs and actions outlined in Chapter 11 were used to develop a budget for each surface type. The goal of the budget was to raise the mimimum allowed (critical) PCI of the network to 70; in other words, by the end of the 5-year prediction period every runway would have at the very least a "satisfactory" rating. Two budget scenarios were examined by varying the minimum PCI during future years. Budget

Scenario 1 aimed to achieve the desired PCI as quickly as possible. Budget Scenario 1 has a high minimum PCI, 55, that is increased by five units the second year and by ten units the third year. During the fourth and fifth year the minimum PCI is kept constant at 70. On the other hand, Budget Scenario 2 started with a low minimum PCI (30) that steadly increased by ten units every year in order to reach the objective by the end of the fifth year.

The budget reports developed for the 56 asphalt runways eligible for FAA funding are included in Appendix F. Table 6.5 presents a comparison between the two budgets proposed to maintain the 56 asphalt runways. As mentioned earlier, the unit repair costs for both cases is the same, and the costs have been outlined in the previous section.

Table 6.5 clearly shows that spending more in the near future results in a lower total expenditure in the long run. The total cost in a five-year period shown in Budget Scenario 1 is $3 million less than that of Budget Scenario 2. This illustrates why pavement management is a matter of “pay now or pay much more later.” Another important aspect to note is that the average pavement condition for the first case is almost always better than that for the second case. The only time Budget Scenario 2 has better pavement condition is during the fifth year, which is due to the backlog of sections that do not receive major maintenance until the last year. Budget Scenario 1 uses higher investment during initial years to stabilize the PCI of the network during the first few years and relies on preventive maintenance during the later years to preserve pavement condition. The initial approach taken in the second scenario could be used to keep the PCI of the network at its current level. However, as it was shown in Table 6.5, taking a proactive stance and investing early can lead to better runway conditions and lower maintenance costs in the long run.

Table 6.5: AC Runways Budget Scenario Comparison

Year	Budget Scenario 1			Budget Scenario 2		
	Min. PCI	***PCI after treatment****	***Cost ($ million)***	***Min. PCI***	***PCI after treatment****	***Cost ($ million)***
2009	55	77	18.9	30	72	7.8
2010	60	79	12.3	40	71	4.6
2011	70	87	19.2	50	72	7.6
2012	70	87	6.6	60	81	25.9
2013	70	86	5.0	70	90	19.1
Total			**62.0**			**65.0**

* Average PCI of sections used to develop budget

Two budget scenarios were also created for concrete runways. However, both budget scenarios came out to be practically the same. The only difference was the time at which major maintenance needed to be carried out, but the amount of money required was identical. Overall, concrete runways already have a high PCI, which can be kept at that level by simply performing routine maintenance. Only two runways (4-22 of Liberal Mid-America airport and 3-21 of Forbes Field) required some major maintenance to increase their PCI above critical condition. MicroPAVER estimated the budget requirement to bring the PCI of those two runways above 70 is $12.5 million ($5.5 million to restore Liberal and $7 million for Forbes Field). Also, approximately additionally $250,000 per year is needed to keep the concrete runways at their current condition.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

In this study, an inventory database for all GA airports in Kansas was developed. This invetory was used to form the basis for a MicroPAVER-based pavement management system for all GA airports in Kansas. Based on the condition survey performed using the MicroPAVER methodology, it was found that approximately 68% of sections surveyed are in “good” to “satisfactory” condition. More importantly, almost one-third (32.8%) of the network can be rated as “good.” Also, it was found that 21.2% of the sections surveyed are in “fair” condition. Ideally, these sections should receive maintenance as soon as possible to avoid costly maintenance actions in the future. Overall, the network has a PCI of 76, which earns it a “satisfactory” rating.

Using MicroPAVER’s “family method,” two condition prediction curves were developed, one for each of the different surface types, asphalt and concrete. During development of the curves, it was found that the climatic zones in Kansas have no impact on pavement performance of the GA runways. Prediction of future condition shows that the number of branches rated “good” could decrease by 50% by 2010 if the branches receive no maintenance. Also, as much as 44% of the entire network could have a rating of “fair” by 2013, if the branches only receive routine maintenance.

A list of maintenance policies based on current PCI values has been presented. These policies can be used to create a strategic plan to maintain the network PCI at a high level. The maintenance policies served as the basis for the budget forecasting reports.

The budget scenario comparison reports developed show that the 108 runways of the 78 GA airports eligible for FAA funding in Kansas could be brought to a “satisfactory” rating or above (i.e. average PCI $\geq$ 70) by spending approximately $15 million on average per year for the next five years. After that, the spending would decrease considerably and the average pavement contidion could be kept above 70 by performing diligent and timely preventive maintenance.

7.2 RECOMMENDATIONS

A few other MicroPAVER-produced reports can be developed in the future with the existing data. For example, a work plan report can be created. A work plan report uses budget restrictions and user-given maintenance policies to estimate future conditions of sections that receive work, and a cost summary and information about the unfunded work, among other things.

In order to avoid increased expenditures on the GA airports in the future, and to keep the network at a high PCI level, it is suggested that the following measures be taken:

- Conduct project-level PCI surveys every one or two years (some airports, like Newton, already do this). At the same time, have an individual agency collect and analyze the data and conduct a network level survey at least every 5 to 10 years. By doing this and using this study as a base, a very powerful database could be developed.
- Gather last construction dates for all sections in the network. This will allow development of more precise pavement prediction models.

- Make the sections with a "fair" PCI rating a top maintenance priority. The more time passes without applying any maintenance action to this sections, the more expensive it becomes to increase their PCI.
- Take good care of sections that have a high PCI. Maintaining these sections in good condition now is much cheaper than waiting years to start thinking about options to bring them up to a decent level.

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APPENDIX A

LAYOUT OF SAMPLE UNITS SURVEYED

Figure A.1: Layout of sample asphalt runways and units surveyed, arranged by increasing width of runway.

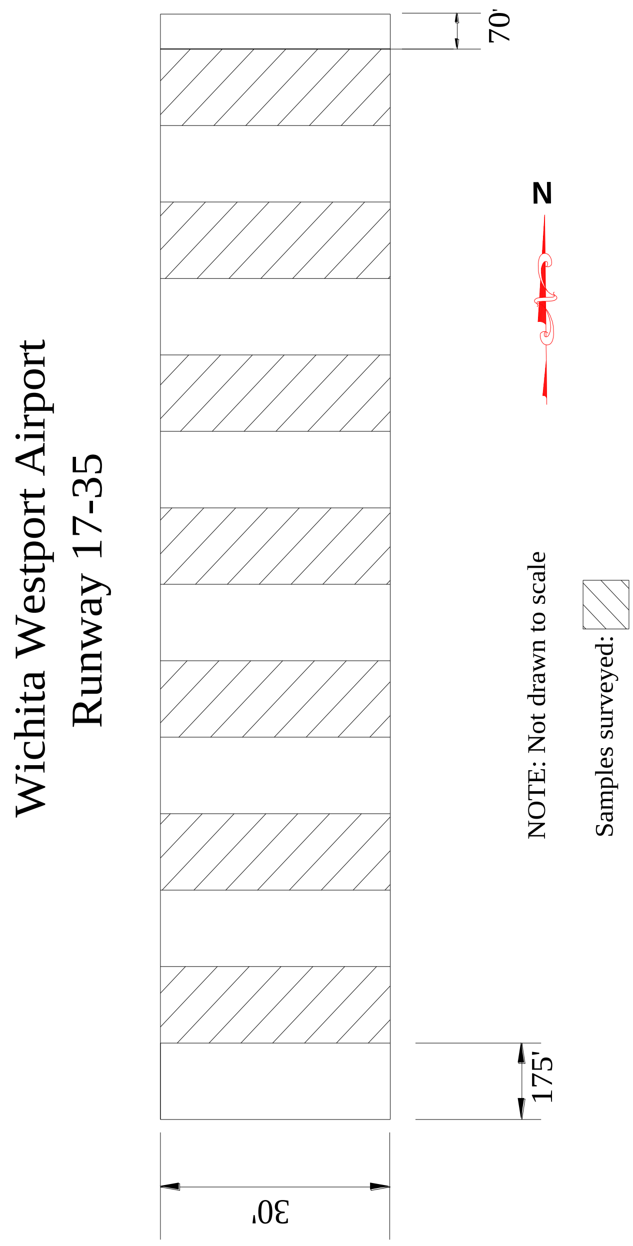


Figure A.1: Layout of sample asphalt runways and units surveyed, arranged by increasing width of runway (continued)

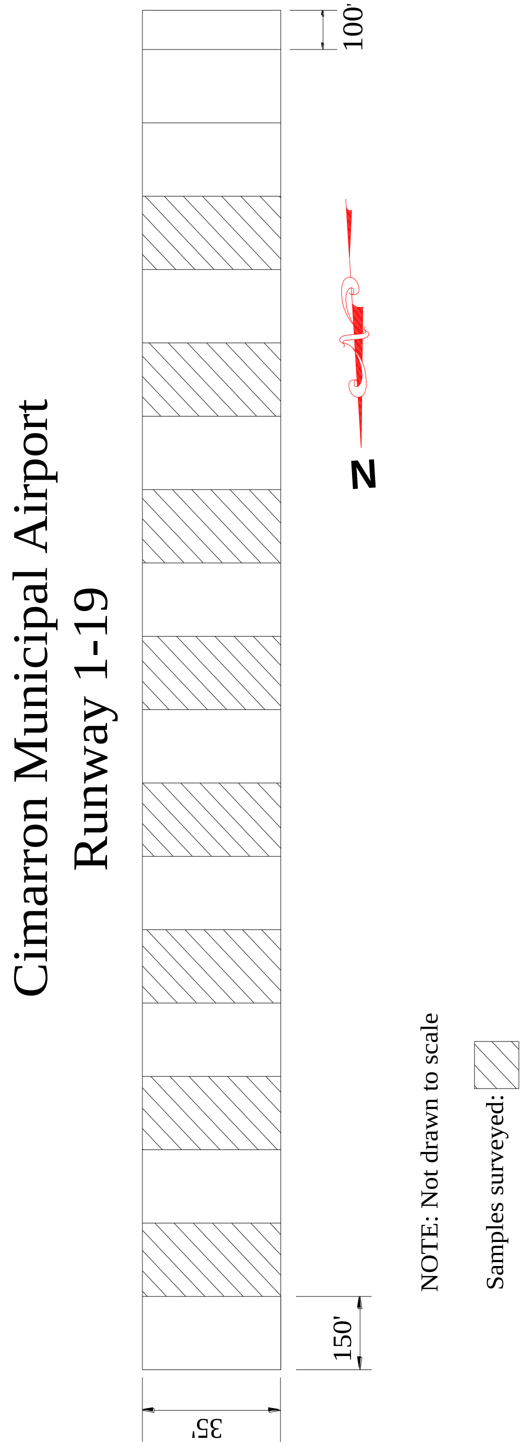


Figure A.1: Layout of sample asphalt runways and units surveyed, arranged by increasing width of runway (continued)

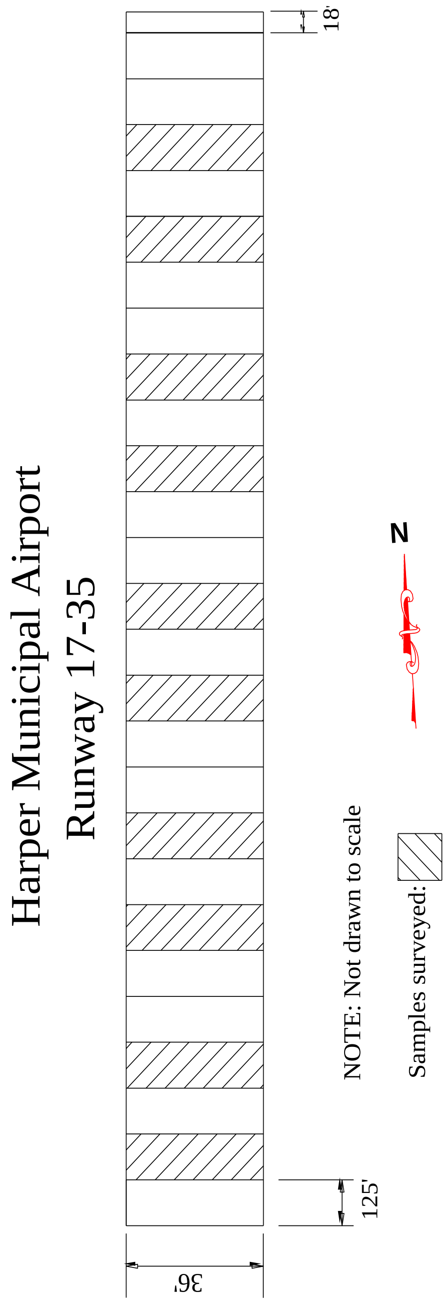


Figure A.1: Layout of sample asphalt runways and units surveyed, arranged by increasing width of runway (continued)

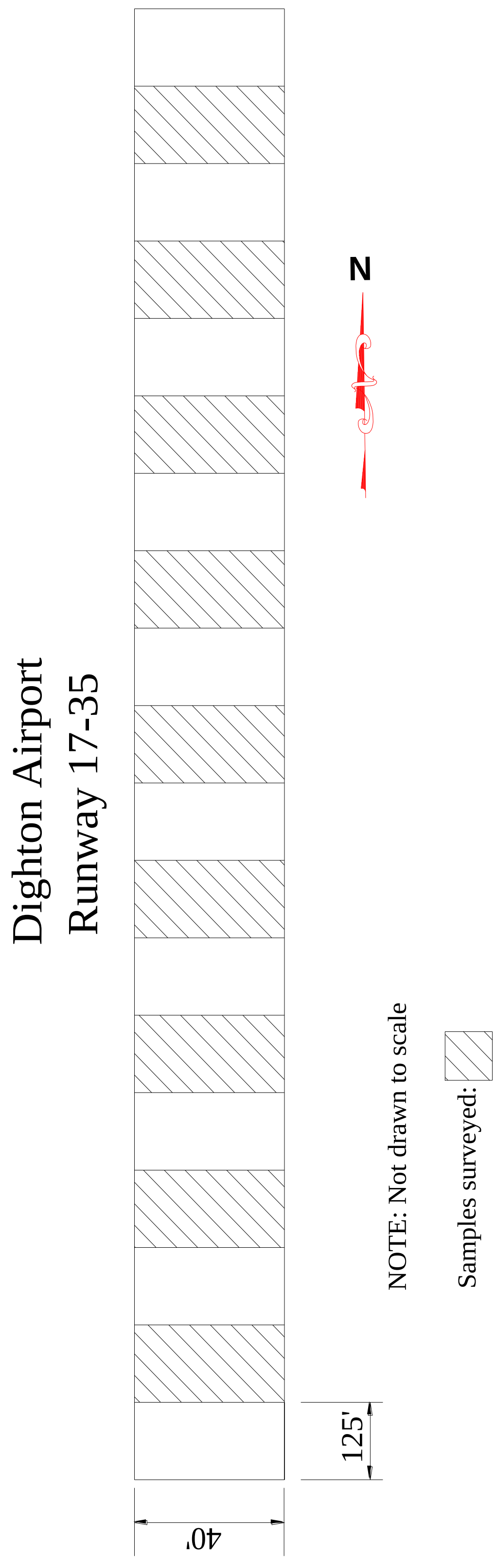


Figure A.1: Layout of sample asphalt runways and units surveyed, arranged by increasing width of runway (continued)

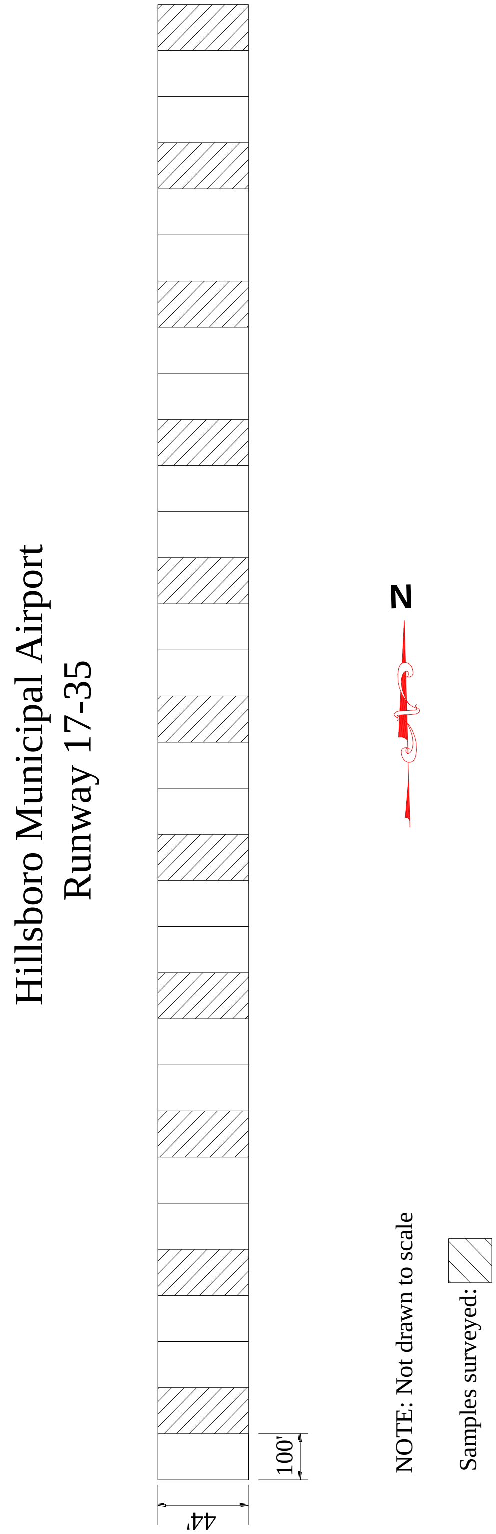


Figure A.1: Layout of sample asphalt runways and units surveyed, arranged by increasing width of runway (continued)

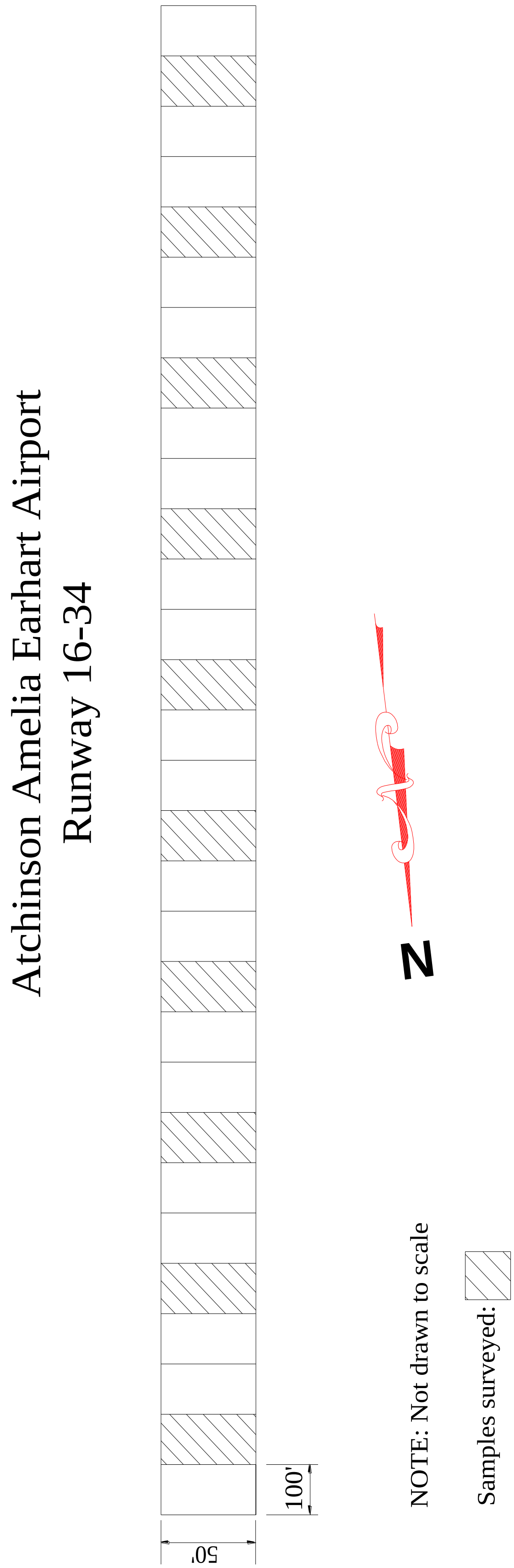


Figure A.1: Layout of sample asphalt runways and units surveyed, arranged by increasing width of runway (continued)

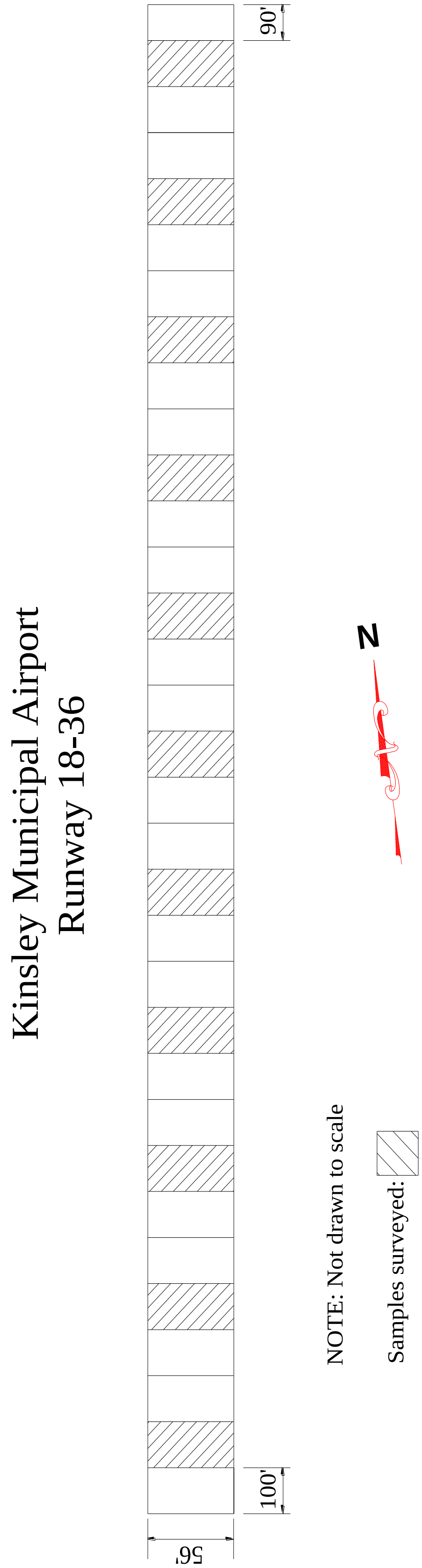


Figure A.1: Layout of sample asphalt runways and units surveyed, arranged by increasing width of runway (continued)

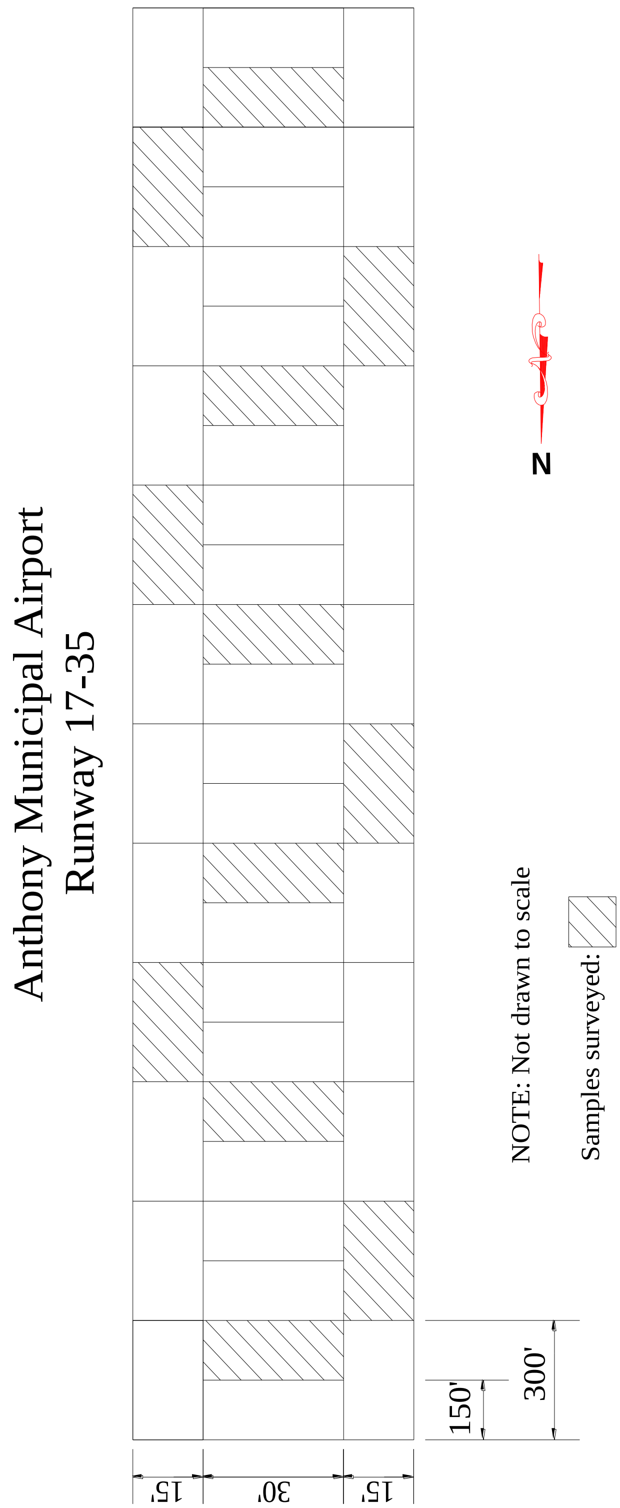


Figure A.1: Layout of sample asphalt runways and units surveyed, arranged by increasing width of runway (continued)

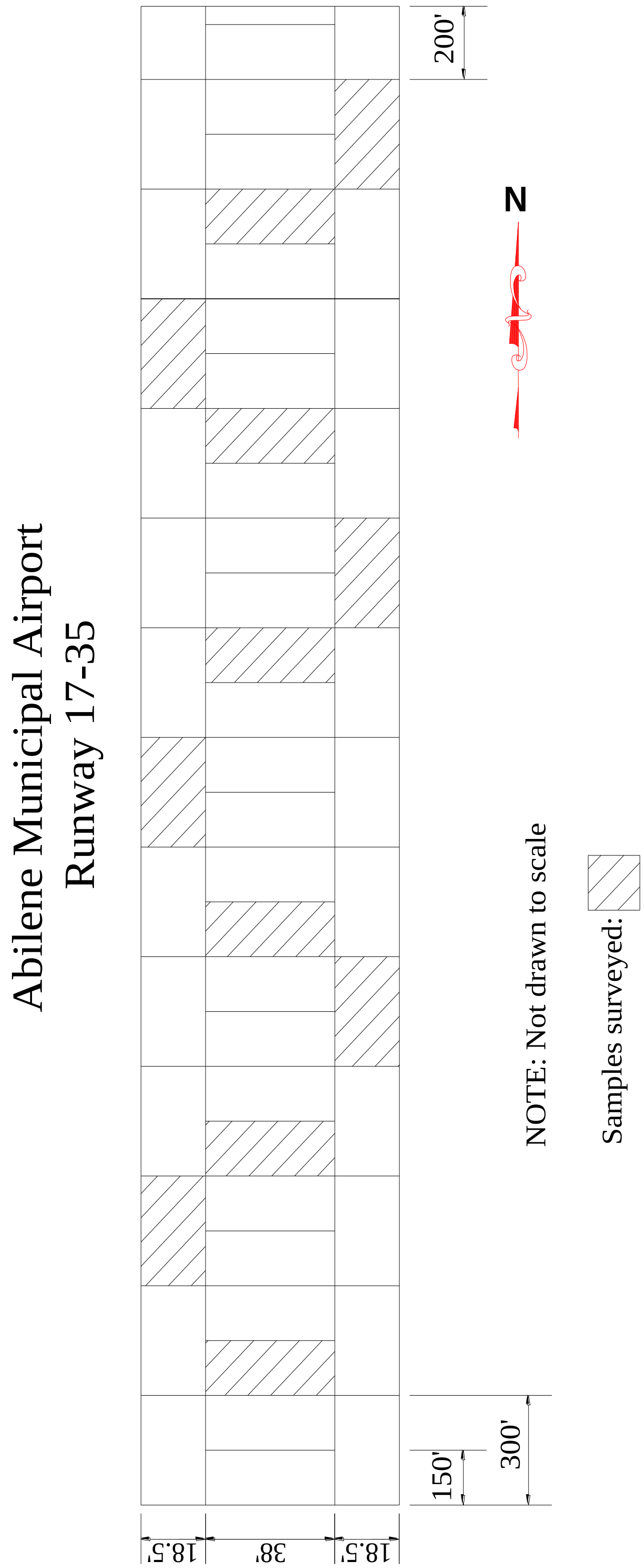


Figure A.1: Layout of sample asphalt runways and units surveyed, arranged by increasing width of runway (continued)

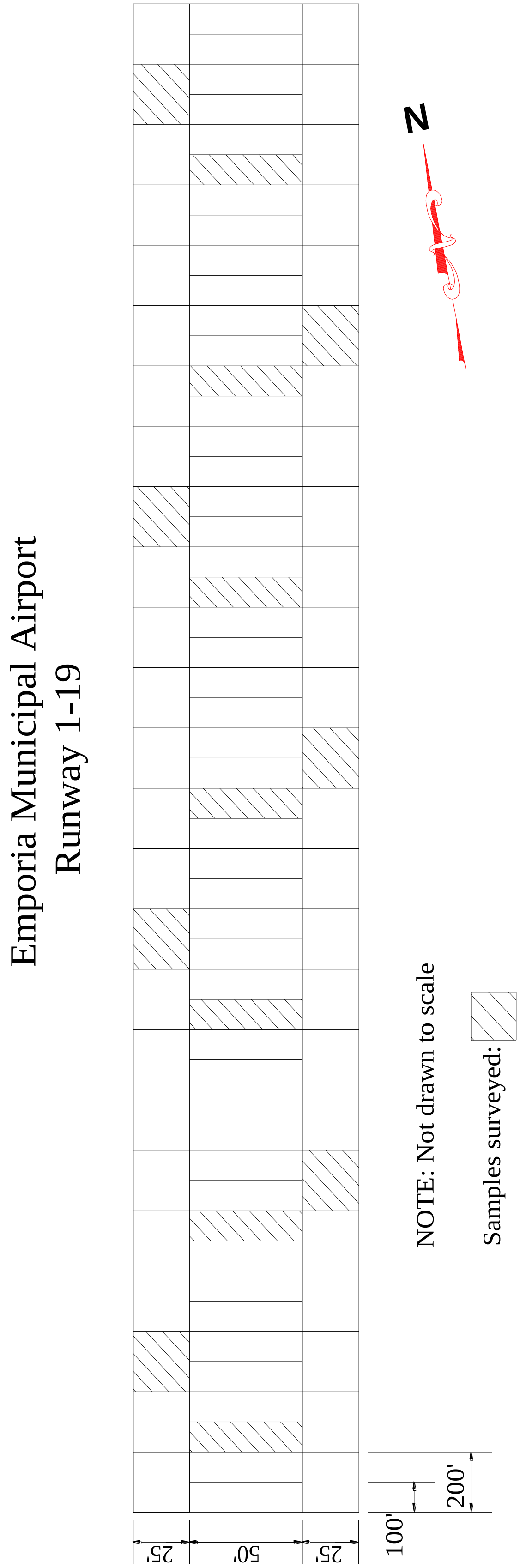


Figure A.1: Layout of sample asphalt runways and units surveyed, arranged by increasing width of runway (continued)

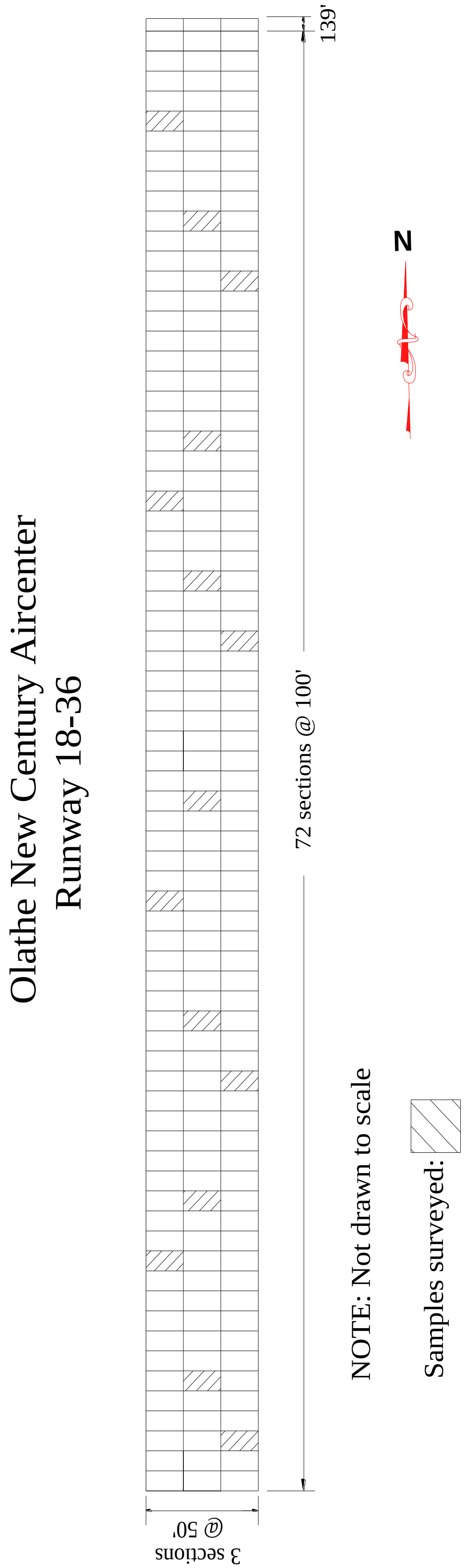


Figure A.2: Layout of sample concrete runways and units surveyed, arranged by increasing number of slabs in width direction

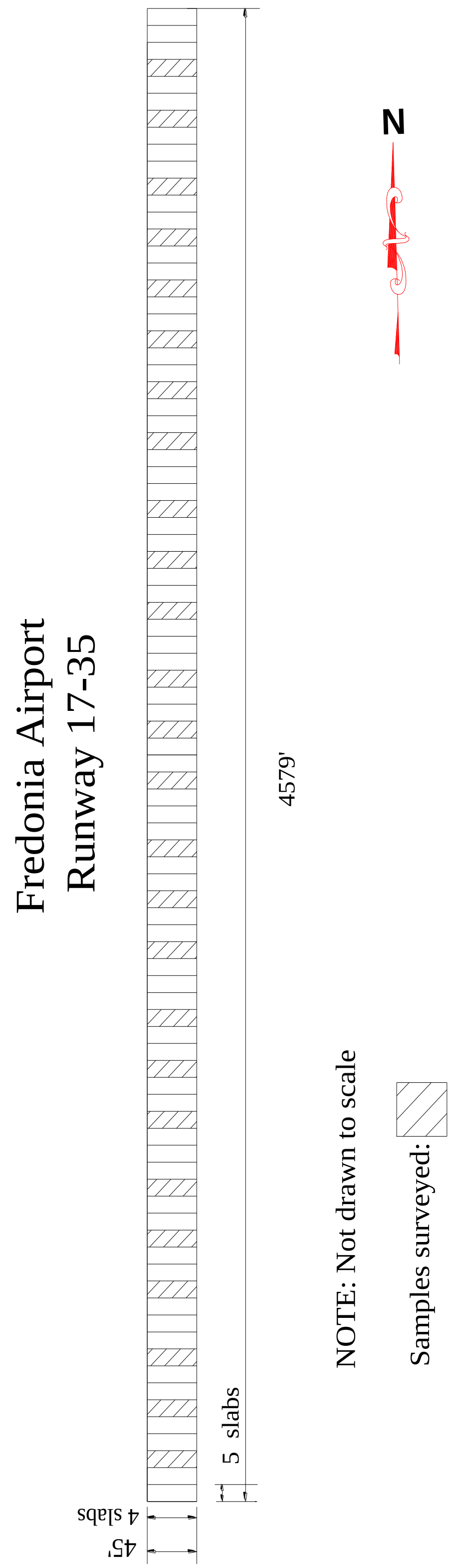


Figure A.2: Layout of sample concrete runways and units surveyed, arranged by increasing number of slabs in width direction (continued)

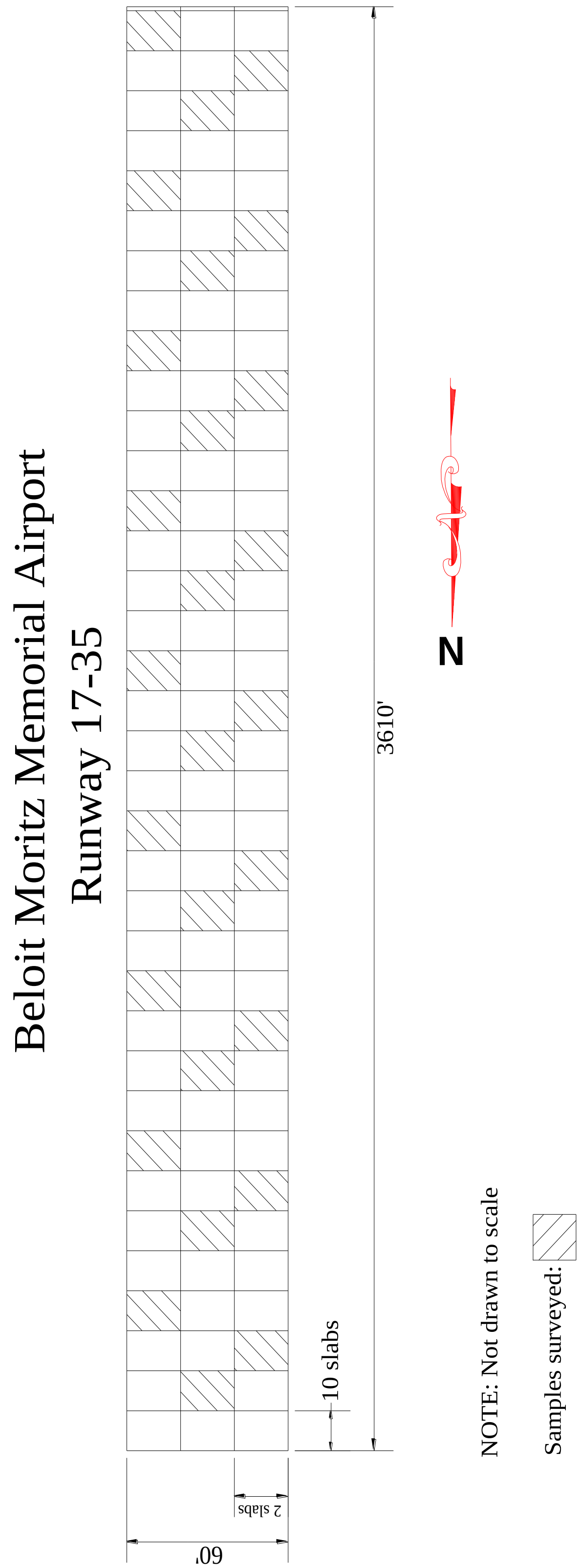


Figure A.2: Layout of sample concrete runways and units surveyed, arranged by increasing number of slabs in width direction (continued)

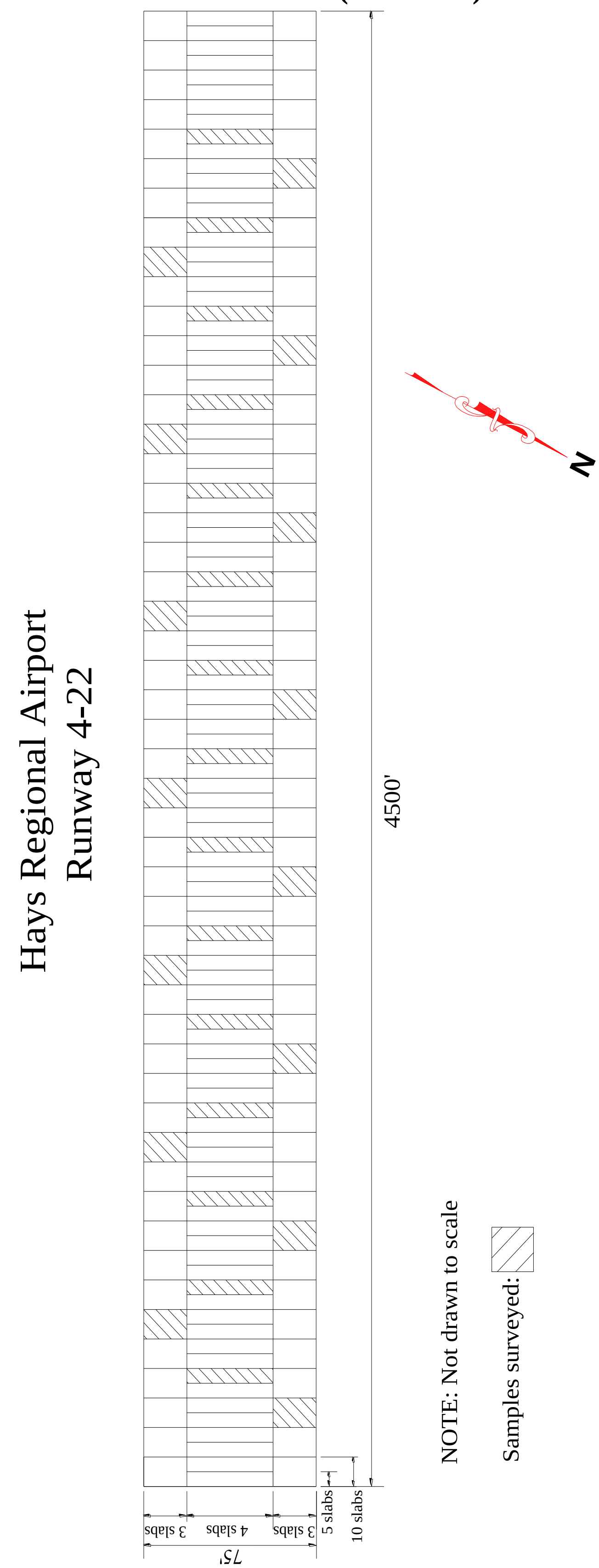
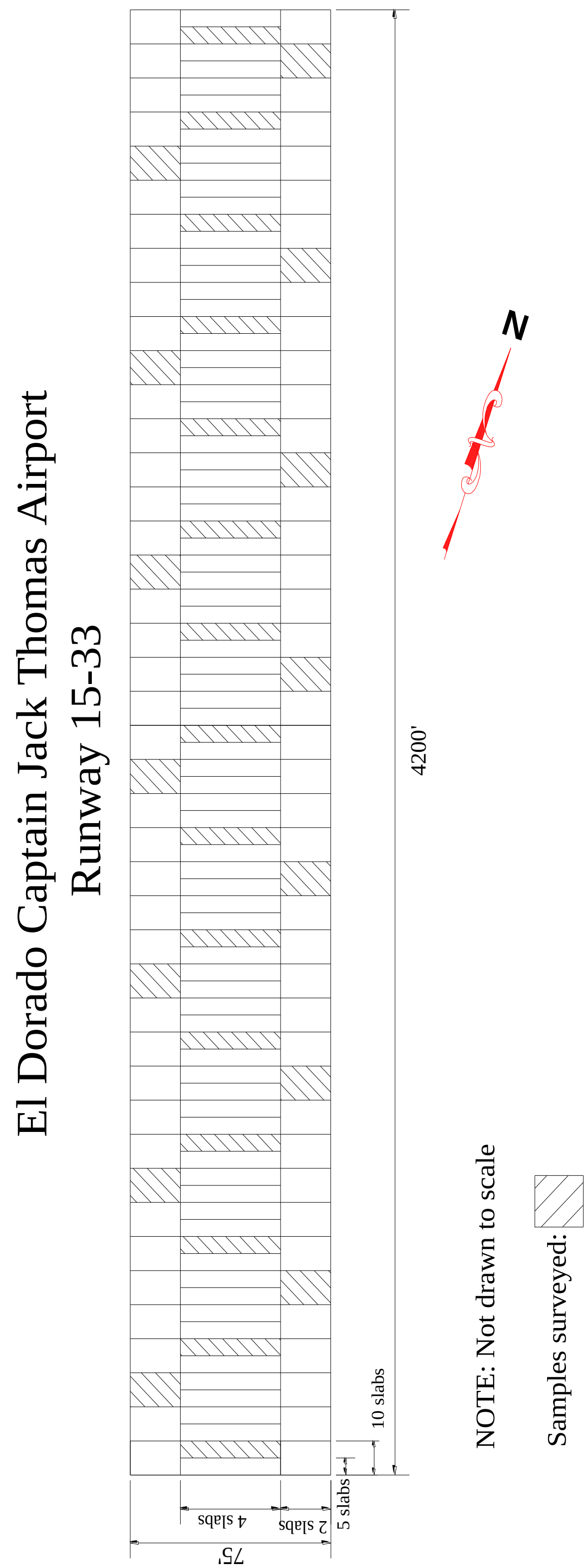


Figure A.2: Layout of sample concrete runways and units surveyed, arranged by increasing number of slabs in width direction (continued)



APPENDIX B
PCI REPORT

Table B.1: PCI Report

Branch name	Branch ID	Section ID	Surface	Date of Inspection	PCI
Abilene Municipal Airport	K78	17-35	AC	06/13/2008	73
Anthony Municipal Airport	ANY	17-35	AC	07/10/2008	39
Atchison Amelia Earhart Airport	K59	16-34	AC	06/12/2008	54
Atwood - Rawlins Co. Airport	ADT	16-34	AC	07/22/2008	94
Augusta Municipal Airport	3AU	18-36	AC	06/24/2008	47
Belleville Municipal Airport	RPB	18-36	AC	06/04/2008	86
Beloit Moritz Memorial Airport	K61	17-35	PCC	06/04/2008	93
Benton Lloyd Stearman Field	1K1	17-35	AC	06/24/2008	93
Burlington Coffey County Airport	UKL	18-36	PCC	06/03/2008	85
Chanute Martin Johnson Airport	CNU	18-36	AC	07/02/2008	84
Cimarron Municipal Airport	8K8	1-19	AC	07/15/2008	80
Clay Center Municipal	CYW	17-35	AC	05/27/2008	53
Coffeyville Municipal	CFV	17-35	AC	07/01/2008	74
Coffeyville Municipal	CFV	4-22	AC	07/01/2008	64
Colby Shaltz Field	CBK	17-35	PCC	07/22/2008	82
Coldwater Comanche County Airport	3K8	17-35	PCC	07/09/2008	87
Concordia Blosser Municipal	CNK	17-35	AC	05/27/2008	92
Dighton Airport	K65	17-35	AC	07/23/2008	74
Dodge City Regional	DDC	14-32	AC	06/17/2008	75
Dodge City Regional	DDC	2-20	AC	06/17/2008	75
El Dorado Captain Jack Thomas	EQA	15-33	PCC	06/24/2008	80
El Dorado Captain Jack Thomas	EQA	4-22	AC	06/24/2008	87
Elkhart Morton County Airport	EHA	17-35	AC	06/19/2008	75
Elkhart Morton County Airport	EHA	4-22	AC	06/19/2008	66
Ellsworth Municipal Airport	9K7	17-35	AC	06/10/2008	92
Emporia Municipal Airport	EMP	1-19	AC	06/03/2008	60
Eureka Municipal Airport	13K	18-36	AC	06/25/2008	57
Fredonia Airport	1K7	17-35	PCC	06/30/2008	88
Ft. Leavenworth Sherman AAF	FLV	15-33	AC	07/28/2008	64
Ft. Scott Municipal Airport	FSK	18-36	AC	07/02/2008	58
Garden City Regional Airport	GCK	12-30	PCC	07/15/2008	83

Table B.1: PCI Report (continued)

Garden City Regional Airport	GCK	17-35	PCC	07/15/2008	89
Gardner Municipal Airport	K34	8-26	AC	06/26/2008	92
Garnett Municipal Airport	K68	1-19	AC	06/11/2008	58
Goodland Renner Field	GLD	12-30	PCC	07/22/2008	84
Goodland Renner Field	GLD	5-23	AC	07/22/2008	70
Great Bend Municipal Airport	GBD	11-29	AC	06/16/2008	52
Great Bend Municipal Airport	GBD	17-35	AC	06/16/2008	81
Harper Municipal Airport	8K2	17-35	AC	07/10/2008	71
Hays Regional Airport	HYS	16-34	AC	07/14/2008	86
Hays Regional Airport	HYS	4-22	PCC	07/14/2008	88
Herington Regional Airport	HRU	17-35	PCC	06/02/2008	99
Hill City Municipal Airport	HLC	17-35	PCC	07/21/2008	94
Hillsboro Municipal Airport	M66	17-35	AC	06/02/2008	76
Hoxie Sheridan County Airport	1F5	17-35	AC	07/21/2008	70
Hugoton Municipal Airport	HQG	13-31	AC	06/19/2008	83
Hugoton Municipal Airport	HQG	2-20	PCC	06/19/2008	81
Hutchinson Municipal Airport	HUT	13-31	AC	06/09/2008	51
Hutchinson Municipal Airport	HUT	17-35	AC	06/09/2008	50
Hutchinson Municipal Airport	HUT	4-22	AC	06/09/2008	57
Independence Municipal Airport	IDP	17-35	AC	07/01/2008	68
Independence Municipal Airport	IDP	4-22	AC	07/01/2008	80
Ingalls Municipal Airport	30K	17-35	PCC	07/15/2008	57
Iola Allen County Airport	K88	1-19	PCC	06/25/2008	87
Jetmore Municipal Airport	K79	17-35	AC	07/14/2008	75
Johnson Stanton County Municipal	2K3	17-35	PCC	06/20/2008	85
Johnson Stanton County Municipal	2K3	8-26	AC	06/20/2008	54
Junction City Freeman Field	3JC	18-36	AC	05/22/2008	82
Kingman Municipal Airport	9K8	11-29	PCC	07/10/2008	96
Kingman Municipal Airport	9K8	18-36	PCC	07/10/2008	95
Kinsley Municipal Airport	33K	18-36	AC	06/17/2008	41
La Crosse Rush County Airport	K94	17-35	AC	07/14/2008	74
Lakin Airport	36K	14-32	AC	07/16/2008	62
Larned Pawnee County Airport	LQR	17-35	PCC	06/17/2008	87
Lawrence Municipal Airport	LWC	1-19	PCC	06/27/2008	92

Table B.1: PCI Report (continued)

Lawrence Municipal Airport	LWC	15-33	AC	06/27/2008	71
Leoti Mark Howard Memorial Airport	3K7	17-35	AC	07/23/2008	86
Leoti Mark Howard Memorial Airport	3K7	8-26	AC	07/24/2008	84
Liberal Mid-America Rgnl Airport	LBL	17-35	PCC	06/18/2008	96
Liberal Mid-America Rgnl Airport	LBL	4-22	PCC	06/18/2008	63
Lucas Airport	38K	17-35	AC	06/10/2008	81
Lyons Rice County Airport	LYO	17-35	AC	06/16/2008	54
Manhattan Regional Airport	MHK	13-31	AC	05/22/2008	59
Manhattan Regional Airport	MHK	3-21	PCC	05/22/2008	84
Mankato Airport	TKO	17-35	AC	06/04/2008	88
Marion Municipal Airport	43K	17-35	AC	06/02/2008	77
Marysville Municipal	MYZ	15-33	AC	05/23/2008	93
McPherson Airport	MPR	18-36	PCC	06/09/2008	88
Meade Municipal Airport	MEJ	17-35	PCC	06/18/2008	86
Medicine Lodge Airport	K51	16-34	AC	07/09/2008	63
Minneapolis City/County Airport	45K	16-34	AC	05/27/2008	95
Moline Elk County Airport	2K6	18-36	AC	06/30/2008	59
Moundridge Municipal Airport	47K	17-35	AC	06/05/2008	82
Neodesha Municipal Airport	2K7	2-20	AC	06/30/2008	77
Ness City Municipal Airport	48K	17-35	AC	07/24/2008	75
Newton City-County Airport	EWK	17-35	AC	06/05/2008	52
Newton City-County Airport	EWK	8-26	AC	06/12/2008	84
Norton Municipal Airport	NRN	16-34	PCC	07/21/2008	93
Oakley Municipal Airport	OEL	16-34	AC	07/22/2008	56
Oberlin Municipal Airport	OIN	17-35	AC	07/21/2008	70
Olathe Johnson County Executive	OJC	18-36	PCC	07/28/2008	89
Olathe New Century Aircenter	IXD	18-36	AC	06/26/2008	94
Olathe New Century Aircenter	IXD	4-22	AC	06/26/2008	46
Osage City Municipal Airport	53K	17-35	AC	06/03/2008	54
Osborne Municipal Airport	K75	2-20	AC	06/06/2008	77
Oswego Municipal Airport	K67	17-35	AC	07/01/2008	76
Ottawa Municipal Airport	OWI	17-35	AC	06/27/2008	70
Oxford Municipal Airport	55K	17-35	AC	07/03/2008	53
Paola Miami County Airport	K81	3-21	AC	06/27/2008	79

Table B.1: PCI Report (continued)

Parsons Tri-City Airport	PPF	17-35	PCC	07/01/2008	94
Phillipsburg Municipal Airport	PHG	13-31	AC	07/21/2008	63
Pittsburg Atkinson Municipal	PTS	16-34	AC	07/02/2008	79
Pittsburg Atkinson Municipal	PTS	4-22	AC	07/02/2008	97
Pleasanton Gilmore Airport	57K	3-21	AC	06/11/2008	7
Pratt Industrial Airport	PTT	17-35	PCC	07/09/2008	95
Rose Hill Cook Airfield	K50	17-35	AC	07/07/2008	80
Russell Municipal Airport	RSL	16-34	PCC	06/16/2008	93
Sabetha Municipal Airport	K83	1-19	AC	06/12/2008	76
Saint Francis Cheyenne Co. Airport	SYF	14R-32L	AC	07/22/2008	80
Salina Municipal Airport	SLN	12-30	AC	07/31/2008	76
Salina Municipal Airport	SLN	17-35	AC	06/13/2008	64
Salina Municipal Airport	SLN	18-36	AC	07/29/2008	93
Salina Municipal Airport	SLN	4-22	AC	07/29/2008	59
Satanta Municipal Airport	1K9	3-21	AC	06/18/2008	73
Scott City Municipal Airport	TQK	17-35	AC	07/23/2008	63
Smith Center Municipal Airport	K82	17-35	AC	06/05/2008	62
Sublette Flying Club Airport	19S	17-35	AC	06/18/2008	83
Syracuse Hamilton County Municipal	3K3	13-31	AC	07/16/2008	76
Syracuse Hamilton County Municipal)	3K3	18-36	PCC	07/16/2008	95
Topeka Billard Municipal Airport	TOP	13-31	AC	07/30/2008	94
Topeka Billard Municipal Airport	TOP	18-36	AC	07/30/2008	92
Topeka Billard Municipal Airport	TOP	4-22	AC	07/30/2008	62
Topeka Forbes Field	FOE	13-31	PCC	07/17/2008	72
Topeka Forbes Field	FOE	3-21	PCC	07/17/2008	64
Tribune Municipal Airport	5K2	17-35	PCC	07/23/2008	90
Ulysses Airport	ULS	12-30	PCC	06/20/2008	96
Ulysses Airport	ULS	17-35	PCC	06/20/2008	89
Wakeeney Trego County Airport	0H1	17-35	AC	07/24/2008	71
Wamego Municipal Airport	69K	17-35	AC	05/23/2008	70
Washington County Memorial	K38	17-35	PCC	05/23/2008	93
Wellington Municipal	EGT	17-35	PCC	07/03/2008	96
Wichita Cessna Aircraft	CEA	17-35	AC	07/07/2008	98
Wichita Jabara Airport	AAO	18-36	PCC	07/07/2008	91

Table B.1: PCI Report (continued)

Wichita Riverside Airport	K32	16-34	AC	07/08/2008	85
Wichita Westport Airport	71K	17-35	AC	07/07/2008	83
Winfield Strother Field Airport	WLD	13-31	AC	07/03/2008	76
Winfield Strother Field Airport	WLD	17-35	AC	07/03/2008	68

APPENDIX C

STATISTICAL ANALYSIS OF COMPARISONS

INPUT FILE

Determining if PCI varies with surface type

```
data airports;
input surface $ pci @@;
cards;
AC 94 AC 80 AC 74 AC 75 AC 75 AC 66 AC 75 AC 70 AC 86 AC 70 AC 83 AC 75 AC 54
AC 41 AC 74 AC 62 AC 84 AC 86 AC 75 AC 56 AC 70 AC 63 AC 80 AC 73 AC 63 AC 83
AC 76 AC 71
AC 73 AC 39 AC 54 AC 47 AC 86 AC 93 AC 53 AC 92 AC 87 AC 92 AC 60 AC 57 AC 64
AC 92 AC 58 AC 52 AC 81 AC 71 AC 76 AC 51 AC 50 AC 57 AC 82 AC 71 AC 81 AC 54
AC 59 AC 88 AC 77 AC 93 AC 63 AC 95 AC 82 AC 52 AC 84 AC 94 AC 46 AC 54 AC 77
AC 70 AC 53 AC 79 AC 80 AC 76 AC 76 AC 64 AC 93 AC 59 AC 62 AC 94 AC 92 AC 62
AC 70 AC 98 AC 85 AC 83 AC 76 AC 68
AC 84 AC 74 AC 64 AC 68 AC 80 AC 59 AC 77
AC 58 AC 76 AC 79 AC 97 AC 7
PC 82 PC 87 PC 83 PC 89 PC 84 PC 88 PC 94 PC 81 PC 57 PC 85 PC 87 PC 63 PC 96
PC 86 PC 93 PC 95 PC 90 PC 89 PC 96
PC 93 PC 85 PC 80 PC 99 PC 96 PC 95 PC 92 PC 84 PC 88 PC 89 PC 95 PC 93 PC 72
PC 64 PC 93 PC 96 PC 91
PC 88 PC 87 PC 94
;
proc print;
title 'Surface Comparison';
run;
proc means;
var pci;
by surface;
run;
proc glm;
class surface;
model pci=surface / clm;
estimate 'AC-PC' surface 1 -1;
contrast 'AC-PC' surface 1 -1;
run;
```

OUTPUT

```
                               Surface Comparison

------------------------------------------ surface=AC ------------------------------------------

                              The MEANS Procedure

                            Analysis Variable : pci

              N            Mean         Std Dev         Minimum         Maximum

             98      71.7755102      15.4229248       7.0000000      98.0000000


------------------------------------------ surface=PC ------------------------------------------

                            Analysis Variable : pci

              N            Mean         Std Dev         Minimum         Maximum

             39      87.1538462       9.3879499      57.0000000      99.0000000




                               The GLM Procedure

                            Class Level Information

                         Class         Levels    Values

                         surface            2    AC PC


                    Number of Observations Read         137
                    Number of Observations Used         137
```

Surface Comparison

The GLM Procedure

Dependent Variable: pci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	6597.64287	6597.64287	33.71	<.0001
Error	135	26422.13815	195.71954		
Corrected Total	136	33019.78102			

R-Square	Coeff Var	Root MSE	pci Mean
0.199809	18.37082	13.98998	76.15328

Source	DF	Type I SS	Mean Square	F Value	Pr > F
surface	1	6597.642874	6597.642874	33.71	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
surface	1	6597.642874	6597.642874	33.71	<.0001

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
AC-PC	1	6597.642874	6597.642874	33.71	**<.0001**

Parameter	Estimate	Standard Error	t Value	Pr > |t|
AC-PC	-15.3783359	2.64869552	-5.81	<.0001

Note:

Null hypothesis (Ho): C = 0, which would mean PCI AC = PCI PC

Pr > F (<0.0001) is smaller than α-level (0.05). Reject Ho.

The PCI of asphalt runways is significantly different than the PCI of concrete runways.

INPUT FILE

Determining if PCI of asphalt runways varies with climatic regions

```
data airports;
input zone $ pci @@;
cards;
1 94 1 80 1 74 1 75 1 75 1 66 1 75 1 70 1 86 1 70 1 83 1 75 1 54 1 41 1 74 1
62 1 84 1 86 1 75 1 56 1 70 1 63 1 80 1 73 1 63 1 83 1 76 1 71
2 73 2 39 2 54 2 47 2 86 2 93 2 53 2 92 2 87 2 92 2 60 2 57 2 64 2 92 2 58 2
52 2 81 2 71 2 76 2 51 2 50 2 57 2 82 2 71 2 81 2 54 2 59 2 88 2 77 2 93 2 63
2 95 2 82 2 52 2 84 2 94 2 46 2 54 2 77 2 70 2 53 2 79 2 80 2 76 2 76 2 64 2
93 2 59 2 62 2 94 2 92 2 62 2 70 2 98 2 85 2 83 2 76 2 68
3 84 3 74 3 64 3 68 3 80 3 59 3 77
4 58 4 76 4 79 4 97 4 7
;
proc print;
title 'Weather Zone Comparison for Asphalt Runways';
run;
proc means;
var pci;
by zone;
run;
proc glm;
class zone;
model pci=zone / clm;
estimate '1-2' zone 1 -1 0 0;
estimate '1-3' zone 1 0 -1 0;
estimate '1-4' zone 1 0 0 -1;
estimate '2-3' zone 0 1 -1 0;
estimate '2-4' zone 0 1 0 -1;
estimate '3-4' zone 0 0 1 -1;
contrast '1-2' zone 1 -1 0 0;
contrast '1-3' zone 1 0 -1 0;
contrast '1-4' zone 1 0 0 -1;
contrast '2-3' zone 0 1 -1 0;
contrast '2-4' zone 0 1 0 -1;
contrast '3-4' zone 0 0 1 -1;
run;
```

OUTPUT

```
                    Weather Zone Comparison for Asphalt Runways

--------------------------------------------- zone=1 ---------------------------------------------

                                The MEANS Procedure

                              Analysis Variable : pci

                 N           Mean         Std Dev         Minimum         Maximum

                28     72.6428571      11.0561338      41.0000000      94.0000000


--------------------------------------------- zone=2 ---------------------------------------------

                              Analysis Variable : pci

                 N           Mean         Std Dev         Minimum         Maximum

                58     72.0172414      15.7663770      39.0000000      98.0000000


--------------------------------------------- zone=3 ---------------------------------------------

                              Analysis Variable : pci

                 N           Mean         Std Dev         Minimum         Maximum

                 7     72.2857143       8.9947074      59.0000000      84.0000000

--------------------------------------------- zone=4 ---------------------------------------------

                              Analysis Variable : pci

                 N           Mean         Std Dev         Minimum         Maximum

                 5     63.4000000      34.4281861       7.0000000      97.0000000


                  Weather Zone Comparison for Asphalt Runways


                                 The GLM Procedure

                              Class Level Information

                          Class         Levels    Values

                          zone               4    1 2 3 4


                      Number of Observations Read          98
                      Number of Observations Used          98
```

Weather Zone Comparison for Asphalt Runways

The GLM Procedure

Dependent Variable: pci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	377.02132	125.67377	0.52	0.6692
Error	94	22696.03990	241.44723		
Corrected Total	97	23073.06122			

R-Square	Coeff Var	Root MSE	pci Mean
0.016340	21.64885	15.53857	71.77551

Source	DF	Type I SS	Mean Square	F Value	Pr > F
zone	3	377.0213230	125.6737743	0.52	0.6692

Source	DF	Type III SS	Mean Square	F Value	Pr > F
zone	3	377.0213230	125.6737743	0.52	0.6692

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
1-2	1	7.3909955	7.3909955	0.03	0.8615
1-3	1	0.7142857	0.7142857	0.00	0.9567
1-4	1	362.4320346	362.4320346	1.50	0.2236
2-3	1	0.4502084	0.4502084	0.00	0.9656
2-4	1	341.8172414	341.8172414	1.42	0.2371
3-4	1	230.2880952	230.2880952	0.95	0.3313

Parameter	Estimate	Standard Error	t Value	Pr > |t|
1-2	0.62561576	3.57575150	0.17	0.8615
1-3	0.35714286	6.56624530	0.05	0.9567
1-4	9.24285714	7.54404149	1.23	0.2236
2-3	-0.26847291	6.21734229	-0.04	0.9656
2-4	8.61724138	7.24239808	1.19	0.2371
3-4	8.88571429	9.09845638	0.98	0.3313

Note:

Null hypothesis for all 6 comparisons (Ho) : C = 0, which would mean PCI zone(x) = PCI zone(y)

Pr > F for all comparison is greater than α-level (0.05). So, accept Ho.

There is no significant difference in PCI from zone to zone for asphalt runways

INPUT FILE

Determining if PCI of asphalt runways varies with climatic regions

```
data airports;
input zone $ pci @@;
cards;
1 82 1 87 1 83 1 89 1 84 1 88 1 94 1 81 1 57 1 85 1 87 1 63 1 96 1 86 1 93 1
95 1 90 1 89 1 96
2 93 2 85 2 80 2 99 2 96 2 95 2 92 2 84 2 88 2 89 2 95 2 93 2 72 2 64 2 93 2
96 2 91
3 88 3 87 3 94
;
;
proc print;
title 'Weather Zone Comparison for Concrete Runways';
run;
proc means;
var pci;
by zone;
run;
proc glm;
class zone;
model pci=zone / clm;
estimate '1-2' zone 1 -1 0;
estimate '1-3' zone 1 0 -1;
estimate '2-3' zone 0 1 -1;
contrast '1-2' zone 1 -1 0;
contrast '1-3' zone 1 0 -1;
contrast '2-3' zone 0 1 -1;
run;
```

OUTPUT

```
                      Weather Zone Comparison for Concrete Runways

--------------------------------------------- zone=1 ---------------------------------------------

                                The MEANS Procedure

                              Analysis Variable : pci

       N            Mean         Std Dev         Minimum         Maximum

      19      85.5263158      10.1509081      57.0000000      96.0000000


--------------------------------------------- zone=2 ---------------------------------------------

                              Analysis Variable : pci

       N            Mean         Std Dev         Minimum         Maximum

      17      88.5294118       9.2338890      64.0000000      99.0000000


--------------------------------------------- zone=3 ---------------------------------------------

                              Analysis Variable : pci

       N            Mean         Std Dev         Minimum         Maximum

       3      89.6666667       3.7859389      87.0000000      94.0000000



                   Weather Zone Comparison for Concrete Runways


                                 The GLM Procedure

                              Class Level Information

                           Class         Levels    Values

                           zone               3    1 2 3


                        Number of Observations Read          39
                        Number of Observations Used          39
```

Weather Zone Comparison for Concrete Runways

The GLM Procedure

Dependent Variable: pci

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	101.438120	50.719060	0.56	0.5749
Error	36	3247.638803	90.212189		
Corrected Total	38	3349.076923			

R-Square	Coeff Var	Root MSE	pci Mean
0.030288	10.89798	9.498010	87.15385

Source	DF	Type I SS	Mean Square	F Value	Pr > F
zone	2	101.4381202	50.7190601	0.56	0.5749

Source	DF	Type III SS	Mean Square	F Value	Pr > F
zone	2	101.4381202	50.7190601	0.56	0.5749

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
1-2	1	80.91675267	80.91675267	0.90	0.3499
1-3	1	44.41467305	44.41467305	0.49	0.4874
2-3	1	3.29803922	3.29803922	0.04	0.8494

Parameter	Estimate	Standard Error	t Value	Pr > |t|
1-2	-3.00309598	3.17090039	-0.95	0.3499
1-3	-4.14035088	5.90074060	-0.70	0.4874
2-3	-1.13725490	5.94788441	-0.19	0.8494

Note:

Null hypothesis for all 3 comparisons (Ho) : C = 0, which would mean PCI zone(x) = PCI zone(y)

Pr > F for all comparison is greater than α-level (0.05). So, accept Ho.

There is no significant difference in PCI from zone to zone for concrete runways

APPENDIX D

INVENTORY REPORT

Table D.1: Inventory Report

Name	Branch ID	Section	Surface	Length (ft)	Width (ft)	Area (sq. ft)	Rank	Zone	Last Inspec. Date	Last Const. Date
Abilene Municipal Airport	K78	17-35	AC	4,100.00	75	307,500	A	zne2	6/13/2008	1/1/2003
Anthony Municipal Airport	ANY	17-35	AC	3,600.00	60	216,000	A	zne2	7/10/2008	
Atchison Amelia Earhart Airport	K59	16-34	AC	3,000.00	48	144,000	A	zne2	6/12/2008	
Atwood - Rawlins Co. Airport	ADT	16-34	AC	5,000.00	75	375,000	A	zne1	7/22/2008	4/1/2005
Augusta Municipal Airport	3AU	18-36	AC	4,200.00	60	252,000	A	zne2	6/24/2008	5/1/2003
Belleville Municipal Airport	RPB	18-36	AC	3,507.00	60	210,420	A	zne2	6/4/2008	4/1/2005
Beloit (Moritz) Memorial Airport	K61	15-35	PCC	3,610.00	60	216,600	A	zne2	6/4/2008	
Benton Lloyd Stearman Field	1K1	17-35	AC	2,163.00	60	129,780	A	zne2	6/24/2008	9/1/2005
Burlington Coffey County Airport	UKL	18-36	PCC	5,500.00	75	412,500	A	zne2	6/3/2008	
Chanute Martin Johnson Airport	CNU	18-36	AC	4,255.00	75	319,125	A	zne3	7/2/2008	
Cimarron Municipal Airport	8K8	1-19	AC	2,800.00	35	98,000	A	zne1	7/15/2008	7/1/2003
Clay Center Municipal	CYW	17-35	AC	4,200.00	75	315,000	A	zne2	5/27/2008	
Coffeyville Municipal	CFV	4-22	AC	4,000.00	75	300,000	A	zne3	7/1/2008	
Coffeyville Municipal	CFV	18-35	AC	5,872.00	100	587,200	A	zne3	7/1/2008	
Colby Shaltz Field	CBK	17-35	PCC	5,110.00	75	383,250	A	zne1	7/22/2008	8/1/1985
Coldwater Comanche County Airport	3K8	17-35	PCC	4,500.00	60	270,000	A	zne1	7/9/2008	6/1/2003
Concordia Blosser Municipal	CNK	17-35	AC	3,600.00	60	216,000	A	zne2	5/27/2008	8/1/2005

Table D.1: Inventory Report (continued)

Dighton Airport	K65	17-35	AC	2,400.00	40	96,000	A	zne1	7/23/2008	11/1/2002
Dodge City Regional	DDC	2-20	AC	4,649.00	100	464,900	A	zne1	6/17/2008	8/1/2000
Dodge City Regional	DDC	14-32	AC	6,900.00	100	690,000	A	zne1	6/17/2008	5/1/2001
El Dorado Captain Jack Thomas	EQA	15-33	PCC	4,200.00	75	315,000	A	zne2	6/24/2008	6/1/1993
El Dorado Captain Jack Thomas	EQA	4-22	AC	4,204.00	75	315,300	A	zne2	6/24/2008	6/1/2005
Elkhart Morton County Airport	EHA	17-35	AC	4,900.00	60	294,000	A	zne1	6/19/2008	
Elkhart Morton County Airport	EHA	4-22	AC	4,900.00	60	294,000	A	zne1	6/19/2008	8/1/2000
Ellsworth Municipal Airport	9K7	17-35	AC	3,919.00	50	195,950	A	zne2	6/10/2008	9/1/2000
Emporia Municipal Airport	EMP	1-19	AC	5,000.00	100	500,000	A	zne2	6/3/2008	
Eureka Municipal Airport	13K	18-36	AC	3,503.00	60	210,180	A	zne2	6/25/2008	8/1/2000
Fredonia Airport	1K7	17-35	PCC	4,579.00	45	206,055	A	zne3	6/30/2008	
Ft. Leavenworth Sherman AAF	FLV	15-33	AC	5,905.00	100	590,500	A	zne2	7/28/2008	
Ft. Scott Municipal Airport	FSK	18-36	AC	4,403.00	75	330,225	A	zne4	7/2/2008	8/1/2001
Garden City Regional Airport	GCK	12-30	PCC	5,700.00	100	570,000	A	zne1	7/15/2008	
Garden City Regional Airport	GCK	17-35	PCC	7,300.00	100	730,000	A	zne1	7/15/2008	8/1/2002
Gardner Municipal Airport	K34	8-36	AC	2,960.00	36	106,560	A	zne2	6/26/2008	3/1/2008
Garnett Municipal Airport	K68	1-19	AC	2,400.00	45	108,000	A	zne2	6/11/2008	
Goodland Renner Field	GLD	5-23	AC	3,500.00	75	262,500	A	zne1	7/22/2008	8/1/1997
Goodland Renner Field	GLD	12-30	PCC	5,500.00	100	550,000	A	zne1	7/22/2008	

Table D.1: Inventory Report (continued)

Great Bend Municipal Airport	GBD	11-29	AC	4,698.00	75	352,350	A	zne2	6/16/2008	
Great Bend Municipal Airport	GBD	17-35	AC	7,850.00	100	785,000	A	zne2	6/16/2008	10/1/2003
Harper Municipal Airport	8K2	17-35	AC	3,268.00	38	124,184	A	zne2	7/10/2008	
Hays Regional Airport	HYS	4-22	PCC	4,500.00	75	337,500	A	zne1	7/14/2008	6/1/2002
Hays Regional Airport	HYS	16-34	AC	6,500.00	100	650,000	A	zne1	7/14/2008	8/1/2004
Herington Regional Airport	HRU	17-35	PCC	4,184.00	75	313,800	A	zne2	6/2/2008	6/1/2007
Hill City Municipal Airport	HLC	17-35	PCC	5,000.00	75	375,000	A	zne1	7/21/2008	8/1/2002
Hillsboro Municipal Airport	M66	17-35	AC	3,229.00	44	142,076	A	zne2	6/2/2008	10/1/2001
Hoxie Sheridan County Airport	1F5	17-35	AC	4,400.00	50	220,000	A	zne1	7/21/2008	8/1/2002
Hugoton Municipal Airport	HQG	13-31	AC	2,627.00	60	157,620	A	zne1	6/19/2008	7/1/2005
Hugoton Municipal Airport	HQG	2-20	PCC	5,000.00	75	375,000	A	zne1	6/19/2008	
Hutchinson Municipal Airport	HUT	13-31	AC	7,004.00	100	700,400	A	zne2	6/9/2008	
Hutchinson Municipal Airport	HUT	17-35	AC	4,252.00	75	318,900	A	zne2	6/9/2008	
Hutchinson Municipal Airport	HUT	4-22	AC	6,000.00	100	600,000	A	zne2	6/9/2008	9/1/2000
Independence Municipal Airport	IDP	17-35	AC	5,500.00	100	550,000	A	zne3	7/1/2008	8/1/2004
Independence Municipal Airport	IDP	4-22	AC	3,400.00	60	204,000	A	zne3	7/1/2008	8/1/2003
Ingalls Municipal Airport	30K	17-35	PCC	3,000.00	75	225,000	A	zne1	7/15/2008	
Iola Allen County Airport	K88	1-19	PCC	5,500.00	100	550,000	A	zne3	6/25/2008	8/1/2006
Jetmore Municipal Airport	K79	17-35	AC	4,205.00	75	315,375	A	zne1	7/14/2008	9/1/2000

Table D.1: Inventory Report (continued)

Johnson Stanton County Municipal	2K3	17-35	PCC	4,100.00	60	246,000	A	zne1	6/20/2008	
Johnson Stanton County Municipal	2K3	8-26	AC	2,140.00	60	128,400	A	zne1	6/20/2008	
Junction City Freeman Field	3JC	18-36	AC	3,495.00	75	262,125	A	zne2	5/22/2008	7/1/2000
Kingman Municipal Airport	9K8	11-29	PCC	3,400.00	60	204,000	A	zne2	7/10/2008	10/1/2001
Kingman Municipal Airport	9K8	18-36	PCC	4,300.00	75	322,500	A	zne2	7/10/2008	10/1/2001
Kinsley Municipal Airport	33K	18-36	AC	3,290.00	56	184,240	A	zne1	6/17/2008	
La Crosse Rush County Airport	K94	17-35	AC	3,200.00	50	160,000	A	zne1	7/14/2008	4/1/2000
Lakin Airport	36K	14-32	AC	3,400.00	40	136,000	A	zne1	7/16/2008	8/1/2002
Larned Pawnee County Airport	LQR	17-35	PCC	4,200.00	75	315,000	A	zne1	6/17/2008	8/1/2001
Lawrence Municipal Airport	LWC	15-33	AC	5,700.00	100	570,000	A	zne2	6/27/2008	8/1/1992
Lawrence Municipal Airport	LWC	1-19	PCC	3,900.00	75	292,500	A	zne2	6/27/2008	8/1/2004
Leoti Mark Howard Memorial Airport	3K7	17-35	AC	4,300.00	50	215,000	A	zne1	7/23/2008	7/1/2003
Leoti Mark Howard Memorial Airport	3K7	8-26	AC	2,450.00	38	93,100	A	zne1	7/24/2008	7/1/2003
Liberal Mid-America Rgnl Airport	LBL	4-22	PCC	5,721.00	150	858,150	A	zne1	6/18/2008	
Liberal Mid-America Rgnl Airport	LBL	17-35	PCC	7,105.00	100	710,500	A	zne1	6/18/2008	8/1/2006
Lucas Airport	38K	17-35	AC	2,904.00	50	145,200	A	zne2	6/10/2008	6/1/2004
Lyons Rice County Airport	LYO	17-35	AC	3,000.00	50	150,000	A	zne2	6/16/2008	
Manhattan Regional Airport	MHK	13-31	AC	3,800.00	100	380,000	A	zne2	5/22/2008	
Manhattan Regional Airport	MHK	3-32	PCC	7,000.00	150	1,050,000	A	zne2	5/22/2008	

Table D.1: Inventory Report (continued)

Mankato Airport	TKO	17-35	AC	3,540.00	50	177,000	A	zne2	6/4/2008	7/1/2001
Marion Municipal Airport	43K	17-35	AC	2,573.00	40	102,920	A	zne2	6/2/2008	
Marysville Municipal	MYZ	15-33	AC	4,200.00	60	252,000	A	zne2	5/23/2008	
McPherson Airport	MPR	18-36	PCC	5,500.00	100	550,000	A	zne2	6/9/2008	5/1/1994
Meade Municipal Airport	MEJ	17-35	PCC	4,800.00	75	360,000	A	zne1	6/18/2008	
Medicine Lodge Airport	K51	16-34	AC	3,200.00	42	134,400	A	zne2	7/9/2008	
Minneapolis City/County Airport	45K	16-34	AC	3,970.00	50	198,500	A	zne2	5/27/2008	8/1/2004
Moline Elk County Airport	2K6	18-36	AC	2,510.00	40	100,400	A	zne3	6/30/2008	
Moundridge Municipal Airport	47K	17-35	AC	3,405.00	50	170,250	A	zne2	6/5/2008	8/1/1999
Neodesha Municipal Airport	2K7	2-20	AC	2,998.00	46	137,908	A	zne3	6/30/2008	
Ness City Municipal Airport	48K	17-35	AC	3,156.00	48	151,488	A	zne1	7/24/2008	1/1/2003
Newton City-County Airport	EWK	17-35	AC	7,003.00	100	700,300	A	zne2	6/5/2008	5/1/2002
Newton City-County Airport	EWK	8-26	AC	3,501.00	60	210,060	A	zne2	6/12/2008	5/1/2004
Norton Municipal Airport	NRN	16-34	PCC	4,700.00	60	282,000	A	zne1	7/21/2008	9/1/2000
Oakley Municipal Airport	OEL	16-34	AC	5,000.00	75	375,000	A	zne1	7/22/2008	
Oberlin Municipal Airport	OIN	17-35	AC	3,793.00	50	189,650	A	zne1	7/21/2008	5/1/2002
Olathe Johnson County Executive	OJC	18-36	PCC	4,098.00	75	307,350	A	zne2	7/28/2008	7/1/1996
Olathe New Century Aircenter	IXD	4-22	AC	5,130.00	100	513,000	A	zne2	6/26/2008	
Olathe New Century Aircenter	IXD	18-36	AC	7,339.00	150	1,100,850	A	zne2	6/26/2008	5/1/2005

Table D.1: Inventory Report (continued)

Osage City Municipal Airport	53K	17-35	AC	2,560.00	40	102,400	A	zne2	6/3/2008	6/1/2001
Osborne Municipal Airport	K75	2-20	AC	4,000.00	60	240,000	A	zne2	6/6/2008	
Oswego Municipal Airport	K67	17-35	AC	2,500.00	50	125,000	A	zne4	7/1/2008	8/1/2000
Ottawa Municipal Airport	OWI	17-35	AC	4,500.00	75	337,500	A	zne2	6/27/2008	5/1/1998
Oxford Municipal Airport	55K	17-35	AC	3,380.00	60	202,800	A	zne2	7/3/2008	
Paola Miami County Airport	K81	3-21	AC	3,400.00	60	204,000	A	zne2	6/27/2008	5/1/1999
Parsons Tri-City Airport	PPF	17-35	PCC	5,000.00	75	375,000	A	zne3	7/1/2008	5/1/2006
Phillipsburg Municipal Airport	PHG	13-31	AC	4,503.00	60	270,180	A	zne1	7/21/2008	2/1/2001
Pittsburg Atkinson Municipal	PTS	16-34	AC	5,500.00	100	550,000	A	zne4	7/2/2008	5/1/1994
Pittsburg Atkinson Municipal	PTS	4-22	AC	4,000.00	75	300,000	A	zne4	7/2/2008	8/1/2005
Pleasanton Gilmore Airport	57K	3-21	AC	2,870.00	35	100,450	A	zne4	6/11/2008	
Pratt Industrial Airport	PTT	17-35	PCC	5,500.00	100	550,000	A	zne2	7/9/2008	7/1/2005
Rose Hill Cook Airfield	K50	17-35	AC	2,507.00	40	100,280	A	zne2	7/7/2008	9/1/2004
Russell Municipal Airport	RSL	16-34	PCC	5,000.00	75	375,000	A	zne2	6/16/2008	10/1/2005
Sabetha Municipal Airport	K83	1-19	AC	3,100.00	40	124,000	A	zne2	6/12/2008	8/1/2001
Saint Francis Cheyenne Co. Airport	SYF	32L-14R	AC	3,138.00	50	156,900	A	zne1	7/22/2008	5/1/2006
Salina Municipal Airport	SLN	12-30	AC	6,510.00	100	651,000	A	zne2	7/31/2008	
Salina Municipal Airport	SLN	17-35	AC	12,300.00	150	1,845,00 0	A	zne2	6/13/2008	
Salina Municipal Airport	SLN	18-36	AC	4,300.00	75	322,500	A	zne2	7/29/2008	7/1/2006

Table D.1: Inventory Report (continued)

Salina Municipal Airport	SLN	4-22	AC	3,648.00	75	273,600	A	zne2	7/29/2008	
Satanta Municipal Airport	1K9	3-21	AC	3,250.00	40	130,000	A	zne1	6/18/2008	7/1/2000
Scott City Municipal Airport	TQK	17-35	AC	4,999.00	75	374,925	A	zne1	7/23/2008	8/1/1993
Smith Center Municipal Airport	K82	17-35	AC	3,600.00	50	180,000	A	zne2	6/5/2008	7/1/2000
Sublette Flying Club Airport	19S	17-35	AC	4,500.00	60	270,000	A	zne1	6/18/2008	8/1/2002
Syracuse Hamilton County Municipal	3K3	13-31	AC	3,000.00	40	120,000	A	zne1	7/16/2008	11/1/2001
Syracuse Hamilton County Municipal	3K3	18-36	PCC	4,600.00	75	345,000	A	zne1	7/16/2008	12/1/2006
Topeka Billard Municipal Airport	TOP	18-36	AC	4,331.00	75	324,825	A	zne2	7/30/2008	8/1/2006
Topeka Billard Municipal Airport	TOP	13-31	AC	5,100.00	100	510,000	A	zne2	7/30/2008	8/1/2005
Topeka Billard Municipal Airport	TOP	4-22	AC	3,002.00	100	300,200	A	zne2	7/30/2008	
Topeka Forbes Field	FOE	13-31	PCC	12,802.00	150	1,920,300	A	zne2	7/17/2008	
Topeka Forbes Field	FOE	3-21	PCC	7,000.00	150	1,050,000	A	zne2	7/17/2008	6/1/1997
Tribune Municipal Airport	5K2	17-35	PCC	5,000.00	60	300,000	A	zne1	7/23/2008	10/1/2004
Ulysses Airport	ULS	17-35	PCC	6,000.00	100	600,000	A	zne1	6/20/2008	8/1/1995
Ulysses Airport	ULS	12-30	PCC	4,600.00	60	276,000	A	zne1	6/20/2008	8/1/2001
Wakeeney Trego County Airport	0H1	17-35	AC	4,000.00	50	200,000	A	zne1	7/24/2008	
Wamego Municipal Airport	69K	17-35	AC	3,184.00	45	143,280	A	zne2	5/23/2008	10/1/2001
Washington County Memorial	K38	17-35	PCC	3,400.00	60	204,000	A	zne2	5/23/2008	9/1/2004
Wellington Municipal	EGT	17-35	PCC	4,201.00	100	420,100	A	zne2	7/3/2008	8/1/2002

Table D.1: Inventory Report (continued)

Wichita Cessna Aircraft	CEA	17-35	AC	3,873.00	40	154,920	A	zne2	7/7/2008	5/1/2007
Wichita Jabara Airport	AAO	18-36	PCC	6,101.00	100	610,100	A	zne2	7/7/2008	8/1/2005
Wichita Riverside Airport	K32	16-34	AC	3,200.00	40	128,000	A	zne2	7/8/2008	6/1/2002
Wichita Westport Airport	71K	17-35	AC	2,520.00	30	75,600	A	zne2	7/7/2008	11/1/2007
Winfield Strother Field Airport	WLD	13-31	AC	3,137.00	75	235,275	A	zne2	7/3/2008	
Winfield Strother Field Airport	WLD	17-35	AC	5,506.00	100	550,600	A	zne2	7/3/2008	8/1/1998

APPENDIX E

CONDITION PREDICTION REPORT

Table E.1: Condition Prediction Report

Branch name	Branch ID	2008	2009	2010	2011	2012	2013
ALL	ALL	76	74	72	71	70	69
Abilene Municipal Airport	K78	73	71	70	69	69	69
Anthony Municipal Airport	ANY	39	38	36	35	34	33
Atchison Amelia Earhart Airport	K59	54	53	51	50	49	48
Atwood - Rawlins Co. Airport	ADT	94	89	85	81	77	74
Augusta Municipal Airport	3AU	47	46	44	43	42	41
Belleville Municipal Airport	RPB	85	81	77	75	72	71
Beloit Moritz Memorial Airport	K61	93	91	90	90	89	89
Benton Lloyd Stearman Field	1K1	92	88	83	80	76	74
Burlington Coffey County Airport	UKL	85	84	83	82	81	81
Chanute Martin Johnson Airport	CNU	83	79	76	74	72	70
Cimarron Municipal Airport	8K8	80	76	74	72	70	69
Clay Center Municipal	CYW	53	52	50	49	48	47
Coffeyville Municipal	CFV	69	67	66	65	64	64
Colby Shaltz Field	CBK	82	81	81	80	80	80
Coldwater Comanche County Airport	3K8	87	86	85	85	84	83
Concordia Blosser Municipal	CNK	91	86	82	79	75	73

Table E.1: Condition Prediction Report (continued)

Dighton Airport	K65	74	72	70	70	69	69
Dodge City Regional	DDC	74	72	71	70	69	69
El Dorado Captain Jack Thomas	EQA	83	81	79	77	75	74
Elkhart Morton County Airport	EHA	70	68	67	66	65	64
Ellsworth Municipal Airport	9K7	91	87	82	79	76	73
Emporia Municipal Airport	EMP	60	59	57	56	55	54
Eureka Municipal Airport	13K	57	56	54	53	52	51
Fredonia Airport	1K7	88	87	87	86	85	85
Ft. Leavenworth Sherman AAF	FLV	64	63	62	60	59	58
Ft. Scott Municipal Airport	FSK	58	57	55	54	53	52
Garden City Regional Airport	GCK	86	85	85	84	84	84
Gardner Municipal Airport	K34	91	87	83	79	76	73
Garnett Municipal Airport	K68	58	57	55	54	53	52
Goodland Renner Field	GLD	77	76	76	75	75	74
Great Bend Municipal Airport	GBD	66	64	62	60	59	58
Harper Municipal Airport	8K2	71	70	69	69	69	69
Hays Regional Airport	HYS	87	84	82	81	79	78
Herington Regional Airport	HRU	98	95	93	92	91	90
Hill City Municipal Airport	HLC	94	92	91	90	90	89

Table E.1: Condition Prediction Report (continued)

Hillsboro Municipal Airport	M66	75	73	71	70	69	69
Hoxie Sheridan County Airport	1F5	70	69	69	69	69	69
Hugoton Municipal Airport	HQG	82	79	78	76	75	74
Hutchinson Municipal Airport	HUT	52	51	50	49	48	47
Independence Municipal Airport	IDP	74	71	69	67	66	65
Ingalls Municipal Airport	30K	57	56	56	56	55	55
Iola Allen County Airport	K88	87	86	85	85	84	83
Jetmore Municipal Airport	K79	75	72	71	70	69	69
Johnson Stanton County Municipal	2K3	69	68	67	66	65	64
Junction City Freeman Field	3JC	81	77	75	72	71	70
Kingman Municipal Airport	9K8	95	93	92	91	90	89
Kinsley Municipal Airport	33K	41	40	38	37	36	35
La Crosse Rush County Airport	K94	74	72	70	70	69	69
Lakin Airport	36K	62	61	60	58	57	56
Larned Pawnee County Airport	LQR	87	86	85	84	84	83
Lawrence Municipal Airport	LWC	81	80	80	79	79	79
Leoti Mark Howard Memorial Airport	3K7	85	81	77	74	72	71
Liberal Mid-America Rgnl Airport	LBL	79	78	77	76	76	75
Lucas Airport	38K	80	77	74	72	70	70

Table E.1: Condition Prediction Report (continued)

Lyons Rice County Airport	LYO	54	53	51	50	49	48
Manhattan Regional Airport	MHK	71	70	69	68	67	67
Mankato Airport	TKO	87	83	79	76	73	71
Marion Municipal Airport	43K	76	74	72	70	69	69
Marysville Municipal	MYZ	92	87	83	79	76	73
McPherson Airport	MPR	88	87	87	86	85	84
Meade Municipal Airport	MEJ	86	85	84	83	82	81
Medicine Lodge Airport	K51	63	62	60	59	58	57
Minneapolis City/County Airport	45K	94	89	85	81	77	75
Moline Elk County Airport	2K6	59	58	56	55	54	53
Moundridge Municipal Airport	47K	81	78	75	72	71	70
Neodesha Municipal Airport	2K7	76	74	72	70	70	69
Ness City Municipal Airport	48K	75	72	71	70	69	69
Newton City-County Airport	EWK	67	65	63	61	59	58
Norton Municipal Airport	NRN	93	91	90	90	89	89
Oakley Municipal Airport	OEL	56	55	54	52	51	50
Oberlin Municipal Airport	OIN	70	69	69	69	69	69
Olathe Johnson County Executive	OJC	89	89	89	88	88	87
Olathe New Century Aircenter	IXD	69	67	64	61	59	57

Table E.1: Condition Prediction Report (continued)

Osage City Municipal Airport	53K	54	53	51	50	49	48
Osborne Municipal Airport	K75	76	74	72	70	69	69
Oswego Municipal Airport	K67	76	73	71	70	69	69
Ottawa Municipal Airport	OWI	70	69	69	69	69	68
Oxford Municipal Airport	55K	53	52	50	49	48	47
Paola Miami County Airport	K81	78	75	73	71	70	69
Parsons Tri-City Airport	PPF	94	92	91	90	90	89
Phillipsburg Municipal Airport	PHG	63	62	61	59	58	57
Pittsburg Atkinson Municipal	PTS	87	84	80	77	75	73
Pleasanton Gilmore Airport	57K	7	6	4	3	2	1
Pratt Industrial Airport	PTT	95	93	91	90	90	89
Rose Hill Cook Airfield	K50	79	76	74	72	70	69
Russell Municipal Airport	RSL	93	91	90	90	89	89
Sabetha Municipal Airport	K83	75	73	71	70	69	69
Saint Francis Cheyenne Co. Airport	SYF	80	76	74	72	70	69
Salina Municipal Airport	SLN	73	70	68	66	65	63
Satanta Municipal Airport	1K9	73	71	70	69	69	69
Scott City Municipal Airport	TQK	63	62	61	59	58	57
Smith Center Municipal Airport	K82	62	61	59	58	57	56

Table E.1: Condition Prediction Report (continued)

Sublette Flying Club Airport	19S	82	78	75	73	71	70
Syracuse Hamilton County Municipal	3K3	85	83	81	80	80	79
Topeka Billard Municipal Airport	TOP	82	79	76	73	70	68
Topeka Forbes Field	FOE	68	67	67	67	66	66
Tribune Municipal Airport	5K2	90	89	89	89	89	88
Ulysses Airport	ULS	92	91	90	89	89	88
Wakeeney Trego County Airport	0H1	71	70	69	69	69	69
Wamego Municipal Airport	69K	70	69	69	69	69	68
Washington County Memorial	K38	93	91	90	90	89	89
Wellington Municipal	EGT	96	93	92	91	90	90
Wichita Cessna Aircraft	CEA	97	93	89	84	80	77
Wichita Jabara Airport	AAO	91	90	90	89	89	89
Wichita Riverside Airport	K32	84	80	77	74	72	71
Wichita Westport Airport	71K	82	79	76	73	71	70
Winfield Strother Field Airport	WLD	72	69	68	67	66	65

APPENDIX F

BUDGET PREDICTION REPORT

Table F.1: Budget Prediction Report Scenario #1

BUDGET SCENARIO #1						
Airport	**Section**	**2009**	**2010**	**2011**	**2012**	**2015**
Abilene Municipal	17-35	Preventive $13569 Before: 71 After: 72	Preventive $15119 Before: 70 After: 70	Major $559653 Before: 69 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91
Anthony Municipal	17-35	Major $1228260 Before: 38 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91	Preventive $641 Before: 87 After: 87	Preventive $1516 Before: 83 After: 83
Atchison Amelia Earhart	16-34	Major $582202 Before: 53 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91	Do Nothing Before: 87 After: 87	Do Nothing Before: 83 After: 83
Atwood - Rawlins County	16-36	Do Nothing Before: 91 After: 91	Preventive $1335 Before: 86 After: 87	Preventive $2839 Before: 82 After: 83	Preventive $5523 Before: 79 After: 79	Preventive $10128 Before: 76 After: 76
Augusta Municipal	18-36	Major $1232666 Before: 46 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91	Preventive $747 Before: 87 After: 87	Preventive $1768 Before: 83 After: 83
Belleville Municipal	18-36	Preventive $1572 Before: 83 After: 83	Preventive $3020 Before: 79 After: 79	Preventive $5615 Before: 76 After: 76	Preventive $7717 Before: 73 After: 73	Preventive $9287 Before: 71 After: 72
Chanute Martin Johnson	18-36	Preventive $2877 Before: 81 After: 81	Preventive $6296 Before: 78 After: 78	Preventive $9929 Before: 75 After: 75	Preventive $12781 Before: 72 After: 73	Preventive $14836 Before: 71 After: 71
Cimarron Municipal	1-19	Preventive $1963 Before: 77 After: 78	Preventive $3073 Before: 75 After: 75	Preventive $3943 Before: 72 After: 73	Preventive $4570 Before: 71 After: 71	Major $174922 Before: 69 After: 100
Clay Center Municipal	17-35	Major $1323244 Before: 52 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91	Do Nothing Before: 87 After: 87	Do Nothing Before: 83 After: 83
Coffeyville Municipal	17-35	Preventive $23897 Before: 72 After: 72	Preventive $27565 Before: 71 After: 71	Major $1047399 Before: 70 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91
Coffeyville Municipal	4-22	Preventive $25343 Before: 63 After: 63	Preventive $27041 Before: 62 After: 62	Major $871392 Before: 61 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91

Table F.1: Budget Prediction Report Scenario #1 (continued)

Concordia Blosser Municipal	17-35	Preventive $395 Before: 88 After: 88	Preventive $1289 Before: 84 After: 84	Preventive $2106 Before: 80 After: 80	Preventive $4806 Before: 77 After: 77	Preventive $7159 Before: 74 After: 74
Dodge City Regional	14-32	Preventive $26101 Before: 73 After: 73	Preventive $31015 Before: 71 After: 71	Preventive $34283 Before: 70After: 70	Major $1262396 Before: 69 After: 100	Do Nothing Before: 96 After: 96
Dodge City Regional	2-20	Preventive $17586 Before: 73 After: 73	Preventive $20897 Before: 71 After: 71	Preventive $23099 Before: 70 After: 70	Major $850562 Before: 69 After: 100	Do Nothing Before: 96 After: 96
El Dorado Captain Jack Thomas	4-22	Preventive $1992 Before: 84 After: 84	Preventive $3233 Before: 80 After: 80	Preventive $7332 Before: 77 After: 77	Preventive $10708 Before: 74 After: 74	Preventive $13292 Before: 72 After: 72
Elkhart Morton County	17-35	Preventive $11107 Before: 73 After: 73	Preventive $13207 Before: 71 After: 71	Preventive $14605 Before: 70 After: 70	Major $537806 Before: 69 After: 100	Do Nothing Before: 96 After: 96
Elkhart Morton County	4-22	Preventive $22346 Before: 65 After: 65	Preventive $24008 Before: 64 After: 64	Major $791692 Before: 62 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91
Ellsworth Municipal	17-35	Preventive $325 Before: 88 After: 89	Preventive $1138 Before: 84 After: 84	Preventive $1882 Before: 80 After: 81	Preventive $4265 Before: 77 After: 77	Preventive $6419 Before: 74 After: 74
Emporia Municipal	1-19	Preventive $52464 Before: 59 After: 59	Major $1661617 Before: 58 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91	Do Nothing Before: 87 After: 87
Eureka Municipal	18-36	Do Nothing Before: 56 After: 56	Major $790832 Before: 55 After: 100	Do Nothing Before: 91 After: 91	Preventive $623 Before: 87 After: 87	Preventive $1475 Before: 83 After: 83
Ft. Scott Municipal	18-36	Do Nothing Before: 57 After: 57	Major $1191870 Before: 56 After: 100	Do Nothing Before: 92 After: 92	Preventive $979 Before: 87 After: 87	Preventive $2317 Before: 83 After: 83
Gardner Municipal	8-26	Preventive $156 Before: 89 After: 89	Preventive $599 Before: 84 After: 85	Preventive $1006 Before: 81 After: 81	Preventive $2259 Before: 77 After: 77	Preventive $3442 Before: 74 After: 75
Garnett Municipal	1-19	Do Nothing Before: 57 After: 57	Major $390893 Before: 56 After: 100	Do Nothing Before: 96 After: 95	Do Nothing Before: 91 After: 91	Do Nothing Before: 87 After: 87
Goodland Renner Field	5-23	Preventive $13785 Before: 70 After: 70	Preventive $14219 Before: 69 After: 69	Major $489056 Before: 69 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91
Great Bend Municipal	11-29	Major $1529602 Before: 51 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91	Do Nothing Before: 87 After: 87	Do Nothing Before: 83 After: 83

Table F.1: Budget Prediction Report Scenario #1 (continued)

Great Bend Municipal	17-35	Preventive $13767 Before: 78 After: 78	Preventive $23035 Before: 75 After: 75	Preventive $30380 Before: 73 After: 73	Preventive $35777 Before: 71 After: 71	Major $1387081 Before: 70 After: 100
Hays Regional	16-34	Preventive $4571 Before: 83 After: 83	Preventive $8327 Before: 79 After: 79	Preventive $16526 Before: 76 After: 76	Preventive $2319 7 Before: 74 After: 74	Preventive $28226 Before: 71 After: 72
Hugoton Municipal	13-31	Preventive $1619 Before: 80 After: 80	Preventive $3671 Before: 77 After: 77	Preventive $5354 Before: 74 After: 74	Preventive $6648 Before: 72 After: 72	Preventive $7553 Before: 71 After: 71
Hutchinson Municipal	13-31	Major $3147959 Before: 50 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91	Do Nothing Before: 87 After: 87	Preventive $2077 Before: 87 After: 87
Hutchinson Municipal	17-35	Major $1465774 Before: 49 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91	Do Nothing Before: 87 After: 87	Preventive $2238 Before: 83 After: 83
Hutchinson Municipal	4-22	Preventive $71902 Before: 56 After: 56	Major $2262208 Before: 55 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91	Do Nothing Before: 87 After: 87
Independen ce Municipal	17-35	Preventive $36459 Before: 67 After: 67	Preventive $41308 Before: 65 After: 65	Major $1390931 Before: 64 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91
Independen ce Municipal	4-22	Preventive $4187 Before: 77 After: 77	Preventive $6481 Before: 75 After: 75	Preventive $8269 Before: 72 After: 72	Preventive $9552 Before: 71 After: 71	Major $364810 Before:70 After: 100
Johnson Stanton County Municipal	8-26	Major $518635 Before: 53 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91	Do Nothing Before: 87 After: 87	Do Nothing Before: 83 After: 83
Junction City Freeman Field	18-36	Preventive $3916 Before: 79 After: 79	Preventive $7124 Before: 76 After: 76	Preventive $9707 Before: 73 After: 73	Preventive $11639 Before: 71 After: 71	Preventive $12934 Before: 70 After: 70
Lakin	14-32	Preventive $12817 Before: 61 After: 61	Major $408342 Before: 60 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91	Do Nothing Before: 87 After: 87
Lawrence Municipal	15-33	Preventive $28302 Before: 70 After: 70	Preventive $30166 Before: 69 After: 69	Major $1059289 Before: 69 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91
Leoti Mark Howard Memorial	17-35	Preventive $1491 Before: 83 After: 83	Preventive $2679 Before: 79 After: 80	Preventive $5400 Before: 76 After: 76	Preventive $7619 Before: 74 After: 74	Preventive $9296 Before: 72 After: 72
Leoti Mark Howard Memorial	8-26	Preventive $818 Before: 81 After: 81	Preventive $1763 Before: 78 After: 78	Preventive $2837 Before: 75 After: 75	Preventive $3684 Before: 73 After: 73	Preventive $4298 Before: 71 After: 71

Table F.1: Budget Prediction Report Scenario #1 (continued)

Lyons Rice County	17-35	Major $606171 Before: 53 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91	Do Nothing Before: 87 After: 87	Do Nothing Before: 83 After: 83
Manhattan Regional	13-31	Preventive $41845 Before: 58 After: 58	Major $1322026 Before: 57 After: 100	Do Nothing Before: 96 After: 95.9	Do Nothing Before: 91 After: 91	Do Nothing Before: 87 After: 87
Marysville Municipal	15-33	Preventive $224 Before: 89 After: 89	Preventive $1279 Before: 84 After: 85	Preventive $2253 Before: 81 After: 81	Preventive $4912 Before: 78 After: 78	Preventive $7792 Before: 75 After: 75
Medicine Lodge	16-34	Preventive $12009 Before: 62 After: 62	Preventive $12770 Before: 61 After: 61	Preventive $13529 Before: 60 After: 60	Preventive $14291 Before: 59 After: 59	Preventive $15051 Before: 58 After: 58
Ness City Municipal	17-35	Preventive $5595 Before: 73 After: 73	Preventive $6713 Before: 71 After: 71	Preventive $7468 Before: 70 After: 70	Major $276318 Before: 69 After: 100	Do Nothing Before: 96 After: 95
Newton City-County	17-35	Major $3043814 Before: 51 After: 100	Do Nothing Before: 96 After: 95	Do Nothing Before: 91 After: 91	Do Nothing Before: 87 After: 87	Do Nothing Before: 83 After: 83
Newton City-County	8-26	Preventive $1938 Before: 81 After: 81	Preventive $4292 Before: 77 After: 78	Preventive $6656 Before: 75 After: 75	Preventive $8507 Before: 73 After: 73	Preventive $9830 Before: 71 After: 71
Oakley Municipal	16-34	Preventive $46554 Before: 55 After: 55	Major $1462360 Before: 54 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91	Do Nothing Before: 87 After: 87
Oberlin Municipal	17-35	Do Nothing Before: 70 After: 70	Do Nothing Before: 69 After: 69	Major $353331 Before: 69 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91
Olathe New Century Aircenter	18-36	Do Nothing Before: 91 After: 91	Preventive $4256 Before: 86 After: 86	Preventive $8646 Before: 82 After: 82	Preventive $17302 Before: 79 After: 79	Preventive $30635 Before: 76 After: 76
Olathe New Century Aircenter	4-22	Major $2560326 Before: 45 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91	Preventive $1521 Before: 87 After: 87	Preventive $3600 Before: 83 After: 83
Osage City Municipal	17-35	Major $414454 Before: 53 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91	Do Nothing Before: 87 After: 87	Do Nothing Before: 83 After: 83
Oswego Municipal	17-35	Preventive $4277 Before: 74 After: 74	Preventive $5294 Before: 72 After: 72	Preventive $6003 Before: 70 After: 71	Major $225624 Before:70 After: 100	Do Nothing Before: 96 After: 96
Ottawa Municipal	17-35	Preventive $17784 Before: 69 After: 69	Preventive $18301 Before: 69 After: 69	Major $628791 Before: 69 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91

Table F.1: Budget Prediction Report Scenario #1 (continued)

Paola Miami County	3-21	Preventive $4927 Before: 76 After: 77	Preventive $7071 Before: 74 After: 74	Preventive $8706 Before: 72 After: 72	Preventive $9847 Before: 70 After: 70	Major $369403 Before: 70 After: 100
Phillipsburg Municipal	13-31	Preventive $24090 Before: 62 After: 62	Preventive $25617 Before: 61 After: 61	Major $817547 Before: 60 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91
Pittsburg Atkinson Municipal	16-34	Preventive $13193 Before: 77 After: 77	Preventive $18991 Before: 74 After: 74	Preventive $23425 Before: 72 After: 72	Preventive $26512 Before: 70 After: 70	Major $995416 Before: 69 After: 100
Pittsburg Atkinson Municipal	4-22	Do Nothing Before: 93 After: 93	Preventive $231 Before: 89 After: 89	Preventive $1488 Before: 85 After: 85	Preventive $2656 Before: 81 After: 81	Preventive $5746 Before: 77 After: 78
Sabetha Municipal	1-19	Preventive $4305 Before: 74 After: 74	Preventive $5297 Before: 72 After: 72	Preventive $5986 Before: 70 After: 70	Major $224285 Before: 69 After: 100	Do Nothing Before: 96 After: 96
Saint Francis Cheyenne County	14R-32L	Preventive $3103 Before: 77 After: 77	Preventive $4889 Before: 75 After: 75	Preventive $6288 Before: 72 After: 73	Preventive $7300 Before: 71 After: 71	Major $279785 Before: 69 After: 100
Salina Municipal	12-30	Preventive $21750 Before: 74 After: 74	Preventive $27177 Before: 72 After: 72	Preventive $31009 Before: 71 After: 71	Major $1170974 Before: 70 After: 100	Do Nothing Before: 96 After: 96
Salina Municipal	17-35	Preventive $156393 Before: 63 After: 63	Preventive $166835 Before: 62 After: 62	Major $5372396 Before: 61 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91
Salina Municipal	18-36	Preventive $23 Before: 90 After: 90	Preventive $1384 Before: 85 After: 86	Preventive $2657 Before: 82 After: 82	Preventive $5499 Before: 78 After: 78	Preventive $9329 Before: 75 After: 75
Salina Municipal	4-22	Preventive $29830 Before: 58 After: 58	Major $942896 Before: 57 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91	Do Nothing Before: 87 After: 87
Satanta Municipal	3-21	Preventive $5725 Before: 71 After: 72	Preventive $6386 Before: 70 After: 70	Major $236492 Before: 69 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91
Scott City Municipal	17-35	Preventive $33417 Before: 62. After: 62	Preventive $35536 Before: 61 After: 61	Major $1134138 Before: 60 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 92 After: 92
Smith Center Municipal	17-35	Preventive $17082 Before: 61 After: 61	Major $544008 Before: 60 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91	Do Nothing Before: 87 After: 87
Syracuse Hamilton County Municipal	13-31	Preventive $4058 Before: 74 After: 74	Preventive $5048 Before: 72 After: 72	Preventive $5741 Before: 71 After: 71	Major $216230 Before: 69 After: 100	Do Nothing Before: 96 After: 96

Table F.1: Budget Prediction Report Scenario #1 (continued)

Topeka Billard Municipal	13-31	Do Nothing Before: 91 After: 91	Preventive $1768 Before: 87 After: 87	Preventive $3817 Before: 82 After: 83	Preventive $7351 Before: 79 After: 79	Preventive $13643 Before: 76 After: 76
Topeka Billard Municipal	18-36	Preventive $344 Before: 89 After: 89	Preventive $1700 Before: 85 After: 85	Preventive $2954 Before: 81 After: 81	Preventive $6509 Before: 77 After: 78	Preventive $10188 Before: 75 After: 75
Topeka Billard Municipal	4-22	Preventive $28224 Before: 61 After: 61	Preventive $29918 Before: 60 After: 60	Major $952115 Before: 59 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91
Wakeeney Trego County	17-35	Preventive $9873 Before: 70 After: 70	Preventive $10551 Before: 69 After: 69	Major $371450 Before: 69 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91
Winfield Strother Field	13-31	Preventive $8038 Before: 74 After: 74	Preventive $9955 Before: 72 After: 72	Preventive $11295 Before: 70 After: 71	Major $424574 Before: 70 After: 100	Do Nothing Before: 96 After: 96
Winfield Strother Field	17-35	Preventive $36467 Before: 67 After: 67	Preventive $41336 Before: 65 After: 65	Major $1392008 Before: 64 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91

Table F.2: Budget Prediction Report Scenario #2

BUDGET SCENARIO #2						
Airport	Section	2009	2010	2011	2012	2015
Abilene Municipal	17-35	Preventive $13569 Before: 71 After: 72	Preventive $15119 Before: 70 After: 70	Preventive $16181 Before: 69 After: 69	Preventive $16670 Before: 69 After: 69	Major $572900 Before: 69 After: 100
Anthony Municipal	17-35	Major $1228260 Before: 38 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91	Preventive $641 Before: 87 After: 87	Preventive $1516 Before: 83 After: 83
Atchison Amelia Earhart	16-34	Preventive $19409 Before: 53 After: 53	Preventive $20227 Before: 52 After: 52	Preventive $21041 Before: 51 After: 51	Major $654820 Before: 50 After: 100	Do Nothing Before: 96 After: 96
Atwood - Rawlins County	16-36	Do Nothing Before: 91 After: 91	Preventive $1335 Before: 86 After: 87	Preventive $2839 Before: 82 After: 83	Preventive $5523 Before: 79 After: 79	Preventive $10128 Before: 76 After: 76
Augusta Municipal	18-36	Major $1232666 Before: 46 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91	Preventive $747 Before: 87 After: 87	Preventive $1768 Before: 83 After: 83
Belleville Municipal	18-36	Preventive $1572 Before: 83 After: 83	Preventive $3020 Before: 79 After: 79	Preventive $5615 Before: 76 After: 76	Preventive $7717 Before: 73 After: 73	Preventive $9287 Before: 71 After: 72
Chanute Martin Johnson	18-36	Preventive $2877 Before: 81 After: 81	Preventive $6296 Before: 78 After: 78	Preventive $9929 Before: 75 After: 75	Preventive $12781 Before: 72 After: 73	Preventive $14836 Before: 71 After: 71
Cimarron Municipal	1-19	Preventive $1963 Before: 77 After: 78	Preventive $3073 Before: 75 After: 75	Preventive $3943 Before: 72 After: 73	Preventive $4570 Before: 71 After: 71	Major $174922 Before: 70 After: 100
Clay Center Municipal	17-35	Preventive $44115 Before: 52 After: 52	Preventive $45900 Before: 51 After: 51	Major $1428511 Before: 50 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91
Coffeyville Municipal	17-35	Preventive $23897 Before: 72 After: 72	Preventive $27565 Before: 71 After: 71	Preventive $30010 Before: 70 After: 70	Preventive $31495 Before: 69 After: 69	Major $1093552 Before: 69 After: 100
Coffeyville Municipal	4-22	Preventive $25343 Before: 63 After: 63	Do Nothing Before: 62 After: 62	Do Nothing Before: 61 After: 61	Major $918564 Before: 60 After: 100	Do Nothing Before: 96 After: 96
Concordia Blosser Municipal	17-35	Preventive $395 Before: 88 After: 88	Preventive $1289 Before: 84 After: 84	Preventive $2106 Before: 80 After: 80	Preventive $4806 Before: 77 After: 77	Preventive $7159 Before: 74 After: 74

Table F.2: Budget Prediction Report Scenario #2 (continued)

Dodge City Regional	14-32	Preventive $26101 Before: 73 After: 73	Preventive $31015 Before: 71 After: 71	Preventive $34283 Before: 70 After: 70	Preventive $36540 Before: 69 After: 69	Major $1283075 Before: 69 After: 100
Dodge City Regional	2-20	Preventive $17586 Before: 73 After: 73	Preventive $20897 Before: 71 After: 71	Preventive $23099 Before: 70 After: 70	Preventive $24619 Before: 69 After: 69	Major $864495 Before: 69 After: 100
El Dorado Captain Jack Thomas	4-22	Preventive $1992 Before: 84 After: 84	Preventive $3233 Before: 80 After: 80	Preventive $7332 Before: 77 After: 77	Preventive $10708 Before: 74 After: 74	Preventive $13292 Before: 72 After: 72
Elkhart Morton County	17-35	Preventive $11107 Before: 73 After: 73	Preventive $13207 Before: 71 After: 71	Preventive $14605 Before: 70 After: 70	Preventive $15562 Before: 69 After: 69	Major $546682 Before: 69 After: 100
Elkhart Morton County	4-22	Preventive $22346 Before: 65 After: 65	Preventive $24008 Before: 64 After: 64	Preventive $25670 Before: 63 After: 63	Preventive $27336 Before: 61 After: 61	Major $877967 Before: 60 After: 100
Ellsworth Municipal	17-35	Preventive $325 Before: 88 After: 89	Preventive $1138 Before: 84 After: 84	Preventive $1882 Before: 80 After: 81	Preventive $4265 Before: 77 After: 77	Preventive $6419 Before: 74 After: 74
Emporia Municipal	1-19	Preventive $52464 Before: 59 After: 59	Do Nothing Before: 58 After: 58	Do Nothing Before: 57 After: 57	Major $1837687 Before: 56 After: 100	Do Nothing Before: 96 After: 96
Eureka Municipal	18-36	Do Nothing Before: 56 After: 56	Do Nothing Before: 55 After: 55	Do Nothing Before: 54 After: 54	Major $864843 Before: 53 After: 100	Do Nothing Before: 96 After: 96
Ft. Scott Municipal	18-36	Do Nothing Before: 57 After: 57	Do Nothing Before: 56 After: 56	Do Nothing Before: 55 After: 55	Major $1308152 Before: 53 After: 100	Do Nothing Before: 96 After: 96
Gardner Municipal	8-26	Preventive $156 Before: 89 After: 89	Preventive $599 Before: 84 After: 85	Preventive $1006 Before: 81 After: 81	Preventive $2259 Before: 77 After: 77	Preventive $3442 Before: 74 After: 75
Garnett Municipal	1-19	Do Nothing Before: 57 After: 57	Do Nothing Before: 56 After: 56	Do Nothing Before: 55 After: 55	Major $428924 Before: 54 After: 100	Do Nothing Before: 96 After: 96
Goodland Renner Field	5-23	Preventive $13785 Before: 70 After: 70	Preventive $14219 Before: 69 After: 69	Preventive $14312 Before: 69 After: 69	Preventive $14337 Before: 69 After: 69	Major $499305 Before: 69 After: 100
Great Bend Municipal	11-29	Preventive $50994 Before: 51 After: 51	Preventive $53107 Before: 50 After: 50	Major $1630864 Before: 49 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91
Great Bend Municipal	17-35	Preventive $13767 Before: 78 After: 78	Preventive $23035 Before: 75 After: 75	Preventive $30380 Before: 73 After: 73	Preventive $35777 Before: 71 After: 71	Major $1387081 Before: 70 After: 100

Table F.2: Budget Prediction Report Scenario #2 (continued)

Hays Regional	16-34	Preventive $4571 Before: 83 After: 83	Preventive $8327 Before: 79 After: 79	Preventive $16526 Before: 76 After: 76	Preventive $23197 Before: 74 After: 74	Preventive $28226 Before: 72 After: 72
Hugoton Municipal	13-31	Preventive $1619 Before: 80 After: 80	Preventive $3671 Before: 77 After: 77	Preventive $5354 Before: 74 After: 74	Preventive $6648 Before: 72 After: 72	Preventive $7553 Before: 71 After: 71
Hutchinson Municipal	13-31	Preventive $104944 Before: 50 After: 50	Major $3231340 Before: 49 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91	Preventive $2077 Before: 87 After: 87
Hutchinson Municipal	17-35	Major $1465774 Before: 49 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91	Preventive $946 Before: 87 After: 87	Preventive $2238 Before: 83 After: 83
Hutchinson Municipal	4-22	Preventive $71902 Before: 56 After: 56	Do Nothing Before: 55 After: 55	Do Nothing Before: 54 After: 54	Major $2473487 Before: 53 After: 100	Do Nothing Before: 96 After: 96
Independence Municipal	17-35	Preventive $36459 Before: 67 After: 67	Preventive $41308 Before: 65 After: 65	Preventive $44418 Before: 64 After: 65	Preventive $47536 Before: 63 After: 63	Major $1552329 Before: 61 After: 100
Independence Municipal	4-22	Preventive $4187 Before: 77 After: 77	Preventive $6481 Before: 75 After: 75	Preventive $8269 Before: 72 After: 72	Preventive $9552 Before: 71 After: 71	Major $364810 Before: 70 After: 100
Johnson Stanton County Municipal	8-26	Preventive $17290 Before: 53 After: 53	Do Nothing Before: 52 After: 52	Do Nothing Before: 51 After: 51	Major $583551 Before: 50 After: 100	Do Nothing Before: 96 After: 96
Junction City Freeman Field	18-36	Preventive $3916 Before: 79 After: 79	Preventive $7124 Before: 76 After: 76	Preventive $9707 Before: 73 After: 73	Preventive $11639 Before: 71 After: 71	Preventive $12934 Before: 70 After: 70
Lakin	14-32	Preventive $12817 Before: 61 After: 61	Do Nothing Before: 60 After: 60	Do Nothing Before: 59 After: 59	Major $456233 Before: 58 After: 100	Do Nothing Before: 96 After: 96
Lawrence Municipal	15-33	Preventive $28302 Before: 70 After: 70	Preventive $30166 Before: 69 After: 69	Preventive $30947 Before: 69 After: 69	Preventive $31078 Before: 69 After: 69	Major $1065682 Before: 69 After: 100
Leoti Mark Howard Memorial	17-35	Preventive $1491 Before: 83 After: 83	Preventive $2679 Before: 79 After: 79	Preventive $5400 Before: 76 After: 76	Preventive $7619 Before: 74 After: 74	Preventive $9296 Before: 72 After: 72
Leoti Mark Howard Memorial	8-26	Preventive $818 Before: 81 After: 81	Preventive $1763 Before: 78 After: 78	Preventive $2837 Before: 75 After: 75	Preventive $3684 Before: 73 After: 73	Preventive $4298 Before: 71 After: 71
Lyons Rice County	17-35	Preventive $20208 Before: 53 After: 53	Do Nothing Before: 52 After: 52	Do Nothing Before: 51 After: 51	Major $681911 Before: 50 After: 100	Do Nothing Before: 96 After: 96

Table F.2: Budget Prediction Report Scenario #2 (continued)

Manhattan Regional	13-31	Preventive $41845 Before: 58 After: 58	Do Nothing Before: 57 After: 57	Do Nothing Before: 56 After: 56	Major $1455838 Before: 54 After: 100	Do Nothing Before: 96 After: 96
Marysville Municipal	15-33	Preventive $224 Before: 89 After: 89	Preventive $1279 Before: 85 After: 85	Preventive $2253 Before: 81 After: 81	Preventive $4912 Before: 78 After: 78	Preventive $7792 Before: 75 After: 75
Medicine Lodge	16-34	Preventive $12009 Before: 62 After: 62	Do Nothing Before: 61 After: 61	Do Nothing Before: 60 After: 60	Major $431159 Before: 59 After: 100	Do Nothing Before: 96 After: 96
Ness City Municipal	17-35	Preventive $5595 Before: 73 After: 73	Preventive $6713 Before: 71 After: 71	Preventive $7468 Before: 70 After: 70	Preventive $7985 Before: 69 After: 69	Major $281488 Before: 69 After: 100
Newton City-County	17-35	Preventive $101474 Before: 51 After: 51	Preventive $105831 Before: 50 After: 50	Major $3243836 Before: 49 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91
Newton City-County	8-26	Preventive $1938 Before: 81 After: 81	Preventive $4292 Before: 77 After: 78	Preventive $6656 Before: 75 After: 75	Preventive $8507 Before: 72 After: 72	Preventive $9830 Before: 71 After: 71
Oakley Municipal	16-34	Preventive $46554 Before: 55 After: 55	Do Nothing Before: 54 After: 54	Do Nothing Before: 53 After: 53	Major $1594412 Before: 52 After: 100	Do Nothing Before: 96 After: 96
Oberlin Municipal	17-35	Major $343844 Before: 70 After: 100	Do Nothing Before: 95.9 After: 95.9	Do Nothing Before: 91.48 After: 91.48	Preventive $946 Before: 87 After: 87	Preventive $2238 Before: 83 After: 83
Olathe New Century Aircenter	18-36	Do Nothing Before: 91 After: 91	Preventive $4256 Before: 86 After: 86	Preventive $8646 Before: 82 After: 82	Preventive $17302 Before: 79 After: 79	Preventive $30635 Before: 76 After: 76
Olathe New Century Aircenter	4-22	Major $2560326 Before: 45 After: 100	Do Nothing Before: 96 After: 96	Do Nothing Before: 91 After: 91	Preventive $1521 Before: 87 After: 87	Preventive $3600 Before: 83 After: 83
Osage City Municipal	17-35	Preventive $13817 Before: 53 After: 53	Do Nothing Before: 52 After: 52	Do Nothing Before: 51 After: 51	Major $465945 Before: 50 After: 100	Do Nothing Before: 96 After: 96
Oswego Municipal	17-35	Preventive $4277 Before: 74 After: 74	Preventive $5294 Before: 72 After: 72	Preventive $6003 Before: 70 After: 70	Preventive $6484 Before: 70 After: 70	Major $231553 Before: 69 After: 100
Ottawa Municipal	17-35	Preventive $17784 Before: 69 After: 69	Preventive $18301 Before: 69 After: 69	Preventive $18401 Before: 69 After: 69	Do Nothing Before: 69 After: 69	Major $643488 Before: 69 After: 100
Paola Miami County	3-21	Preventive $4927 Before: 76 After: 77	Preventive $7071 Before: 74 After: 74	Preventive $8706 Before: 72 After: 72	Preventive $9847 Before: 70 After: 70	Major $369403 Before: 70 After: 100

Table F.2: Budget Prediction Report Scenario #2 (continued)

Phillipsburg Municipal	13-31	Preventive $24090 Before: 62 After: 62	Do Nothing Before: 61 After: 61	Do Nothing Before: 60 After: 60	Major $865183 Before: 59 After: 100	Do Nothing Before: 96 After: 96
Pittsburg Atkinson Municipal	16-34	Preventive $13193 Before: 77 After: 77	Preventive $18991 Before: 74 After: 74	Preventive $23425 Before: 72 After: 72	Preventive $26512 Before: 70 After: 70	Major $995416 Before: 70 After: 100
Pittsburg Atkinson Municipal	4-22	Do Nothing Before: 94 After: 94	Preventive $231 Before: 89 After: 89	Preventive $1488 Before: 85 After: 85	Preventive $2656 Before: 81 After: 81	Preventive $5746 Before: 78 After: 78
Sabetha Municipal	1-19	Preventive $4305 Before: 74 After: 74	Preventive $5297 Before: 72 After: 72	Preventive $5986 Before: 70 After: 70	Preventive $6454 Before: 70 After: 70	Major $229854 Before: 69 After: 100
Saint Francis Cheyenne County	14R-32L	Preventive $3103 Before: 78 After: 78	Preventive $4889 Before: 75 After: 75	Preventive $6288 Before: 72 After: 73	Preventive $7300 Before: 71 After: 71	Major $279785 Before: 70 After: 100
Salina Municipal	12-30	Preventive $21750 Before: 74 After: 74	Preventive $27177 Before: 72 After: 72	Preventive $31009 Before: 71 After: 71	Preventive $33594 Before: 70 After: 70	Major $1204516 Before: 69 After: 100
Salina Municipal	17-35	Preventive $156393 Before: 63 After: 63	Do Nothing Before: 62 After: 62	Do Nothing Before: 61 After: 61	Major $5665170 Before: 60 After: 100	Do Nothing Before: 96 After: 96
Salina Municipal	18-36	Preventive $23 Before: 90 After: 90	Preventive $1384 Before: 86 After: 86	Preventive $2657 Before: 82 After: 82	Preventive $5499 Before: 78 After: 78	Preventive $9329 Before: 75 After: 75
Salina Municipal	4-22	Do Nothing Before: 58 After: 58	Do Nothing Before: 57 After: 57	Do Nothing Before: 56 After: 56	Major $1039241 Before: 55 After: 100	Do Nothing Before: 96 After: 96
Satanta Municipal	3-21	Preventive $5725 Before: 71 After: 72	Preventive $6386 Before: 70 After: 70	Preventive $6836 Before: 69 After: 70	Preventive $7045 Before: 69 After: 69	Major $242201 Before: 69 After: 100
Scott City Municipal	17-35	Preventive $33417 Before: 62 After: 62	Do Nothing Before: 61 After: 61	Do Nothing Before: 60 After: 60	Major $1200242 Before: 59 After: 100	Do Nothing Before: 96 After: 96
Smith Center Municipal	17-35	Preventive $17082 Before: 61 After: 61	Do Nothing Before: 60 After: 60	Do Nothing Before: 59 After: 59	Major $607394 Before: 58 After: 100	Preventive $21157 Before: 56 After: 57
Syracuse Hamilton County Municipal	13-31	Preventive $4058 Before: 74 After: 74	Preventive $5048 Before: 72 After: 72	Preventive $5741 Before: 71 After: 71	Preventive $6211 Before: 70 After: 70	Major $222165 Before: 69 After: 100
Topeka Billard Municipal	13-31	Do Nothing Before: 91 After: 91	Preventive $1768 Before: 87 After: 87	Preventive $3817 Before: 83 After: 83	Preventive $7351 Before: 79 After: 79	Preventive $13643 Before: 76 After: 76

Table F.2: Budget Prediction Report Scenario #2 (continued)

Topeka Billard Municipal	18-36	Preventive $344 Before: 89 After: 89	Preventive $1700 Before: 85 After: 85	Preventive $2954 Before: 81 After: 81	Preventive $6509 Before: 77 After: 78	Preventive $10188 Before: 75 After: 75
Topeka Billard Municipal	4-22	Preventive $28224 Before: 61 After: 61	Do Nothing Before: 60 After: 60	Do Nothing Before: 59 After: 59	Major $1005044 Before: 58 After: 100	Do Nothing Before: 96 After: 96
Wakeeney Trego County	17-35	Preventive $9873 Before: 70 After: 70	Preventive $10551 Before: 69 After: 69	Preventive $10849 Before: 69 After: 69	Preventive $10904 Before: 69 After: 69	Major $374057 Before: 69 After: 100
Winfield Strother Field	13-31	Preventive $8038 Before: 74 After: 74	Do Nothing Before: 72 After: 72	Do Nothing Before: 70 After: 70	Do Nothing Before: 70 After: 70	Major $435796 Before: 69 After: 100
Winfield Strother Field	17-35	Preventive $36467 Before: 67 After: 67	Do Nothing Before: 65 After: 65	Do Nothing Before: 64 After: 64	Do Nothing Before: 63 After: 63	Major $1553582 Before: 61 After: 100