UILU-ENG-88-2011

CIVIL ENGINEERING STUDIES
Transportation Engineering Series No. 51
Illinois Cooperative Highway Research Program
Series No. 219

ISSN: 0197-9191

PHASES III & IV

LOGICAL AND PHYSICAL DESIGN OF THE ILLINOIS PAVEMENT FEEDBACK SYSTEM

EXECUTIVE SUMMARY REPORT

By

Mark E. Dwiggins
James P. Hall
Michael I. Darter
Craig L. Flowers
James B. DuBose

An Interim Report of the Investigation of:

DEVELOPMENT AND FIELD TESTING OF AN
ILLINOIS PAVEMENT FEEDBACK SYSTEM

Project IHR-517
Illinois Cooperative Highway Research Program

Conducted by the

DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

and the

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

In Cooperation with the

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

JUNE, 1988

PHASES III & IV

"LOGICAL AND PHYSICAL DESIGN OF THE ILLINOIS PAVEMENT FEEDBACK SYSTEM"

EXECUTIVE SUMMARY REPORT

By

Mark E. Dwiggins
James P. Hall
Michael I. Darter
Craig L. Flowers
James B. DuBose

An Interim Report Of The Investigation Of:

DEVELOPMENT AND FIELD TESTING
OF AN ILLINOIS PAVEMENT FEEDBACK SYSTEM

Project IHR-517
Illinois Cooperative Highway Research Program

Conducted By The

DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

and the

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

In Cooperation With The

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

JUNE 1988

Technical Report Documentation Page

1. Report No. FHWA-IL-UI-219	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle "LOGICAL AND PHYSICAL DESIGN OF THE ILLINOIS PAVEMENT FEEDBACK SYSTEM"		5. Report Date June 1988
		6. Performing Organization Code
7. Author(s) Mark E. Dwiggins, James P. Hall, Michael I. Darter, Craig L. Flowers, James B. DuBose		8. Performing Organization Report No. UILU-ENG-88-2011
9. Performing Organization Name and Address Department of Civil Engineering, Engineering Experiment Station, University of Illinois at Urbana-Champaign		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. IHR-517
12. Sponsoring Agency Name and Address Illinois Department of Transportation, Bureau of Materials and Physical Research, 126 East Ash Street, Springfield, IL 62706		13. Type of Report and Period Covered Interim Report 1985-88
		14. Sponsoring Agency Code

15. Supplementary Notes

Study was conducted in cooperation with the U.S. Department of Transportation Federal Highway Administration. Study Title: Development and Field Testing of an Illinois Pavement Feedback System.

16. Abstract

This report documents the work accomplished during Phases III and IV of the development of the Illinois Pavement Feedback System (IPFS). Phase III involves the logical design and Phase IV is the physical design of IPFS. The overall scope and capabilities of the IPFS are described.

17. Key Words Pavement performance, database, survival curves, pavement life, traffic loadings, pavement management	18. Distribution Statement

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

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

List of Reports

Research Report 517-1 (unnumbered), "An Illinois Pavement Feedback System: Feasibility and System Requirements," by Ron J. Roman, Mark B. Snyder and Michael I. Darter, presents results of investigative study and the system requirements study for an Illinois Pavement Feedback System, 1985.

Research Report 517-2, "Logical and Physical Design of the Illinois Pavement Feedback System," by Mark E. Dwiggins, James P. Hall, Michael I. Darter, Craig L. Flowers and James B. DuBose, summarizes two years of designing the Illinois Pavement Feedback System and provides some results, 1988.

Research Report 517-3, "Pavement Performance Analysis on the Illinois Interstate Highway System," by Mark E. Dwiggins, Michael I. Darter, James P. Hall and James B. DuBose, describes performance analysis of two pavement designs used extensively on the Illinois Interstate system, 1988.

Research Report 517-4, "Analysis of the Traffic Loadings for Interstate Highways in Illinois," by Mark E. Dwiggins, Ricardo A. Salsilli, Michael I. Darter, Thomas Fitch and Alan Lundberg, describes the compilation of annual traffic volumes and classifications on the Illinois Interstate system and the reduction of that data to equivalent single axle loads (ESAL's) for pavement analysis, 1988.

Research Report 517-5, "Rehabilitation Strategy Selection for Possible Demonstration Projects," by Mark E. Dwiggins and Craig Flowers, explains the methods used to select candidate rehabilitation demonstration projects for the Illinois Interstate system, 1988.

ACKNOWLEDGMENTS

This Report was prepared as a part of the Illinois Cooperative Highway Research Program, Project IHR-517 - Development and Field Testing of an Illinois Pavement Feedback System, by the Department of Civil Engineering, University of Illinois at Urbana-Champaign, in cooperation with the Illinois Department of Transportation and the United States Department of Transportation, Federal Highway Administration.

DISCLAIMER

The contents of this report reflect the of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Illinois Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification or regulation.

TABLE OF CONTENTS

APPENDIX II (unpublished)

REPORT MOCK UPS, COMPLETE

NETWORK OPTIMIZATION DEMONSTRATION

PAVEMENT PERFORMANCE ANALYSIS ON THE ILLINOIS INTERSTATE HIGHWAY SYSTEM

NETWORK REHABILITATION STRATEGY SELECTION DEMONSTRATION

PROJECT LEVEL REHABILITATION STRATEGY SELECTION DEMONSTRATION

DISTRESS DATA COLLECTION USING AUTOMATED MEANS, PASCO AND GERPHO

1987 PAVEMENT DISTRESS SURVEY MANUAL

TRAFFIC DATA FOR INTERSTATE HIGHWAYS IN ILLINOIS

APPENDIX I

EXAMPLE OUTPUT REPORTS

FOR THE

ILLINOIS PAVEMENT FEEDBACK SYSTEM

EXECUTIVE SUMMARY REPORT

LOGICAL AND PHYSICAL DESIGN OF THE IPFS

INTRODUCTION

The State of Illinois manages over 17,000 miles of highway pavement. The 1700 miles of pavement that comprise the Interstate highway system have a replacement cost estimated at over 7 billion dollars. During the 1950's, 1960's and early 1970's funds were adequate for most construction and maintenance needs. After the oil embargo of 1973, highway construction and maintenance costs skyrocketed. Funding failed to keep pace with rising costs. The Interstate Highway system began to require rehabilitation as portions reached deteriorated conditions in the mid 1970's. There are now insufficient resources to maintain the highway pavement system to an adequate service level. More effective tools are needed to aid State highway managers in making decisions and in allocating scarce resources.

The Interstate highway pavements are constructed of several different designs as shown in Figure 1. Each pavement type is designed to provide acceptable performance under estimated traffic loadings for a period of 20 years. However, the actual rate of traffic loading has exceeded expected loadings by a factor of three as shown in Figure 2 (The term 'downstate' used in this figure and elsewhere refers to outside the Chicago Area District). In spite of experiencing greatly increased traffic loadings, these pavements have performed extremely well. This good performance is indicated in Figure 3 (page 4) by the fact that only 35% of the Interstate highway pavements have been overlaid, even though they have experienced more than double the planned traffic loadings during the 20 year design life.

Illinois Interstate Highway Pavements

Original Construction

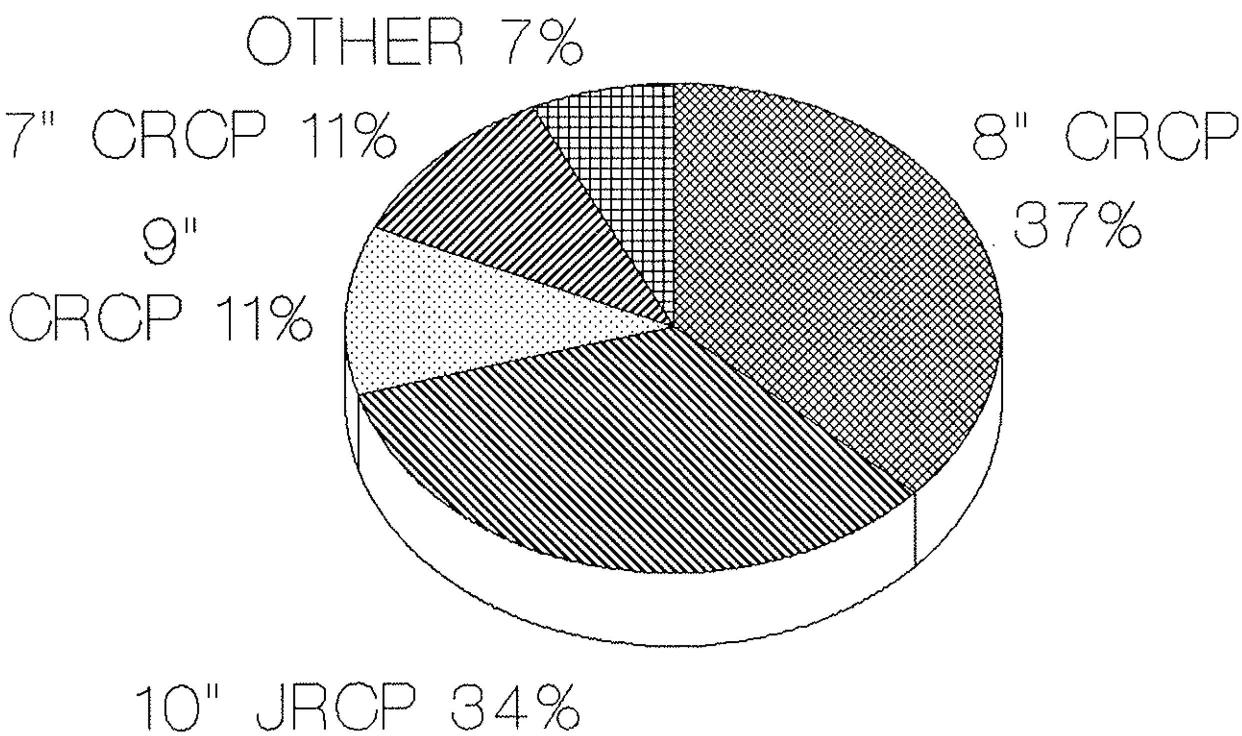


Figure 1

Traffic Loading by Year

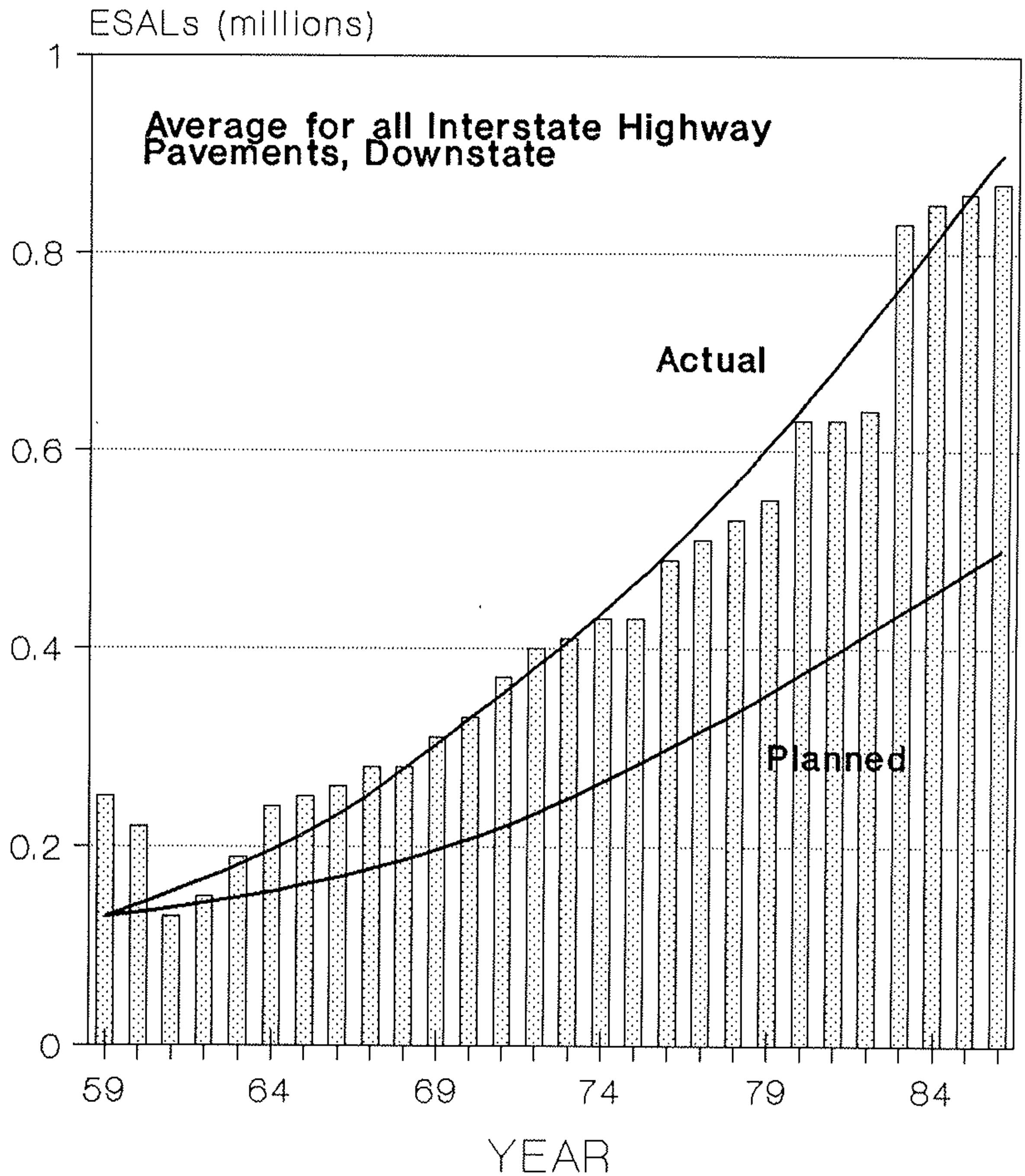


Figure 2

Interstate Highway Pavement Status

Average Age = 20 Years
Average Loading = 10 million 18K-ESALs

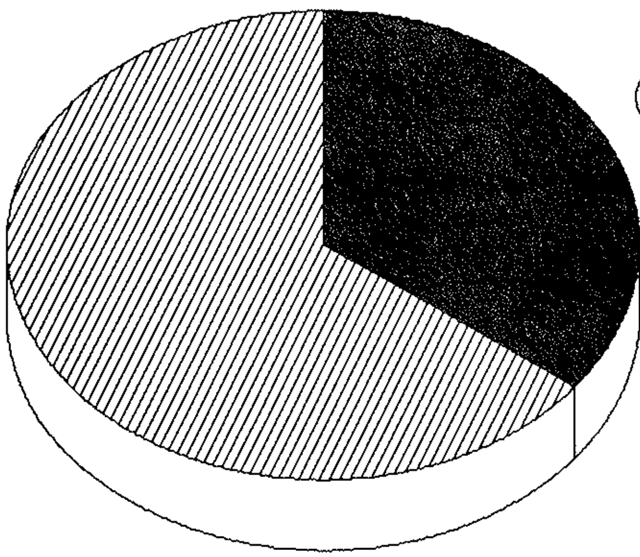


Figure 3

In an attempt to provide pavement managers with the effective tools necessary to make good decisions, the Illinois Department of Transportation (IDOT) is in the midst of a multi-year effort to develop the Illinois Pavement Feedback System (IPFS). IDOT managers will be able to use IPFS to obtain comprehensive pavement data quickly and easily, to evaluate pavement policies, and to answer "what if" questions of project level and network level rehabilitation strategies and budget levels for short and long-range planning.

This report details the logical design and the physical design phases of the IPFS project during fiscal years 1986 and 1987. The logical and physical design discussion is preceded by a brief background of the overall project.

PREVIOUS WORK ACCOMPLISHED

1. Investigative Study

In 1982 the Illinois Department of Transportation (IDOT) formed a high level Standing Committee on Pavement Management composed of representatives from all pavement related areas within the Department to oversee the IDOT pavement management process. The Committee recognized that a major deficiency in the Illinois pavement management process was the lack of and accessibility of many types of pavement data. They undertook an Investigative Study with the University of Illinois in 1983 and 1984 to determine the feasibility of an Illinois Pavement Feedback System (IPFS). The results of this study indicated a great need for improved pavement information plus the following tools to aid IDOT officials in performing pavement management-related activities:

1. Evaluation of design procedures and departmental policies
2. Capability for special studies and research
3. Pavement performance life prediction models
4. Rehabilitation strategy selection for individual projects
5. Rehabilitation programming and budget analysis for pavement networks

From the Investigative Study, a four year effort was initiated to develop the Illinois Pavement Feedback System (IPFS) as a <u>joint effort</u> between the University and IDOT. IPFS development was scheduled in six phases:

I Investigative Study - Completed as mentioned above during 1983-84
II Definition of System Requirements - FY85
III Logical design - FY86
IV Physical Design - FY87
V Implementation - FY88
VI System Adjustment - FY89.

Illinois has over 17,000 centerline miles of State maintained pavements. 1700 miles of these pavements are part of the Interstate highway system. In order to facilitate implementation of the IPFS, the scope of the initial data collection effort was limited to the Interstate highway system and selected primary and secondary sections. The Interstate system includes a sufficient number and diversity of pavement sections to compile a database to perform evaluations of many of the specific designs that are used on the primary and secondary routes.

2. Requirements Definition

During the Requirements Definition, Phase II, deficiencies in the current IDOT information system were identified. Deficiencies included data residing in several separate and uniquely referenced files that were difficult to access and interface and often contained inadequate detail. Much of the data required were not stored in any existing computerized IDOT data base. Several special studies had required extensive new data collection efforts (i.e. "D" cracking).

Pavement data that is available is currently limited to hard copy listings of information. The capability to graphically display trends in pavement performance versus various design, construction, and traffic parameters would be a great aid to the busy top level managers making critical network rehabilitation strategy decisions and in communicating highway pavement needs to the State legislature and the general public.

The following bureaus or offices were identified as the primary users of the initial pavement data system and participated in interviews with the project team to determine system requirements:

1. Bureau of Materials and Physical Research
2. Bureau of Design
3. Office of Planning and Programming
4. Bureau of Maintenance
5. Bureau of Location and Environment
6. Districts

The broad objectives stated by the Investigative Study were refined to the following general applications during the Requirements Definition phase:

- Detailed information from a specific pavement section or networks of sections.
- Summary information of a specific section or network.
- Prediction of future performance or life.
- Evaluation of IDOT pavement policies, design and construction procedures, and rehabilitation strategies.
- Special pavement studies and research.
- Life-cycle costs for various pavement types.
- Capability to answer many "what if" questions to help improve management strategies and budgeting.

An Interim Report published in 1985 entitled An Illinois Pavement Feedback System: Feasibility and System Requirements, described the accomplishments of the project team during the Investigative and Requirements Definition phase.

At the completion of the Requirements Definition phase a Steering Committee was established to set the overall direction of system development, and to maintain upper and lower level management support and involvement. The Steering Committee is composed of a top level manager as chairman and representatives of middle management of the affected areas, including Design, Materials, Physical Research, Planning and Programming, Finance and Administration, Information Processing, two of the state's Districts, and the Federal Highway Administration. A project team of the University of Illinois Department of Civil Engineering and IDOT Bureau of Materials and Physical Research personnel was put together to spearhead the day to day development process with the organizational responsibilities of keeping the IPFS development on schedule and maintaining communication flows.

SUMMARY OF THE LOGICAL DESIGN OF IPFS

Fiscal year 1986 was devoted to the logical design (Phase III) of the Illinois Pavement Feedback System (IPFS). The following major tasks were accomplished:

1. development of criteria for individual pavement management units,
2. identification of all reports that users would need from the system and prepared mock-ups,
3. identification of all data elements required to produce the proposed reports,
4. evaluation of final hardware/software selections and setup of pilot workstations,
5. pavement distress survey of Illinois Interstate highway network (1985), and
6. demonstration of some IPFS capabilities to management.

During the logical design phase, brainstorming sessions were held to mock up desired report outputs from the IPFS without regard to existing IDOT data handling systems or to pavement data currently being collected. A Pavement Feedback User Team (PFUT) was established comprised of IDOT low to middle level managers, many of whom would be direct users of the IPFS, to aid the project team in determining desired reports.

1. Criteria for Pavement Management Units

A pavement management unit was defined as a section of roadway which has uniform characteristics along its length, including:

- pavement structural design,
- truck traffic/ ADT,
- number of lanes,
- traffic direction,
- responsible district,
- visual condition, and
- minimum length of 1/4 mile.

The pavement management sections are usually initially defined by the original construction section boundaries, except where the pavement design varies within the section or an interchange within the section causes traffic volume changes. Overlays require defining of new section boundaries such that uniformity is maintained. Over 800 sections were identified on the Interstate highway system.

2. Report determination

The logical design of the IPFS was accomplished by mocking up all the pavement management reports that IDOT planners, managers, and engineers felt were needed as the outputs of the system. The intent was to create reports that would meet the user's needs, without considering constraints imposed by the present system. The reports included examples of business graphics such as charts and graphs and also geographical mapping applications. The draft reports were circulated among the Pavement Feedback User Team and then edited according to their comments. This process was repeated twice before a final version of the reports was established and accepted by the IPFS Steering Committee. A total of 45 reports were created to demonstrate the required capability of the IPFS. Six representative reports are given in Appendix IB. A full set of reports is in Appendix II.

3. Data element identification

The data elements necessary for IPFS were identified by analyzing the required reports. A total of 451 data elements were identified for each pavement management unit. Data elements were then divided into three groups based on their primary purpose. The first group consisted of those data elements necessary in network programming of pavement improvements. These would be collected for all management units and would be the first ones to be collected. The second group consisted of data elements necessary for evaluating design policies. They would also be collected for every management unit. The third group consisted of those additional data elements needed for special studies and research. These data elements would be collected for enough management units to achieve a good statistical sample. The present location of each data element in existing IDOT files/data bases was tentatively identified. The list of data elements is presented in Appendix IC.

The data elements that are presently in computerized files will be relatively easy to input or reference. The other data elements must be located in the paper files of the Central Office archives or the district records. Since searching the archives and the district files will be time consuming and costly, those data elements will be carefully screened before a search is made for them. Several data elements are not presently being collected by IDOT. They were identified and the means to collect them were recommended.

4. Evaluation of hardware/software

The IPFS project team worked closely with the IDOT Roadway Referencing project team. The Roadway Referencing project is a department wide effort to integrate several independent roadway information files together by using a common referencing scheme; in effect, creating a centralized data base. When successful, this will eliminate several of the data system deficiencies that were noted in the 1985 IPFS Interim Report.

The IPFS Steering Committee has strongly recommended that the IPFS project proceed on the assumption that Referencing will be successful. This will eliminate the need for a separate mainframe computer system for IPFS, and will satisfy the business graphics and graphic mapping capabilities required by IPFS. The physical design of the formal IPFS data base and hardware selection will be accomplished as part of the Referencing effort. The system IDOT currently utilizes for most mainframe applications is the State of Illinois IBM 370 mainframe computer. The data base manager software currently used by IDOT is IBM's Information Management System (IMS). Intergraph graphical workstations are being installed by IDOT for CADD and the graphic mapping applications of the Department and will be used by the IPFS. The statistical and business graphics will be created by existing software such as SAS on the mainframe computer. Updating the system will be greatly simplified since active files would be referenced and the updates on those files will be accomplished by the responsible agency as in the past.

For developmental purposes, the IPFS project team built a separate prototype data base on the IDOT mainframe computer. The team is building this database using the fourth generation NOMAD2 database management software. The project database will include most of the data elements required by the IPFS for section and network inventory reports and for condition prediction and network rehabilitation strategy selection. Additional elements can easily be added to the database. This data flexibility is one of the most important reasons for selecting the NOMAD2 software. The relation between the project NOMAD2 data base and the formal IMS data base will be more fully discussed later in this report.

5. Initial Field Distress survey

In 1985 the IDOT Bureau of Materials and Physical Research conducted an extensive survey to identify the distresses present along each Interstate highway, excluding the Chicago expressways. Sample units 500 feet in length were surveyed at each milepost in each direction. These distress data were input into a data base on the IDOT mainframe computer and are being used by the project team to develop pavement condition prediction models and network optimization routines. A sample distress survey form is shown in Appendix ID.

Several pavements in the Chicago area were surveyed by the Japanese PASCO high speed automated photographic system to determine the feasibility of high speed distress data collection in high traffic areas. A similar demonstration was conducted by the French Gerpho system on pavements in the Springfield area. BPR Roadometer roughness measurements and skid measurements were also taken over the entire Interstate system. This data collection experience was evaluated and recommendations for permanent monitoring data collection procedures and equipment needed to perform the data collection were prepared during the Physical Design Phase.

6. IPFS demonstration

The IPFS Steering Committee met in June, October, and December of 1985 and March and June of 1986. At the March, 1986 meeting, the University of Illinois team was asked to present a demonstration of the proposed system at the June Steering Committee meeting. The intervening months were spent developing a two part demonstration.

The first part consisted of a special study utilizing some of the new data available from IPFS. An analysis of the performance of jointed reinforced concrete pavement (JRCP) and continuously reinforced concrete pavement (CRCP). Mathematical performance models have been derived from data previously gathered from in-service pavements. These models were used to compare the number of failures over time and traffic loading in terms of equivalent 18-kip single axle loads (ESAL's) incurred by the different pavement types with varying steel contents and thickness.

The second part consisted of the evaluation of projected Interstate highway network performance and costs for a variety of funding levels and minimum acceptable performance levels for a 20 year analysis period. Figure 4 illustrates the problems that network optimization addresses.

The network analyzed consisted of all CRCP sections on I-57 in Illinois as it existed in 1977 during a major condition survey. Newly derived models for CRCP performance and rutting and reflective cracking of asphalt overlays

Network Optimization
(Maximize Benefits)

1. Preservation of investment
   (pavement condition)
2. Travelling public

Allows for flexibility of management objectives

Figure 4

were developed as a part of the demonstration to evaluate performance. Figure 5 shows the effect of different budget levels on the network condition over a 20 year period.

These demonstrations required considerable efforts to prepare, but were well worth the effort to demonstrate to the Steering Committee the value and capability of the proposed IPFS.

SUMMARY OF THE PHYSICAL DESIGN OF THE IPFS

The Physical Design (Phase IV) of the Illinois Pavement Feedback System was accomplished during FY 1987:

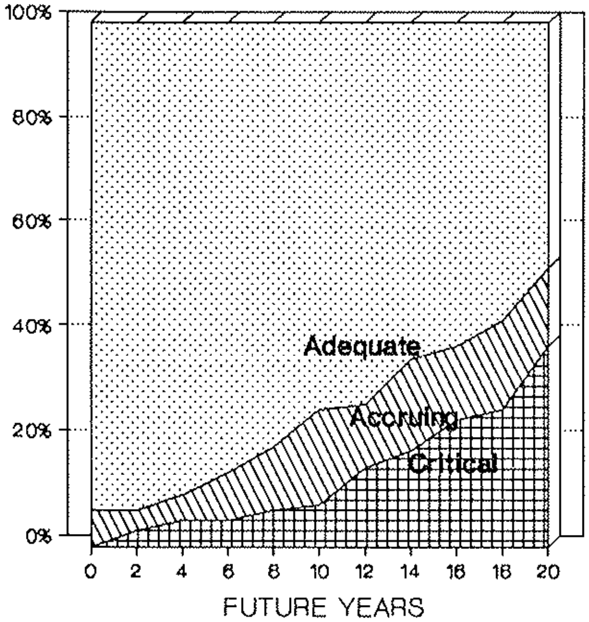
PHYSICAL DESIGN

1 Developed data base loading and data conversion procedures
2 Developed structure of a prototype data base using NOMAD2 software
3 Initiated data collection and verification
4 Developed pavement condition prediction models
5 Developed routines for project and network level rehabilitation selection
6 Developed geographical information system (GIS)
7 Prepared special studies using newly acquired data
8 Acquired required hardware
9 Prepared executive summary

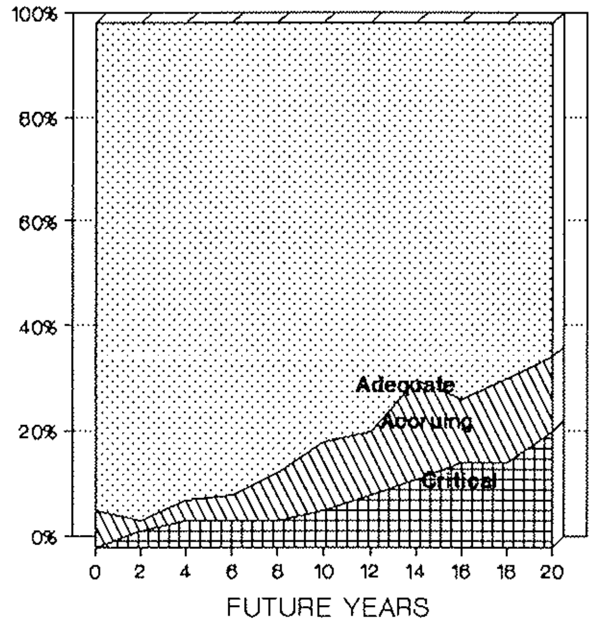
1. Data loading and conversion procedures

All of the data elements identified in Phase III were closely examined to determine the lengths of the data fields that would be required and the units that would be used. Minimum and maximum data ranges for each element were established where they were applicable. Techniques were developed to convert similar data elements derived from different sources into elements that were uniform in length and had the same units.

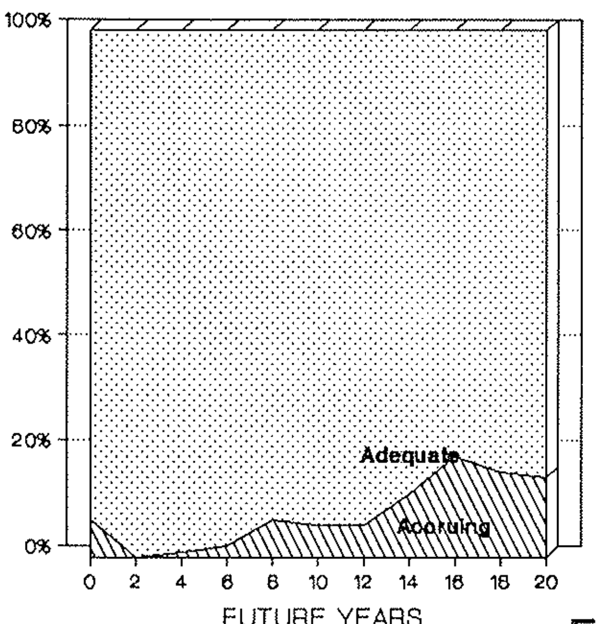
COST PROFILE FOR I57
(DO NOTHING)



COST PROFILE FOR I57
(STATUS QUO)



COST PROFILE I-57
(TAX INCREASE)



Effects of varying proposed budget levels on the overall network.

Figure 5

2. Prototype data base development

The final IPFS data base will be incorporated by IDOT into their long range effort to reference all of IDOT's roadway data bases together. Since it will be several years until the referencing effort is complete, the IPFS project team has developed a prototype data base on the State of Illinois' IBM 370 mainframe computer as discussed in phase III.

The prototype data base will be used for several purposes, including development of the distress prediction models, the project and network level rehabilitation optimization procedures and the development of output reports. Applications will be patterned after the previously defined user output reports defined in the logical design phase. Specifically, the output reports containing summary data for individual sections and several sections within a user specified network will be an immediate output result from the prototype data base. This data base will greatly speed up the development and implementation of the IPFS.

The software used to construct the prototype data base is the NOMAD2 software. This software was chosen because changes could easily be made in the data base structure and on the prototype input and output screens and it is supported by IDOT.

The data base includes location and contract data, original design and rehabilitation design data, pavement distress data, roughness data, traffic data, and climatic data. The different categories are related to each other by using either the marked route milepost of the pavement section as the key or the contract number as the key. Any information can be obtained for a section by specifying the route, direction, and a milepost within the section or by specifying a construction contract number.

The data base was developed using IDOT's Bureau of Information Processing's (BIP) guidelines for NOMAD2 applications. This will simplify its integration in the IDOT Referencing effort and provide department support upon completion of the IPFS project. BIP's recommendations were incorporated into the NOMAD2 data base structure. Data loading began in January, 1988. Appendix IE shows the data input screens.

Data input operations will be defined as part of the Roadway Referencing effort. All involved IDOT offices will have access to the data. Completion of the roadway referencing project will allow direct access to other mainframe pavement related data bases including accident, maintenance, and materials information.

3. Initiate data collection

As was previously mentioned, an initial survey of pavement distress was conducted on the downstate Interstate pavements and selected primary routes in 1985. That data was reviewed by the project team and recommendations were made for succeeding surveys. Another distress survey was conducted during the summer of 1987 implementing some of the recommendations for methods and equipment. Appendix IF contains the recommended methods for the distress survey and suggested equipment to use. The 1985 and 1987 distress surveys have been entered into the prototype data base.

The Policies and Procedures Section of the IDOT Bureau of Design has compiled a data file containing some basic design data and construction history of Interstate highway sections. This file is used by the IDOT Pavement Review Team to monitor the condition of the Interstate and recommend rehabilitation strategies. The survey team also notes major distresses present. This file was sent out to the Districts for review and to provide missing data at the request of the project team. All Districts verified the information and added some other information requested by the project team. Data from this verified and expanded file will be input in the prototype data base.

Traffic volume and classification data was obtained for each year for each section of downstate Interstate pavement. Again, the Policies and Procedures section coordinated the efforts of the Districts to gather this data. The data thus obtained was forwarded to the project team for inclusion into the prototype data base. ESAL applications have been calculated for each section or management unit. An initial finding is that Interstate pavements have experienced three times the number of ESAL applications that they were designed for during their design life. ESAL applications have increased at a compound rate of 7 to 8% per year since 1962 as was shown in Figure 2. The average section is currently receiving almost one million 18-kip ESAL's per year. More findings from this data will be included in a technical memo by the project team.

Condition Rating Survey (CRS) values measured since 1979 have been obtained from the Office of Planning and Programming for use in the IPFS.

District One (Chicago and surrounding four county area) presented a special problem in inventory and monitoring data collection. The most heavily travelled highway sections in the world are located in Chicago. It is not possible for a survey crew to get near the pavement to measure distress. Many of the Interstate highway sections were constructed as long ago as the 1930's and later included in the Interstate network. They have been rehabilitated so many times that historical reconstruction of the pavement structure is difficult. Traffic data collection was sporadic and taken at different locations in succeeding years.

The project team recommended that District One distress measurements be taken by automated means. The Japanese PASCO and the French Gerpho high speed data collection vehicles were demonstrated to the project team during the summer of 1986 to provide acceptable results.

The IPFS project team gathered the design, construction, rehabilitation, and traffic data for District One. Cover sheets and typical cross sections for all Interstate highway construction projects and selected supplemental freeways were forwarded to the project team from the District. The team then used this information to identify the pavements in terms of unique management units so that the basic design information could be recorded for each section.

All available traffic data was also forwarded to the project team. This data included total traffic volumes for each section for the years 1965, 1972, and 1984 from the Chicago Area Transportation Study (CATS) and the IDOT vehicle classification maps for selected locations on four year intervals. The project team then used computer methods to calculate vehicle classifications for each section for each year. From these classifications, ESAL's were also calculated.

4. Prediction models

Many prediction models are required to perform project level and network level rehabilitation strategy selection. Individual key distresses are predicted and rehabilitation strategies are chosen at future dates based on the distresses predicted for that date. Total failures for CRCP including the sum of punchouts and steel ruptures were predicted using a model developed using data from the 1977 and 1985 Interstate distress surveys. Various distresses for JRCP including faulting, joint deterioration, pumping, transverse cracks, and PSI are predicted using prediction models developed on the Concrete Pavement Evaluation Study (COPES) performed at the University of Illinois under NCHRP project 1-19, from data collected in 1979. Prediction models for rutting and reflective cracking of asphalt overlays were developed in 1987 on this project using data collected on the asphalt overlay study of Illinois pavements conducted by IDOT in 1982 and data from the 1985 distress survey. A pavement condition prediction report for individual sections will be generated from the prototype data base using these models.

These prediction models must be considered preliminary. However, they are being used to develop rehabilitation strategy selection routines on the project and network level. The rehabilitation selection routines are being written in such a way that the prediction models can easily be updated when data from the complete prototype data base are used to further refine the models.

5. Project and network rehabilitation selection

Project level rehabilitation strategy selection is being accomplished by adapting the project advisory system (EXPEAR) recently developed at the University of Illinois under an FHWA contract for use with the IPFS data base. Life cycle costs, selection strategies for CRCP and asphalt overlays, and the effects of delay on rehabilitation implementation are being added to the system. A set of feasible rehabilitation alternatives and their annual costs for a given section, as developed with the aid of the project advisory system, is shown in Table 1. The details of the life cycle cost calculations are still under development.

The strategy selection procedure is being modified to generate the set of feasible rehabilitation alternatives for each section for the network level optimization routine.

COST COMPARISONS

Alternative	Annual Cost/Mile*	Rank
A	58,400	2
B	67,900	4
C	61,100	3
D	51,060	1

* Discount rate = 5 percent

Example of a rehabilitaion selection routine for a specific section.

Table 1

Network level rehabilitation optimization will be accomplished by first selecting a set of feasible rehabilitation alternatives for each section of the network, then feeding these alternatives into a routine to optimize network condition and worth for a given overall budget. Long range network rehabilitation selection and budgeting reports will be generated from the prototype data base using this routine. Figure 6 shows sample output reports for a network consisting of all pavement sections on I-57.

6. Geographical information system (GIS)

Graphical display of highway data was a prime consideration of IDOT managers as noted in the requirements definition stage. Geographic display of data will be included in IDOT's Roadway Referencing effort. However, work on this will not be started until the link/node base is in place. Since this will not take place for several years, the project team developed a GIS prototype to demonstrate the capabilities of such a system to IDOT managers. Permission was granted from the Illinois Department of Energy and Natural Resources to use their Arc/Info software developed by ESRI of Redlands, California on their Prime computer system at the University of Illinois. This prototype is a stand alone system, ie., not connected with the IDOT IPFS Database or the IDOT CADD capabilities. Information is shared between the IDOT IPFS Database and the U of I GIS prototype through several easy commands. The end result is the impression of an interconnected system for demonstration and special studies.

The Illinois Interstate network was digitized and attribute data was loaded into the local data base. Features of the system include the ability to position cross hairs on a particular pavement section on the map and then retrieve selected information about that section. Additionally, the data base can be searched to locate sections containing similar attributes and then those sections can be highlighted on the screen map.

****
*   *
*   SELECTED PROJECT LISTING   *
*   *
*   NETWORK OPTIMIZATION   *
*   *
****

DECISION LEGEND

- = NO MAINTENANCE
OL = OVERLAY
PA = PATCHING
RC = RECONSTRUCTION
=

NETWORK DESCRIPTION: optimized 46 sec
SPENDING LIMIT(PRESENT WORTH): 10000000
AMOUNT SPENT(PRESENT WORTH): 9770189
OBJECTIVE FUNCTION VALUE: 28805

OPTIMIZATION METHOD: BENEFIT
MINIMUM CI : 6.0
INTEREST RATE: 0.03
INFLATION RATE: 0.00

FEATURE	TOTAL COST	BENEFIT	TFW	LEN	TIME(YEARS)	0	2	4	6	8	10	12	14	16	18	20
57-N-340.32	337582	1590	0	2.78	CI	8.4	8.3	8.2	8.0	7.8	7.5	7.2	6.7	6.2	5.5	7.7
					DECISION	-	-	-	-	-	-	-	-	-	OL	-
					COST(1000$)	0	0	0	0	0	0	0	0	0	337	0
57-N-339.27	126291	1722	0	1.04	CI	9.3	9.2	9.1	8.9	8.6	8.3	7.8	7.3	6.7	5.9	7.6
					DECISION	-	-	-	-	-	-	-	-	-	OL	-
					COST(1000$)	0	0	0	0	0	0	0	0	0	126	0
57-N-302.28	399279	1630	0	3.04	CI	9.0	8.8	8.6	8.3	7.9	7.4	6.8	6.1	5.2	8.3	7.1
					DECISION	-	-	-	-	-	-	-	-	OL	-	-
					COST(1000$)	0	0	0	0	0	0	0	0	399	0	0
57-N-298.12	590965	1646	0	4.16	CI	9.7	9.3	9.0	8.5	7.9	7.2	6.3	5.3	8.3	7.2	6.1
					DECISION	-	-	-	-	-	-	-	OL	-	-	-
					COST(1000$)	0	0	0	0	0	0	0	590	0	0	0
57-N-293.22	643572	1647	0	4.90	CI	9.0	8.8	8.6	8.3	8.0	7.5	6.9	6.3	5.4	8.4	7.2
					DECISION	-	-	-	-	-	-	-	-	OL	-	-
					COST(1000$)	0	0	0	0	0	0	0	0	643	0	0
57-N-289.48	531299	1565	0	3.74	CI	8.1	8.0	7.8	7.6	7.3	6.9	6.4	5.8	8.5	7.4	6.5
					DECISION	-	-	-	-	-	-	-	OL	-	-	-
					COST(1000$)	0	0	0	0	0	0	0	531	0	0	0
57-N-285.15	568711	1751	0	4.33	CI	10.0	9.8	9.5	9.2	8.7	8.1	7.4	6.6	5.6	8.3	7.1
					DECISION	-	-	-	-	-	-	-	-	OL	-	-
					COST(1000$)	0	0	0	0	0	0	0	0	568	0	0
57-N-277.49	1010016	1763	0	7.69	CI	10.0	9.8	9.6	9.2	8.8	8.2	7.6	6.7	5.7	8.3	7.1
					DECISION	-	-	-	-	-	-	-	-	OL	-	-
					COST(1000$)	0	0	0	0	0	0	0	0	1010	0	0

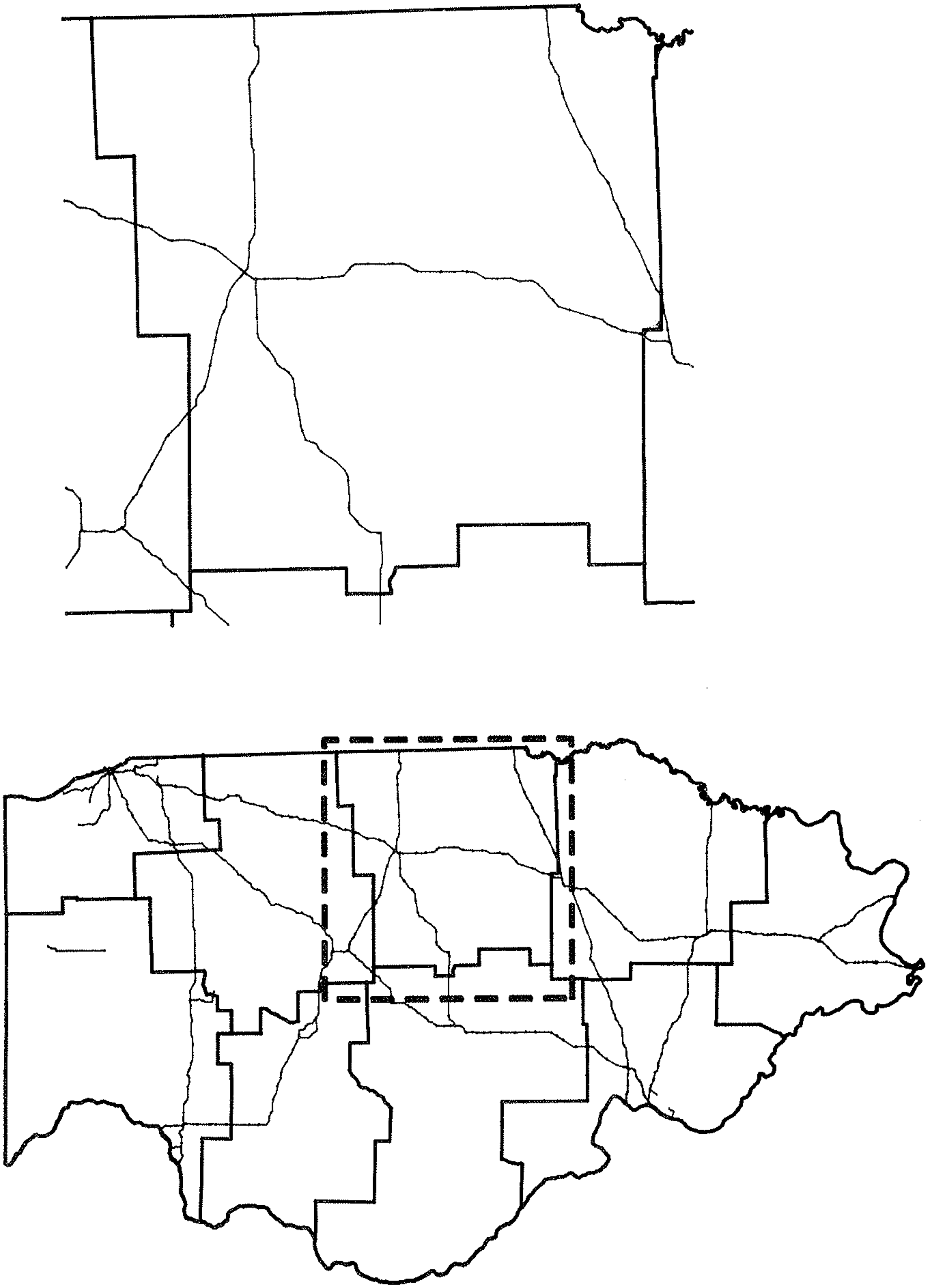
Figure 6

Many maps were generated for various interested parties within IDOT on a request basis and for demonstrations. These maps serve to heighten interest within IDOT for the IPFS. An example of a GIS map and the zoom capability is shown in Figure 7. Attribute data for an example section is shown in Figure 8 (page 27).

7. Special studies

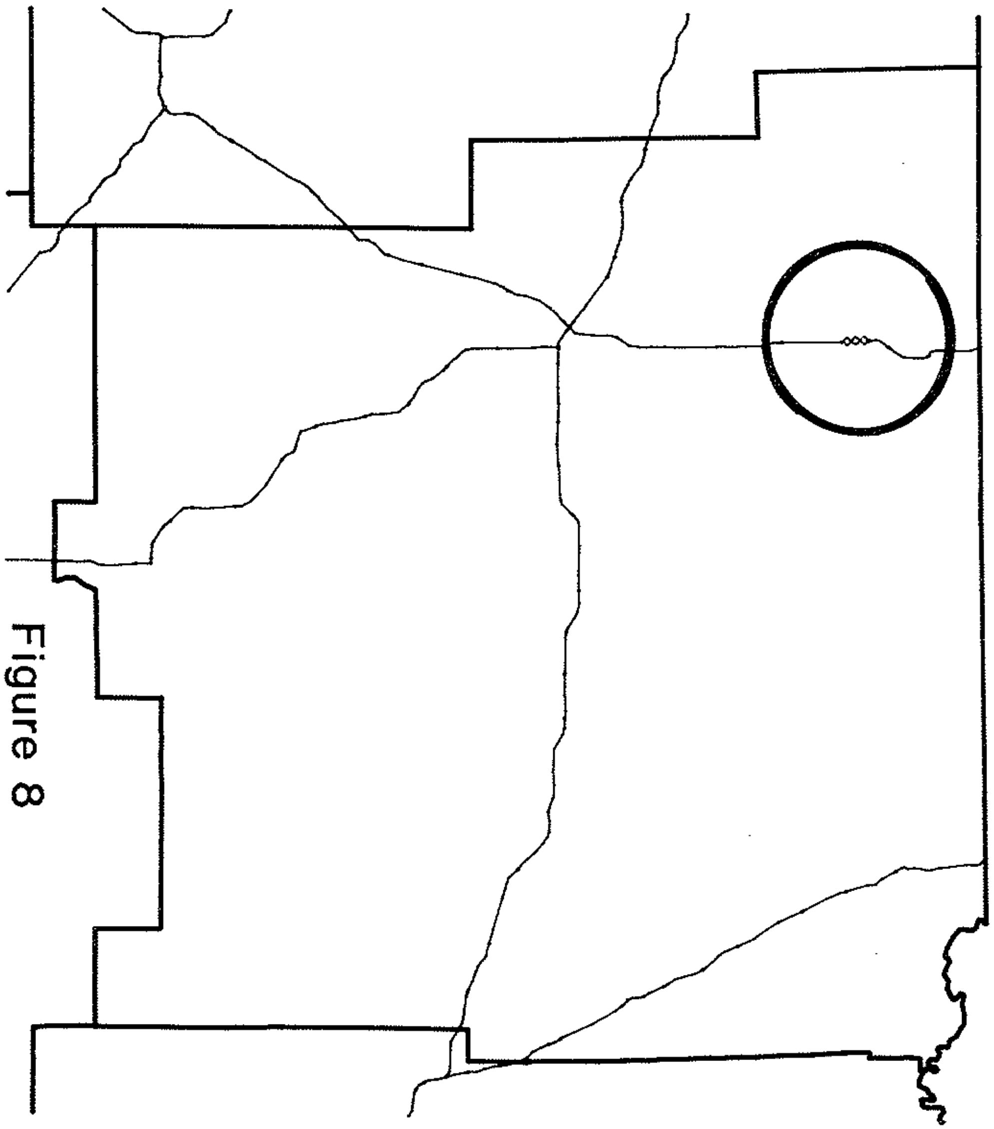
Two special demonstration studies have been conducted by the project team using data newly acquired by the project team. One study analyzed the performance of the major pavement designs employed by IDOT on Interstate highways. A routine was developed in the other study to select demonstration rehabilitation projects on Interstate highways.

The study on pavement performance compared the life and ESAL applications to the first overlay for each of the major pavement types. Several interesting results were obtained. One of the conclusions was that 8 inch CRCP and 10 inch JRCP designed for the same traffic loading performed approximately equally as shown in Figure 9 (page 28). However, the presence of D-cracking aggregate drastically reduced the performance of the CRCP. The JRCP was affected by D-cracking, but not to the same degree. The "D" cracking effects on CRCP are shown in Figure 10 (page 29) and the "D" cracking effects on JRCP are shown in Figure 11 (page 30). A summary showing the actual ESAL and the ratio of actual to design ESAL for various pavement types is shown in Table 2 (page 31). The JRCP and CRCP carried three times the traffic than they were designed for. At the design traffic loadings less than 5% of the pavements had been rehabilitated, indicating a design reliability of about 95%.



STATE VIEW WITH ZOOM SELECTION AND ENLARGED AREA

Figure 7



DATA FOR SELECTED SECTION : RECORD 328 —

328

INTERSTATE-RT1	= 74
BEGIN-MP	=206.00
END-MP	=208.30
DIRECTION	=E
SECTION-LENGTH	= 2.30
DISTRICT	=5
PRIORITY	=2
CONSTRUCTION-YR	=60
PAVEMENT-TYPE	=JOINTED
PAVEMENT-TOP	=BARE
ADT	= 11400
PERCENT-TRUCKS	=27

This is a sample of up to 451 data elements available for each section.

SELECTED SECTION HIGHLIGHTED AND ASSOCIATED DATA.

Figure 8

Survival of Pavement by ESALs
8 in. CRCP and 10 in. JRCP

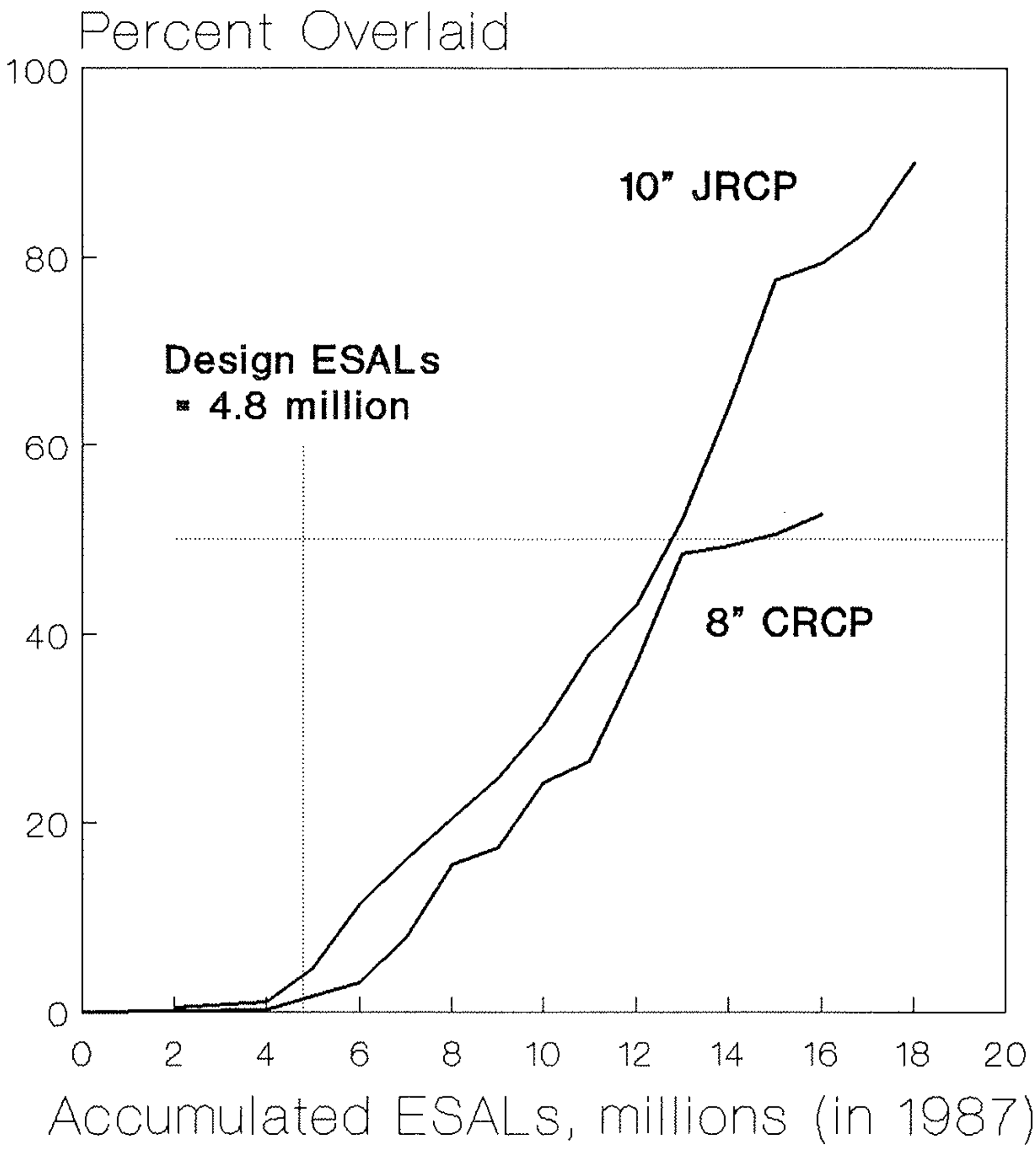


Figure 9

Effects of D-Cracking with Age
8" CRCP

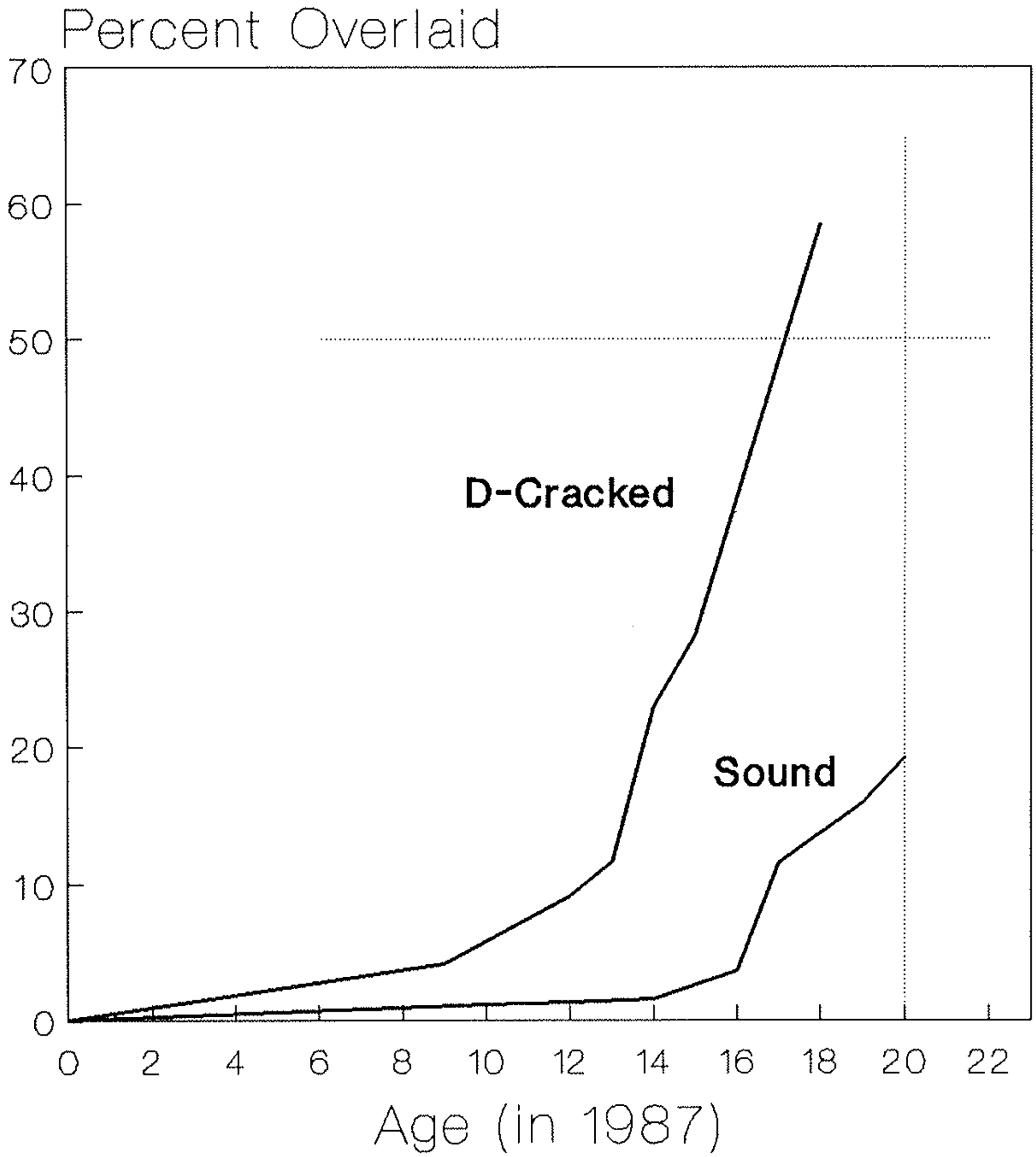


Figure 10

Effects of D-Cracking with Age
10" JRCP

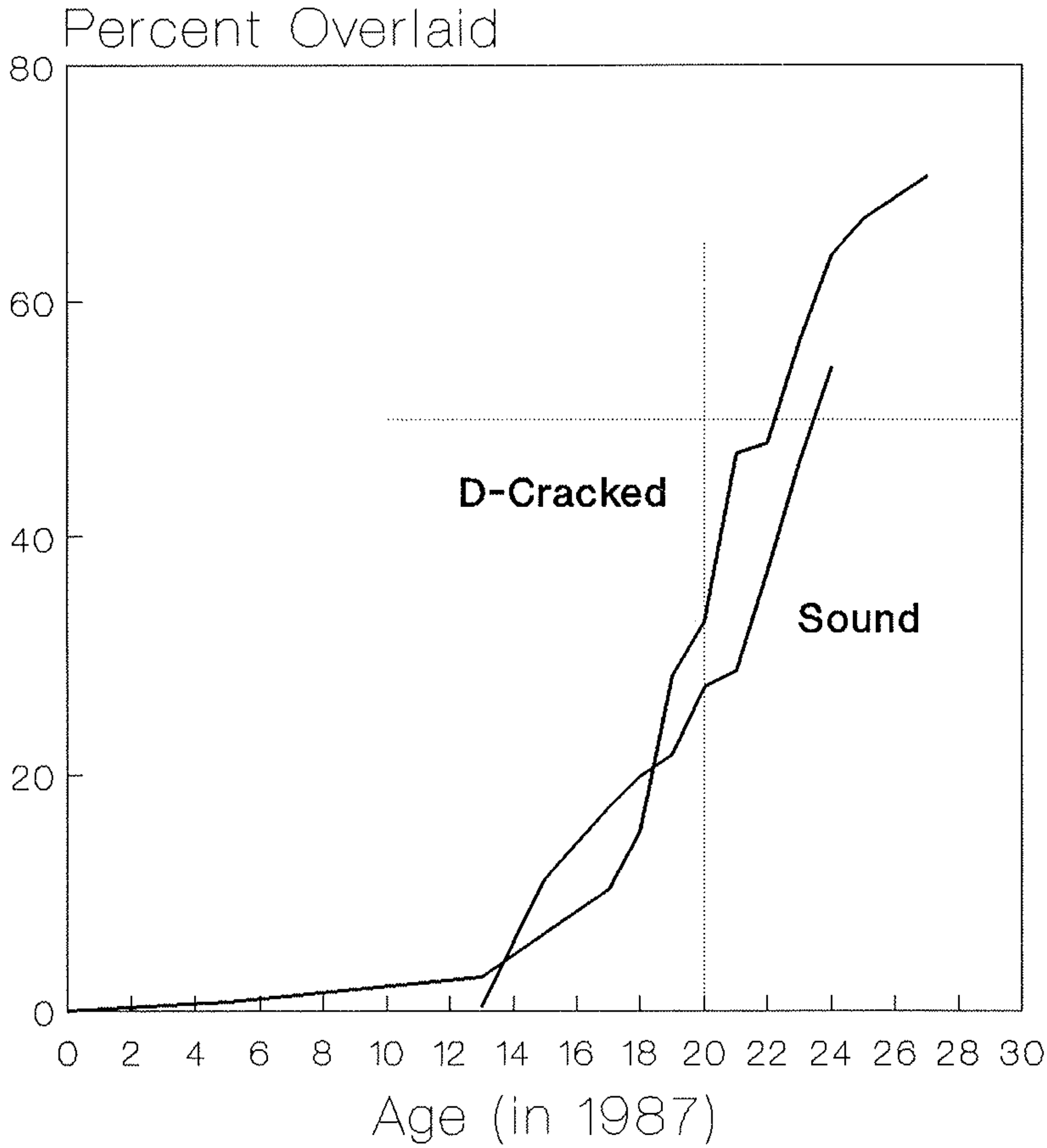


Figure 11

Summary of Pavement Life

Pavement Type	Average Life (yrs)	Average ESAL's	ESAL Design Ratio
7" CRCP	15	6	3.0
8" CRCP	22	13	2.9
9" CRCP	>20	>20	>2.0
10" JOINTED	23	13	2.9

Table 2

A method to objectively choose candidate sections for demonstration projects was the focus of the other study. Generally, IDOT rehabilitates the Interstate highway pavements by restoration or by applying an asphalt overlay. Demonstration funds occasionally become available to experiment with previously untried rehabilitation strategies, such as bituminous or PCC inlays, thin bonded PCC overlays, and crack and seat. The project team was asked to develop a routine to automatically select candidate sections for these rehabilitations using inventory and monitoring data collected on the project. An example of candidate sections for a particular demonstration project are shown in Figure 12.

WORK PLAN FOR PHASES V AND VI

The Implementation of the IPFS will be accomplished during Phase V. This will include the following goals:

IMPLEMENTATION

- Loading of prototype data base
- Generation of the following reports:
  SEC01 - Summary data for a selected section
  NET01 - Summary data for a selected network
  PDP01 - Pavement condition prediction for a selected section
  PDP02 - Project level rehabilitation strategy selection
  NET03, NET06 - Long range network rehabilitation optimization
- Demonstrations and presentations
- Involvement of affected IDOT users into IPFS

The Illinois Pavement Feedback System will be in a working form by the end of the implementation phase, for testing purposes only.

Phase VI will be devoted to System Adjustment in FY 1989 including continued data input, continued report generation, adjusting pavement condition prediction models, and coordination with the Roadway Referencing project to incorporate the prototype data base into IDOT's plan to reference all of IDOT's highway related data bases. Eventually, the entire system will be available to all IDOT users as it is integrated with the Roadway Referencing effort at the end of phase VI.

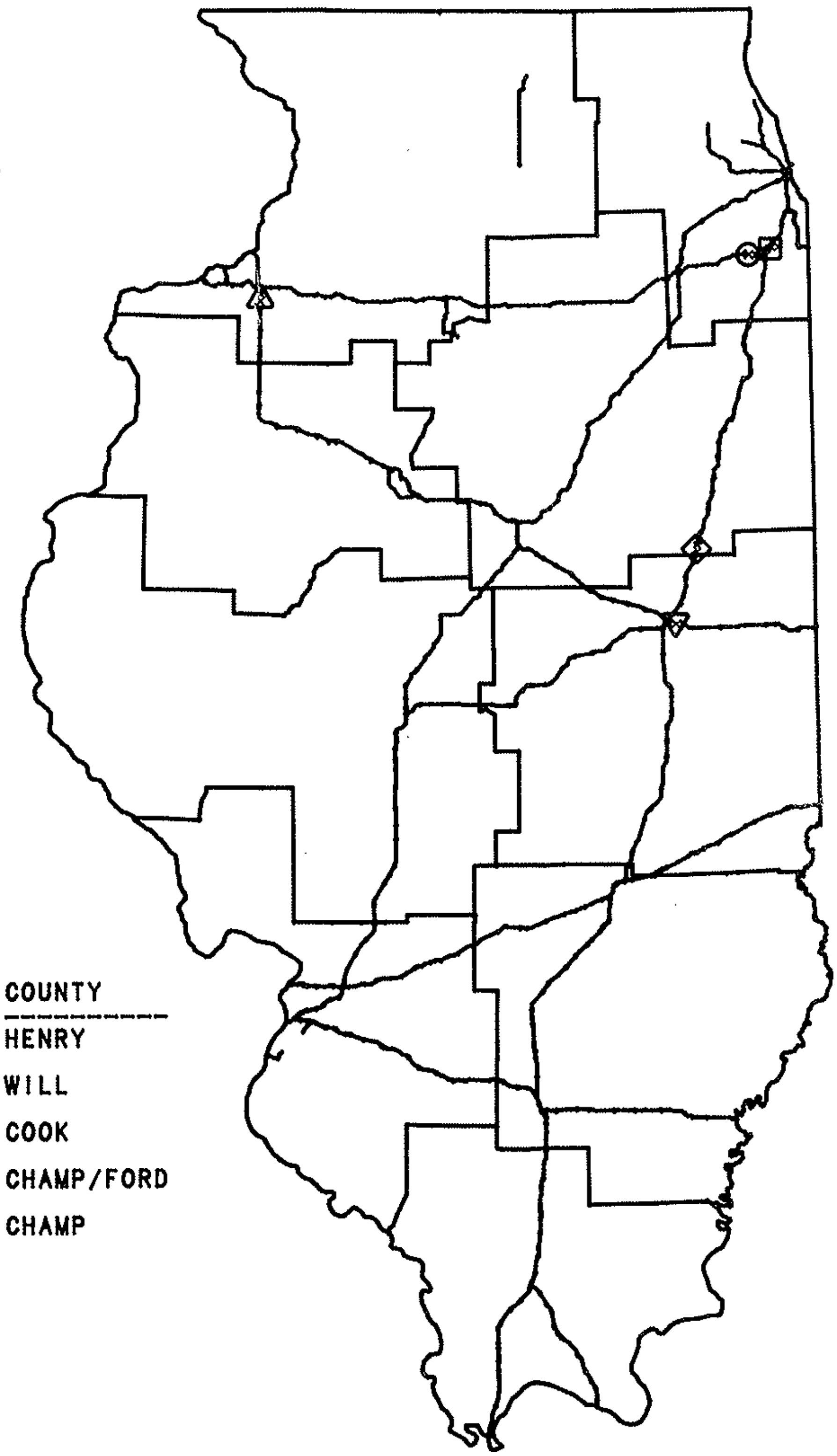
REHABILITATION TYPE "A" CANDIDATES

SELECTED BY REVIEW OF IPFS DATA.

REHAB CANDIDATE

OTHER INTERSTATE

Scale = 1:2,900,000



SELECTED CANDIDATES --

	RTE	DIR	BEGIN	END	COUNTY
△	74	E	14.50	19.46	HENRY
○	80	E	145.60	146.50	WILL
□	80	E	151.28	154.84	COOK
◇	57	N	256.03	260.50	CHAMP/FORD
▽	74	E	179.90	184.30	CHAMP

PAVEMENT FEEDBACK SYSTEM / GIS

Figure 12