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JOINT HIGHWAY RESEARCH PROJECT

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METHODOLOGY FOR EVALUATING
THE IMPACTS OF ENERGY, NATIONAL
ECONOMY, AND PUBLIC POLICIES
ON STATE HIGHWAY FINANCING
AND PERFORMANCE

F. L. Mannering

PURDUE UNIVERSITY
INDIANA STATE HIGHWAY COMMISSION

Final Report

METHODOLOGY FOR EVALUATING THE IMPACTS OF ENERGY, NATIONAL ECONOMY,
AND PUBLIC POLICIES ON STATE HIGHWAY FINANCING AND PERFORMANCE

TO: Harold L. Michael, Director
Joint Highway Research Project

July 11, 1979

File: 3-4-6

FROM: Kumares C. Sinha, Research Engineer
Joint Highway Research Project

Project: C-36-73F

Attached is a Final Report by Mr. Fred L. Mannering, Graduate Instructor in Research on our staff, titled "Methodology for Evaluating the Impacts of Energy, National Economy, and Public Policies on State Highway Financing and Performance". Professor K. C. Sinha directed the research and guided preparation of the Final Report.

The Report describes the development of a computer model that can be utilized to analyze and estimate the complex interactions between the critical factors influencing state highway financing and their impact on highway system performance. The model was extensively tested and applied to the Indiana situation. The options considered in this study revealed that, although a general decline in highway performance can be expected, appropriate highway policy decisions can assure the sustenance of a tolerable level of highway performance well into the future.

The Report is presented as the Final Report on this Study for acceptance as fulfillment of its objectives.

Respectfully submitted,

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Final Report

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by

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ABSTRACT

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Methodology for Evaluating the Impacts of Energy, National Economy, and
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Major Professor: Kumares C. Sinha.

Inflationary pressures, stabilizing road-use tax revenues, energy constraints, and recent national automotive policy decisions have created problems which have dramatically affected the highway financing process. The objective of this project was to develop a tool which can be utilized to analyze and estimate the complex interactions between the critical factors influencing state highway financing and their ultimate impact on highway performance, so that the results could enable legislators to make informed decisions regarding this issue. This objective was achieved by the development of a computer simulation model which was extensively tested and applied to the Indiana problem.

The computer model utilized the national energy and economic forecasts developed by Data Resources Inc. along with various assumptions regarding legislative options to project a probable range of Indiana highway performance. The results of the model application indicated that an overall deterioration in highway performance can be expected to continue in Indiana as the funds required to stabilize or improve highway performance are enormous. However, the extent of future highway performance deterioration can be regulated by new

taxing policies, revised highway performance criteria, and governmental promotion of car pooling, mass transit, and other factors that may effectively reduce future highway congestion. The options considered in this study revealed that, although a general decline in highway performance can be expected, appropriate highway policy decisions can assure the sustenance of a tolerable level of highway performance well into the future.

CHAPTER 1

INTRODUCTION

The present state highway financing process is confronted with a number of serious problems that have been aggravated by recent economic conditions and national policy decisions. On one hand the highway construction, operation, and maintenance costs have experienced rampant increases in recent years, as shown in Figure 1, while the amount of road-user tax revenues has remained the same or declined, as shown in Figure 2. At the same time, increasing proportions of the state highway budget are being consumed by non-capital recurring costs such as routine maintenance, highway patrol, safety, planning, research, administration, and debt service (1).

Such problems have led to the deferral of many needed highway improvement projects, and subsequently, the overall highway performance has suffered. Moreover, the long-term impacts that national and regional energy conservation efforts will have on the state highway financing process are not clearly understood.

It is clear that there is a definite need to examine possible legislative actions to substantially change the state revenue generating structure and/or tax rates in order to provide sufficient resources for highway construction, operation, and maintenance. The intent of the present research project is to provide a tool, in the

FIGURE 1. SUMMARY OF NATIONAL HIGHWAY CONSTRUCTION AND HIGHWAY MAINTENANCE & OPERATION COST INDICES

SOURCE: REFERENCE 1.

FIGURE 2. TOTAL HIGHWAY REVENUES BY SOURCE
IN INDIANA (1970-1975)

SOURCE: REFERENCE 1.

form of a computer model, to systematically evaluate the impacts that various proposed highway related legislative decisions may have on highway performance in Indiana.

Two recent studies investigated the problem of state highway financing in Indiana (2,3). The first study dealt exclusively with revenue generation (2) while the other study projected estimates of "highway needs" which were determined subjectively only on an aggregated basis (3). Most studies performed in connection with state highway financing, such as the one conducted for Vermont (4), tend to oversimplify many of the underlying factors affecting the highway financing process, and as a result, the forecasting capabilities of such studies are limited.

The most comprehensive study performed in this field has been the 1976 National Highway Inventory and Performance Study (NHIPS) (5). The 1976 NHIPS was the first major study to apply the exacting methods of measuring highway performance that were first introduced in the 1974 National Highway Needs Report (6). The application of such highway performance measurements enabled the detailed projections of highway service, physical conditions, and operating conditions to be made under various highway revenue scenarios. Such projections represented a major departure from previous studies in that the relative effectiveness of various financing policies, in terms of highway performance, could now be readily assessed. However, the 1976 NHIPS and most other studies in this area did not explicitly consider many or all of the interactive economic factors that affect future highway financing and performance forecasts.

In the present study a computer model was developed as a tool to analyze the state highway financing problem, and the broad objectives of this study are mentioned below:

1. Incorporate appropriately the interaction between the economic factors and the highway financing and performance variables.
2. Develop a consistent and detailed technique to measure and project highway performance.
3. Provide sufficient flexibility such that the analysis procedure can account for a variety of state and national legislative options.
4. Minimize the modifications necessary to adapt and transfer the use of the model to geographical areas other than the state of Indiana.

The resulting computer model provides detailed projections of a variety of factors relating to highway financing and highway performance in Indiana. Such information enables the analyst to evaluate many of the dynamic processes simulated by the computer model. An overview of the entire modeling procedure used in the present study is presented in Figure 3.

The national macroeconomic forecasts are provided as input to the modeling procedure. These forecasts directly affect fuel efficiency projections, fuel consumption projections, state highway user revenues, projections of highway performance and projections of highway improvements. Fuel efficiency projections are made on the national level and are a critical component in the determination of

FIGURE 3. OVERVIEW OF THE SIMULATION PROCEDURE

fuel consumption projections which are in turn vital to the estimation of future state highway-user revenues. Additionally, Indiana population projections were made by the cohort survival method and are utilized to estimate the number of registered vehicles and the number of licensed drivers both of which are also important factors in the calculation of state highway-user revenues. Revenues from sources such as federal aid are estimated exogenously, and when combined with the internally projected state highway-user revenues constitute the total funds available for highway improvements. Finally, the present highway conditions are simulated internally and are used along with projections of highway improvements and other factors to estimate future highway performance which is the ultimate objective of the modeling procedure.

A more detailed explanation of the model simulation procedure is presented in the following chapters. The final two chapters are concerned with the application of the computer model to the Indiana highway financing problem.

CHAPTER 2

ECONOMIC AND ENERGY FORECASTS

In this chapter discussions are presented relating to the macroeconomic forecasts and energy assumptions incorporated in these forecasts. The macroeconomic forecasts including the associated energy assumptions were taken from the study conducted by Data Resources Inc. on a national level (7).

Macroeconomic Forecasts

The three national macroeconomic forecasts developed by Data Resources, Inc. (DRI), TRENDLONG 0978, CYCLELONG 0978, and PESSIMLONG 0978, were used in this analysis to provide a probable range of future economic conditions. These three forecasts are briefly outlined below:

TRENDLONG is essentially a stable long-run simulation of the U.S. economy. In this model the economy achieves a uniform Gross National Product (GNP) growth by the mid-1980's and full-employment is nearly reached after 1986. In addition, the federal budget and the national trade account achieve a near balance by the early 1980's.

CYCLELONG is a cyclical economic simulation model that forecasts the business cycles that have historically characterized the U.S. economy. The cyclical behavior is induced by factors such as financial pressures, inventory variations, foreign demand shifts, and

imperfect policy decisions. The loss of potential output results in a 1990 GNP that is 2.2% less than that projected by the TRENDLONG model.

PESSIMLONG is an economic simulation model that projects essentially the same price, exogenous factors, and final demand behavior that has typified the U.S. economy in the past 10 years. Inflation becomes increasingly troublesome and is fueled by inappropriate policy decisions and increasing food and oil prices. The resultant 1990 GNP is less than that projected by either of the other two models.

A summary of the basic assumptions underlying these macroeconomic forecasts is presented in Table 1. In Figure 4 are illustrated the GNP forecasts generated by these models. The assumptions involving energy supply and demand, as used in the preparing of the three macroeconomic forecasts, are discussed in detail in the next section.

Energy Supply and Demand

In recent years, a number of studies have been undertaken to forecast future energy demands and supplies. The results of such studies have varied considerably as there is much uncertainty relating to future energy reserves, the effectiveness of conservation efforts, and the impacts of technology. However, the general consensus of these studies indicates that the world faces long-term oil and gas shortages which will result from the inability of reserve additions to match energy consumption growth (8,9).

TABLE 1. MAJOR ASSUMPTIONS UNDERLYING DRI MACROECONOMIC FORECASTS.

ASSUMPTIONS	TRENDLONG	CYCLELONG	PESSIMLONG
FISCAL POLICY	FEDERAL EXPENDITURES INCREASE AT A COMPOUND ANNUAL RATE OF 8.8 PERCENT WITH FEDERAL BUDGET BALANCE AFTER 1986.	FEDERAL EXPENDITURE INCREASE AT A COMPOUND ANNUAL RATE OF 9.3 PERCENT.	FEDERAL EXPENDITURES INCREASE AT A COMPOUND ANNUAL RATE OF 10.6 PERCENT.
MONETARY POLICY	TIGHTENING OF MONEY SUPPLY IN 1980 AS INFLATION ACCELERATES AND AFTERWARDS STABLE CREDIT IS PROMOTED.	FLUCTUATIONS IN POLICY CONTRIBUTE TO THE SEVERITY OF CYCLES.	
CONSUMER BEHAVIOR	LOW INFLATION AND JOB SECURITY INCREASE CONSUMER CONFIDENCE.	CYCLICAL VARIATIONS IN SENTIMENT RESULT IN LARGE FLUCTUATIONS IN DURABLE GOOD EXPENDITURES.	
BUSINESS BEHAVIOR	DECISIONS MADE IN A STABLE ENVIRONMENT.	OUTPUT FLUCTUATIONS AND INFLATION RESULT IN UNCERTAINTY AND INVESTOR CAUTION.	
INFLATION	CAPACITY UTILIZATION AND ENERGY INFLUENCE THE IMMEDIATE FUTURE WITH STEADY IMPROVEMENT BEGINNING IN THE EARLY 1980'S.	CONTINUAL BOOM-BUST PATTERN RAISES THE AVERAGE RATE.	AGGRESSIVE WAGE AND PRICE BEHAVIOR PUSHES RATES UPWARD AND INCREASES THE SEVERITY OF ECONOMIC SLOW DOWNS.

SOURCE: REFERENCE 7.

FIGURE 4. SUMMARY OF DRI GROSS NATIONAL PRODUCT (GNP) FORECASTS

SOURCE: REFERENCE 7.

As a result of these projected shortages, the growth in world energy demand must be curtailed such that future supply and demand equilibrium can be attained. The extent of this curtailment can be estimated by analyzing the four major factors influencing future world energy consumption; 1) economic growth, 2) energy prices, 3) inter-fuel substitution, and 4) availability of energy supplies. It must be noted that the above factors are interdependent and the following discussion is made considering this interdependency.

Economic Growth

In the past, a virtually unlimited supply of energy was available for economic growth. With the prospect of future energy shortages, it is necessary to set realistic economic growth goals and to achieve these goals with a more efficient use of limited energy supplies.

At the conclusion of the recent Bonn Summit meeting (July, 1978), seven heads of state released important statements regarding future energy actions. The emphasis of these actions was placed on conservation and increased domestic energy production. To achieve these objectives, aggressive conservation programs as well as the rapid development of domestic energy resources are necessary.

Table 2 summarizes the projected economic and energy growth rates resulting from the summit. These rates were utilized as input to the three macroeconomic models previously described. Barring any major disruptions in the world economic system, the goals set at the summit are quite reasonable and are likely to be achieved.

TABLE 2. ENERGY AND GNP RELATIONS, THE SEVEN SUMMIT COUNTRIES.

COMPOUND ANNUAL GROWTH RATES (PERCENT)						
	1960-73		1973-77		1977-85	
	REAL GNP	ENERGY	REAL GNP	ENERGY	REAL GNP	ENERGY
EUROPE	4.9	5.0	1.6	0.4	3.3	2.6
JAPAN	10.3	11.2	3.1	0.1	5.1	3.6
CANADA	5.6	5.7	3.3	2.3	4.4	4.0
U.S.	4.1	4.1	2.0	0.3	3.8	2.8
IMPLIED ENERGY-GNP ELASTICITY						
	1960-73		1973-77		1977-85	
EUROPE	1.02		0.25		0.80	
JAPAN	1.09		0.04		0.70	
CANADA	1.02		0.68		0.90	
U.S.	1.00		0.20		0.75	

SOURCE: REFERENCE 7.

Energy Prices

Energy prices have been and will continue to be dominated by the price of crude oil. To a large extent, future world crude oil prices will be set by the OPEC cartel which controls an enormous percentage of the total non-communist oil and gas reserves. Most major energy studies have projected OPEC crude oil prices to remain constant in real terms (i.e. price increases equalling the rate of inflation) or increasing only slightly (8,9,10,11,12).

The average annual projected increases in OPEC crude oil prices utilized in the DRI macroeconomic models vary from 7.4% (1.5% above the average U.S. inflation rate) for the TRENDLONG model to 10.7% (2.8% above the average inflation rate) for the PESSIMLONG model. The actual domestic energy prices are influenced additionally by U.S. governmental policies. Current domestic oil prices are well below world levels and recent energy legislation, which proposes to raise domestic oil prices to world levels by 1980, is given virtually no chance of passing. However, increases in nonregulated domestic oil production from the Alaskan slope, enhanced recovery techniques, and stripper wells, will raise the average price of domestic oil over the next few years. As a result, wholesale fuel prices will rise at a more rapid rate than import fuel prices.

The DRI fuel pricing projections are summarized in Table 3.

Interfuel Substitution

The ability of world economies to convert primary oil and gas consumers to consumers of more plentiful energy sources (such as coal

TABLE 3. SUMMARY OF DRI ENERGY-RELATED PROJECTIONS (COMPOUND ANNUAL GROWTH RATES IN PERCENT).

	TRENDLONG 1977-90	CYCLELONG 1977-90	PESSIMLONG 1977-90
<u>FUEL IMPORTS</u>			
PRICE OF FUEL IMPORTS	7.4	9.2	10.7
REAL FUEL IMPORTS	2.4	2.4	2.4
<u>DOMESTIC PRICES</u>			
WHOLESALE FUEL PRICE	8.9	10.4	11.0
GASOLINE PRICE DEFLATOR	6.2	7.3	8.2
GNP PRICE DEFLATOR	6.1	6.8	7.9

SOURCE: REFERENCE 7.

and nuclear energy) will be an important factor in determining future energy supply and demand equilibrium. The extent of non-OPEC coal resources is substantial. However, due to the inherent time lag in coal conversions resulting from technological problems and short-term coal production limitations, the importance of coal in the total energy picture will be one of only gradual increase over the time period of this analysis.

It is generally acknowledged that the environmental problems associated with nuclear energy will affect only its short-term growth rates and the continual search for inexpensive energy sources will make nuclear energy an increasingly important energy source throughout the 1980's. Other energy sources, such as solar and geothermal, cannot be expected to make significant contributions to the world energy needs until at least the 1990's.

In conclusion, although interfuel substitution will become a relatively important factor in reducing oil and gas demand pressures (particularly in the late 1980's), it must be realized that oil and gas will remain the dominant energy sources well into the 1990's.

A perspective of U.S. energy supply by type of energy source is presented in Figure 5.

Energy Supplies

Future world energy supplies will be determined by; 1) the energy production of energy importing nations, 2) the OPEC energy production, 3) the energy production of communist nations.

FIGURE 5. A PERSPECTIVE OF U.S. LONG-TERM ENERGY SUPPLY

SOURCE: REFERENCE 12.

Estimates of energy production among energy importing nations, represented here by the Organization for Economic Cooperation and Development (OECD) which includes most major non-communist industrial nations, are provided by the Department of Energy (12) and are summarized in Figure 6. This figure is based on the Department of Energy (DOE) projection series C which used an earlier run of the DRI TRENDLONG model to project future world economic conditions and whose basic energy and economic assumptions are similar to those used in the TRENDLONG model run utilized in this analysis. Table 4 reveals that despite significant increases in OECD energy production, the OECD nations will become even more dependent on non-OECD energy imports in the future.

The projected U.S. petroleum and natural gas supplies, under the same DOE projection scenario C (Figures 7 and 8), reflect the future U.S. dependence on imported energy.

As a result of the energy import needs of OECD nations, the OPEC energy production (specifically oil) is the critical driving force in all energy related projections. Estimations of OPEC oil production capabilities vary considerably. But it is generally realized that sufficient OPEC production capacity exists to meet world needs until at least the 1990's providing that controlled worldwide energy growth rates are achieved.

Much uncertainty shrouds the role that communist nations will play in the world energy balance. It seems most likely that the role of communist nations as net importers or net exporters of energy will be relatively small for some time.

FIGURE 6. OECD ENERGY PRODUCTION 1960-1990 DEPARTMENT
OF ENERGY, PROJECTION SERIES C

SOURCE: REFERENCE 12.

TABLE 4. OECD DEPENDENCE UPON ENERGY IMPORTS FROM NON-OECD COUNTRIES (PERCENT OF ENERGY CONSUMPTION). DOE PROJECTION SERIES C.

	1975 ACTUAL	1985	1990
UNITED STATES	16	24	27
CANADA	24	13	22
OECD EUROPE	60	52	55
AUSTRALIA/ NEW ZEALAND	27	24	29
JAPAN	85	79	79
TOTAL OECD	37	39	43

SOURCE: REFERENCE 12.

FIGURE 7, PROJECTED U.S. PETROLEUM LIQUIDS SUPPLY
DEPARTMENT OF ENERGY PROJECTION SERIES C

SOURCE: REFERENCE 12.

FIGURE 8. PROJECTED U.S. NATURAL GAS SUPPLY
DEPARTMENT OF ENERGY PROJECTION SERIES C

SOURCE: REFERENCE 12.

Table 5 presents a comparison of major study forecasts regarding world oil production and consumption in 1985.

TABLE 5. COMPARISON OF ALTERNATIVE WORLD OIL FORECASTS FOR 1985 (MILLION BARRELS PER DAY).

	DOE 1/	CIA 2/	CRS 3/	MAES 4/	OECD 5/
WORLD OIL CONSUMPTION 6/	66	70	69	61	64
NON-OPEC PRODUCTION 6/	24	25	25	23	25
NET COMMUNIST EXPORTS	-2.5	-4	1	NA	1
OPEC PRODUCTION	44.5	49	43	38	39

1/ DEPARTMENT OF ENERGY, PROJECTIONS OF ENERGY SUPPLY AND DEMAND AND THEIR IMPACTS, PROJECTION SERIES C, APRIL 1978.

2/ THE INTERNATIONAL ENERGY SITUATION: OUTLOOK TO 1985, APRIL 1977, MEDIAN FORECAST.

3/ CONGRESSIONAL RESEARCH SERVICE, PROJECT INTERDEPENDENCE, JUNE 1977.

4/ WORKSHOP ON ALTERNATIVE ENERGY STRATEGIES PROJECT, GLOBAL PROSPECTS 1985-2000, MAY 1977, AVERAGE OF CASES PRESENTED.

5/ OECD WORLD ENERGY OUTLOOK, APRIL 1977, REFERENCE CASE.

6/ EXCLUDES CENTRALLY PLANNED ECONOMIES.

SOURCE: REFERENCE 12.

CHAPTER 3

FUEL EFFICIENCY PROJECTIONS

In this study, fuel efficiencies are projected for five vehicle types: a) auto, b) motorcycle, c) bus, d) single-unit truck, and e) combination truck. Projections of auto fuel efficiencies were achieved through a modeling procedure, whereas all other vehicle categories were projected using simple linear extrapolation. Details of the assumptions and techniques used for such projections are presented in the following sections.

Auto Fuel Efficiency Model

The estimation of future auto fleet fuel efficiencies is of vital importance to the projection of revenues derived from fuel taxes. Previous efforts in this area have been highly simplified or have ignored the causal economic factors which affect future fleet fuel efficiencies (2,3,13). The approach developed for the present study considered the possible effects of the national economic climate and included a high degree of interaction between the prevailing economic conditions and the model parameters.

The basic approach used in the model is to a) determine the number of autos in use by model year, b) estimate auto fuel efficiencies by model year, and c) establish the relative auto usage by model year. Once these items are estimated, the average auto fleet

fuel efficiency can be readily determined. The entire model simulation procedure is outlined in Figure 9.

As the state level data was not available for Indiana, the auto fleet fuel efficiency values were generated on the national level and then applied to the Indiana auto fleet.

A detailed discussion of the auto model components is presented in the following paragraphs.

Determination of the Number of Autos in Use by Model Year

The base year information is provided as input data. A cohort survival technique is then utilized to predict the number of autos in use by model year for the subsequent simulation years. The three major components of this technique are described below.

New Car Sales - The obvious impact of new car sales is that it will directly determine the population of the first cohort. However, in addition, new car sales will affect the survival rates of older model years since it is inherently assumed that the same economic conditions that influence new car purchases also influence auto scrappage decisions. Historical data supports this assumption (14).

Alternate projections of new car sales provided by the three macroeconomic model runs prepared by DRI were used for the purpose of this study. These projections are presented in Figure 10. As might be expected, new car sales are influenced considerably by economic conditions as indicated by the variation in sales between the three DRI models.

FIGURE 9. SIMULATION PROCEDURE FOR AUTO FUEL EFFICIENCY MODEL

FIGURE 10. SUMMARY OF DRI NEW CAR SALES FORECASTS

SOURCE: REFERENCE 7.

Automobile Ownership - Clearly, total auto ownership will have a direct impact on survival rates and therefore its accurate projection is vital to model accuracy. For the purpose of this study, the national auto ownership forecasts developed by DRI, based on three scenarios of national economic conditions, were used. These projections are presented in Table 6.

Survival Rates - A survival rate is defined as the probability of a vehicle of a particular model year surviving to the next calendar year, and the appropriate base year values were developed on the basis of the data given in the reports provided by R. L. Polk and Company (14), in which the number of autos in use by model year are estimated.

A number of approaches have been used by previous researchers to estimate future auto survival rates. One of the most notable research efforts (15) in this area applied a Weibull distribution to approximate existing survival rates. Although this approach provided reasonably good estimates of existing survival rate distributions, the projection of future survival rates proved to be inaccurate due to the inherent instability of the survival rate distribution over time. To overcome this problem a procedure was developed in the present study that indirectly approximates future survival rate distributions by estimating annual changes in each cohort survival rate.

The primary task of the proposed procedure is to estimate the relative magnitude of change in each cohort survival rate. An analysis of past data revealed that during periods of high overall

TABLE 6. SUMMARY OF DRI NATIONAL AUTOMOBILE OWNERSHIP FORECASTS (IN MILLIONS).

<u>YEAR</u>	<u>TRENDLONG</u>	<u>CYCLELONG</u>	<u>PESSIMLONG</u>
1976	98.7	98.7	98.7
1977	100.8	100.8	100.8
1978	103.0	103.0	103.0
1979	105.6	105.7	105.9
1980	108.5	109.4	108.4
1981	111.0	111.9	110.7
1982	113.0	112.9	112.7
1983	115.4	115.1	114.8
1984	118.2	118.7	116.9
1985	120.9	122.0	119.5
1986	123.5	123.5	122.4
1987	126.0	126.0	124.6
1988	128.3	129.6	126.9
1989	130.5	132.9	129.8
1990	132.3	134.8	132.4

SOURCE: REFERENCE 7.

survival rate change the survival rates of the older cohorts varied more than those of newer cohorts. This phenomenon is illustrated in Figure 11 and can be attributed to the fact that a larger number of older autos are marginally economic. Therefore, a shift in economic conditions will logically have a larger impact on older auto scrappage decisions and, subsequently, on survival rates.

The above observation led to the development of a random assignment procedure to approximate survival rates. This procedure is based on the assumption that there exists a number of "select" marginally economic autos which can be envisioned as those marginally economic autos that are most likely to be affected by changes in national economic conditions. The number of these autos is computed as the difference between the actual auto ownership and the auto ownership estimated by calculating surviving autos, using the survival rates from the preceding year and adding new car sales. This assumption is based on historical data (14) which reveals a definite relationship between prevailing economic conditions and the magnitude of the difference referred to above. The magnitude of this difference in turn reflects the amount of change in the survival rates, of each cohort, from year to year.

Subsequently, data from years with high survival rate changes was used to determine the historical probabilities of "select" marginally economic autos being retired or retained in each cohort. These historical probabilities were calculated from the following equation:

$$CP = \frac{ACSA - (SURV_{-1} * CPOP_{-1})}{\sum_{i=1}^n CPOP - \sum_{i=1}^n (SURV_{-1} * CPOP_{-1})} \quad (3.1)$$

where

CP = the cohort probability of a "select" marginally economic auto being retired or retained in that cohort during a given year.

ACSA = actual number of surviving autos in the cohort.

SURV₋₁ = preceding year's survival rate.

CPOP₋₁ = cohort population of preceding year.

CPOP = present cohort population.

n = total number of cohorts.

The results of the application of the above equation were used to create the following regression equation. The t-values are indicated in parentheses.

$$Y = .02684 + .000127(X)^3 \quad (3.2)$$

(4.93) (15.69)

F = 246.26 R² = .965

where

Y = the probability of a "select" marginally economic auto being retired or retained in cohort of age X.

X = the age of the cohort in years.

In this analysis, the age of the cohorts (X in the above equation) ranged from 1 to 12 years with the 12th year cohort including all autos 12 years old and older. It was decided to include autos of 12 years or older in the final cohort since the survival

rates of autos at this age or older stabilize at approximately the same rate (see Figure 11).

The number of "select" marginally economic autos in any future year is determined from:

$$SMEA = AO - \left[\sum_{i=1}^n (SURV_{-1} * CPOP_{-1}) + NCS \right] \quad (3.3)$$

where

SMEA = the number of "select" marginally economic autos in given year.

AO = projected auto ownership in given year (see Table 6).

$SURV_{-1}$ = cohort survival rate in preceding year.

$CPOP_{-1}$ = cohort population in preceding year.

NCS = new car sales in given year.

These autos (SMEA) are assigned (or detracted, if negative) from specific cohorts using a random number generator and the probabilities estimated in equation 3.2. Each cohort survival rate is then revised (for future use) such that the multiplication of the survival rate by the cohort population of the preceding year is equal to the new cohort population after the random assignment technique described above is implemented. This procedure is illustrated by the following equation:

$$RCSR = \frac{SURV_{-1} * CPOP_{-1} + AMA}{CPOP_{-1}} \quad (3.4)$$

where

RCSR = the revised cohort survival rate.

$SURV_{-1}$ = the cohort survival rate of the previous year.

FIGURE 11. CHANGES IN SURVIVAL RATE DISTRIBUTIONS BETWEEN YEARS OF
HIGH OVERALL SURVIVAL RATE CHANGES

$CPOP_{-1}$ = the cohort population in the preceding year.

AMA = total number of assigned or detracted autos in the cohort during the desired year.

Equations 3.3 and 3.4 are applied annually until the target year is reached. Thus, the number of autos existing in each cohort, during any given year, can be estimated.

This procedure was validated by estimating historical survival rate changes, and it was found that such estimations compared favorably with historical survival rate changes (14).

Future Auto Fuel Efficiencies by Model Year

Auto fuel efficiency information is provided as exogenous data to the model. The average model year fuel efficiencies can easily be established since the average efficiency of each existing model year is known from existing data and future fuel efficiencies can be assumed to conform with those mandated by government regulations (see Table 7).

Relative Auto Usage by Vehicle Age

Studies have shown that newer autos generally accumulate more annual miles than do older autos (17,18). The most recent study (The Nationwide Personal Transportation Survey 1969-70) was used to develop the following regression equation which estimates the relative auto usage by auto age.

$$Y = 1.8535 - .4813 \ln (X + 1) \quad (3.5)$$

$$(20.38) \quad (-10.039)$$

$$F = 100.796 \quad R^2 = .92$$

TABLE 7. MANDATED FEDERAL FUEL ECONOMY STANDARDS FOR AUTOS.

MODEL YEAR	MILES PER GALLON
1978	18.0
1979	19.0
1980	20.0
1981	21.5
1982	23.0
1983	24.5
1984	26.0
1985 AND BEYOND	27.5

SOURCE: REFERENCE 16.

where

Y = weighted usage by auto age.

X = age of auto in years (e.g. X=0 for autos 0-1 years,

X=1 for autos 1-2 years, etc.)

Auto Fleet Fuel Efficiency Calculations

Overall auto fleet fuel efficiency can now be determined simply by multiplying the average fuel efficiencies of each cohort by; a) the number of autos in use in each cohort divided by the total number of autos in use and b) the relative usage factors estimated from the above equation. The summation of these multiplications will be the average auto fleet fuel efficiency in any given year. The above calculation is represented by Equation 3.6.

$$AFE = \sum_{i=1}^n \left(\frac{CPOP}{TPOP} * RUF * CFE \right) \quad (3.6)$$

where

AFE = auto fleet fuel efficiency in desired year.

CPOP = cohort auto population in desired year.

TPOP = total auto population in desired year.

RUF = relative usage factor calculated in Equation 3.5.

n = total number of cohorts.

CFE = average cohort fleet fuel efficiency.

Other Vehicle Fuel Efficiency Estimations

Due to data limitations, fuel efficiency values for other vehicle types cannot be estimated in a detailed manner. Therefore, the fuel efficiency projections of these vehicle types were made by extrapolating

recent efficiency estimates (1) and utilizing the results of previous studies (2,3). Table 8 summarizes the appropriate fuel efficiency projections.

The fleet fuel efficiencies determined in this chapter are used to estimate annual fuel consumption which is then used to project motor fuel tax revenues. The technique utilized to estimate annual fuel consumption is discussed in the next chapter.

TABLE 8. SUMMARY OF FUTURE FUEL CONSUMPTION ESTIMATES.

YEAR	CYCLE MPG	BUS MPG	TRUCKS	
			SINGLE UNITS MPG	COMBINATIONS MPG
1976	50.00	5.29	10.56	5.77
1977	50.00	5.33	10.37	5.86
1978	50.00	5.37	10.56	5.95
1979	50.00	5.41	10.75	6.04
1980	50.00	5.44	10.94	6.13
1981	50.00	5.47	11.14	6.22
1982	50.00	5.51	11.34	6.32
1983	50.00	5.54	11.55	6.42
1984	50.00	5.57	11.75	6.51
1985	50.00	5.61	11.96	6.61
1986	50.00	5.64	12.18	6.71
1987	50.00	5.67	12.40	6.81
1988	50.00	5.71	12.62	6.91
1989	50.00	5.74	12.85	7.01
1990	50.00	5.80	13.08	7.12

CHAPTER 4

FUEL CONSUMPTION ESTIMATES

An accurate fuel consumption estimate is vital to the prediction of future fuel tax revenues. The approach most commonly used to project fuel consumption is to annually estimate a) future vehicle-miles of travel and b) future fleet fuel efficiencies. Once the above two elements have been determined, total fuel consumption can be obtained simply by dividing vehicle-miles of travel by fleet fuel efficiencies (in miles per gallon).

An outline of the modeling approach used in this analysis is presented in Figure 12. A detailed discussion of the components of this model procedure is given in the following paragraphs.

Determination of Total Vehicle-Miles of Travel (VMT)

The use of a regression model to predict national VMT is the most widely used technique. The independent variables used in previous national VMT regression equations include (19):

1. Relative price of gas and oil
2. Change in consumer price index
3. Real disposable income
4. Cost per vehicle-mile traveled
5. Unemployment rate
6. Population

FIGURE 12. SIMULATION PROCEDURE FOR THE FUEL CONSUMPTION MODEL

7. Number of autos in use
8. Number of households
9. Transit supply

Several forms of regression models were attempted into various combinations of independent variables to develop an acceptable regression equation for predicting the level of annual VMT in Indiana. The most acceptable equation achieved was a multiple time series with real disposable income and the relative gasoline price as independent variables. However, these two variables proved to be highly correlated and therefore the equation could not be used for future VMT estimation.

The problem of multicollinearity in such an analysis is extensive; since any variable that increases regularly with time correlates well with VMT. As a result, it was found that some independent variables accounted for as much as 98% of the VMT variance and that combinations of two or more independent variables seldom accounted for less than 99% of the VMT variance. Therefore, it was virtually impossible to isolate the causal determinants of VMT.

Another factor restricting the application of a regression model is the poor quality of existing VMT data. Traditionally, the most reliable source of VMT data has been the annual estimates provided by the Federal Highway Administration. These estimates are made on the basis of statewide fuel sales and approximations of motor vehicle fleet fuel efficiencies.

The accuracy of the VMT estimates given in Highway Statistics (1) is questionable, because a) fleet fuel efficiency estimates tend to be broad estimates, and b) states in general tend to overestimate the VMT values. The Claffey report (20), which was prepared for the FHWA, presented detailed estimates of VMT from fuel consumption reports in eight states; it was observed that the state estimates of VMT averaged 6.5 percent higher than those estimates based on the fuel consumption reports used by Claffey.

Due to the inherent problems of predicting VMT with a regression model, the total VMT estimation for the purpose of this study was made by utilizing the VMT equation developed from the first principles of elasticity by Poister, Larson, and Rao (21). The VMT estimation equation developed by Poister, et.al. is given below:

$$VMT = VMT_{1977} * (1+GR)^i * (1+EP * \frac{GPI-GPI_{base}}{GPI_{base}}) \quad (4.1)$$

where

VMT = total VMT in desired year

VMT_{1977} = total VMT in base year (1977)

GR = assumed annual growth rate

i = number of years beyond base year

EP = elasticity of demand for VMT with respect to fuel price

GPI = gasoline price index (1977 = 1.00)

The above equation requires the assumption of an annual growth rate and the estimation of the demand elasticity of VMT with respect to fuel price.

The annual growth rate chosen for this analysis is 3.3 percent. A slightly higher value was chosen than the 2.5 percent annual growth rate used in the 1976 National Highway Inventory and Performance Study (5); since the 1976 study accounted for increasing fuel price in the annual growth rate considered, and subsequently, did not consider the elasticity of VMT with fuel price.

The value of $-.10$ was selected as the gasoline price elasticity of VMT. This value was derived from existing Indiana VMT data and the gasoline price changes along with the relevant literature (13).

Future gasoline price indices were determined by using the gas price deflator forecasts provided by the three DRI macroeconomic models (see Figure 13).

The Estimation of the Rate of Change in Commercial Vehicle-Miles of Travel

The separate estimation of commercial VMT (composed primarily of combination truck VMT) is essential as these vehicles determine, to a large extent, pavement deterioration rates. It was decided, on the basis of available data, that the future commercial vehicle VMT values could be most accurately estimated by modeling the annual rate of change in these values. This modeling procedure is described in the following paragraphs.

The technique developed for this analysis estimates future changes in commercial VMT indirectly, by assuming that the change in total commercial vehicle-miles traveled is proportional to the change in motor truck intercity ton-miles. This assumption is the basis for the following equation:

FIGURE 13. SUMMARY OF DRI GASOLINE PRICE DEFLATOR FORECASTS

$$\frac{\Delta \text{CVMT}}{\text{CVMT}} = \frac{\Delta(\text{TITM}/\text{ALCI})}{(\text{TITM}/\text{ALCI})} \quad (4.2)$$

where

TITM = the motor truck intercity ton-miles

CVMT = the total commercial vehicle-miles traveled

ALCI = the average load carried index (1975 = 1.00) (includes empty and loaded trips)

This equation inherently assumes that the growth rate in intra-city ton-miles will be the same as the growth rate in intercity ton-miles. Fortunately, an overwhelming percentage of total ton-miles are intercity ton-miles, and therefore, should the above assumption prove to be invalid, the overall accuracy of the projections will be affected only slightly.

The use of the above equation to estimate commercial VMT requires the projection of both motor truck intercity ton-miles and the average load carried index.

Projection of Motor Truck Intercity Ton-Miles

Several techniques have been developed in recent years to project intercity ton-miles (22). These can be classified into four basic categories: a) the regression analysis, b) econometric models (simultaneous equation systems), c) input-output models and, d) economic base studies. However, almost all of the past studies have been national in scope, and as such, do not address the unique problems encountered when attempting to project intercity ton-miles on a statewide basis. These unique problems include: 1) the non-availability of statewide motor truck intercity ton-mile data,

2) the economic interdependence between states is difficult to quantify, and 3) accurate statewide economic indicators are seldom available.

For the purpose of this study a regression approach was chosen since the lack of necessary statewide data precluded the use of econometric models, input-output models, and economic base studies. The development of a regression model necessitated the accurate approximation of past Indiana motor truck intercity ton-miles. This was achieved by multiplying national motor truck intercity ton-mile estimates by the ratio of the Indiana highway consumption of special fuels to the national highway consumption of special fuels. The highway consumption of special fuels, which constitutes all non-gasoline highway fuel consumption (diesel, LPG, and so on), is documented annually by the Federal Highway Administration. The validity of this proportion technique is based upon the fact that a large percentage of motor truck intercity ton-miles is transported by vehicles which use special fuels. The application of this technique assumes that the national truck characteristics (average load carried, fuel efficiencies, and so on) are approximately equal to the Indiana truck characteristics. This would appear to be a relatively safe assumption on the basis of existing truck characteristic data (23,24).

The following regression model was constructed using the approximated statewide motor truck intercity ton-miles.

$$\text{TITM} = -51.48 + 8.95 \log \text{BI} + 8.72 \log \text{SP} \quad (4.3)$$

(-15.6)
(4.76)
(3.66)

$$R^2 = .97$$

$$F = 265.73$$

where

TITM = Indiana truck intercity ton-miles

BI = national business index (1967 = 100.)

SP = Indiana steel production in millions of tons

The business index, which is a measure of total national industrial production, attempts to account for the economic interdependence between states. In addition, steel production was found to be a strong indicator of Indiana economic conditions and motor truck intercity ton-miles. This is due in part to the fact that steel production correlates highly with coal shipments, production of durable goods (autos, and so on), and other manufacturing activities all of which are determinants of both economic conditions and motor truck intercity shipments. Thus, the inclusion of the business index (BI) and steel production represents the logical assumption that Indiana motor truck intercity ton-mileage is a function of both state and national economic conditions.

Future business index forecasts, as provided by Data Resources Inc. (DRI), are presented in Figure 14. Figure 15 summarizes the DRI forecasts of the national steel production index. It was assumed, on the basis of recent trends and economic projections provided by other sources (12), that the Indiana steel production index would equal the nationally projected steel production index. Therefore, the actual Indiana steel production (in millions of tons) can be calculated from the following equation:

$$SP = SP_b * \frac{SPI}{SPI_b} \quad (4.4)$$

FIGURE 14. SUMMARY OF DRI INDUSTRIAL PRODUCTION (BI) FORECASTS

SOURCE: REFERENCE 7.

FIGURE 15. SUMMARY OF DRI NATIONAL IRON & STEEL PRODUCTION INDEX FORECASTS

SOURCE: REFERENCE 7.

where

SP = steel production in desired year

SP_b = steel production in base year

SPI = steel production index in desired year

SPI_b = steel production index in base year

Projection of Average Load Carried Index

The average load carried index is a function of a) the efficiency of the trucking industry indicating the extent of the number of empty and partially full trips, and b) the prevailing maximum weight limits.

An accurate determination of the future operating efficiency of the trucking industry is virtually impossible since future efficiencies will depend to a large extent on government policies regarding motor carrier regulations. However, an analysis of recent data has revealed that there has been no appreciable change in the percent of trucks carrying loads or the average load carried by loaded trucks (1). Subsequently, this factor was assumed to have no effect on future average load carried indices (ALCI).

Should Indiana decide to raise the maximum axle weight limits, the ALCI would obviously increase resulting in lower commercial truck VMT values (all other factors remaining constant), since less trucks would be required to move the same amount of tonnage. Estimating the extent of the ALCI change is dependent on a) the magnitude of the increase in maximum axle weight limits and b) the effect that this increase will have on truck weight distributions. An example of the calculation procedure used to estimate the ALCI when maximum axle weight limits are increased is presented in Chapter 8.

Estimation of Future VMT by Vehicle Type

Due to the fact that there is considerable variation in the fuel consumption characteristics of different vehicle types, it was necessary to segregate VMT into a) auto VMT, b) motor cycle VMT, c) bus VMT, d) single unit truck VMT, and e) combination truck VMT. This segregation was achieved by a) estimating the apportionments of total VMT constituted by each vehicle type in the base year and b) projecting future VMT values by vehicle type by applying growth rates to the above apportionments.

The apportionment of total VMT constituted by each vehicle type was determined by assuming that the national estimates of these apportionments would apply to Indiana (1). This assumption is consistent with the efforts of previous researchers (2,3).

Estimates of the future growth rates in the VMT apportionments assigned to single unit trucks, buses, and motorcycles, were made on the basis of recent trends (1) and an analysis of past studies (2,3). The resulting values are: a) a 0.5 percent annual VMT apportionment growth rate for both buses and single unit trucks, and b) a zero growth rate for motorcycle VMT apportionments.

The VMT apportionment by combination trucks was assumed to grow at the same rate as the commercial VMT growth rate (see equation 4.2), since combination trucks are almost exclusively used for commercial purposes.

Auto VMT is determined simply by subtracting the VMT apportionments of other vehicle types from the total VMT.

Calculation of Annual Fuel Consumption

Once the VMT values by vehicle type are known along with the appropriate fuel efficiencies (calculated from the previous chapter), total annual fuel consumption can be determined from the following equation:

$$AFC = \sum_{i=1}^5 \frac{VMT_i}{FE_i} \quad (4.5)$$

where

AFC = annual fuel consumption (in gallons)

i = vehicle type (auto, bus, and so on)

VMT_i = annual vehicle-miles traveled by vehicle type i.

FE_i = average annual fuel efficiency of vehicle type i.

The annual fuel consumption values, determined from the above equation, are used as a basis to project the state motor fuel tax revenues which constitute the largest single source of Indiana state highway revenue. The procedures used to calculate motor fuel tax revenues and other state road-user revenues are discussed in the next chapter.

CHAPTER 5

REVENUE GENERATION

For this analysis, highway revenues were categorized by 1) state road user tax revenues, 2) federal road user tax revenues, and 3) non-user tax revenues which include appropriations from general funds. Federal road user tax revenues include those revenues collected by federal agencies from federal taxes on fuel, lubricating oil, motor vehicles, tires, vehicle parts and accessories, and motor vehicle usage. Non-user revenues are derived from such sources as property taxes, bond proceeds, appropriations from general funds, and other miscellaneous non-user receipts. An accurate projection of non-user taxes and the portion of federal road user taxes being returned to the state is difficult to obtain, due to the fact that the projection of funds from these sources depends to a large extent upon future legislative decisions which can vary considerably. As a result, revenue estimations from these sources are determined exogenously. A description of the procedure used for such determinations is presented in Chapter 8.

The revenues derived from state user taxes can be readily calculated once estimates of future tax and fee rates and projections of revenue sources are made. A set of possible future tax and fee rates was considered which were then used in various model runs. Revenue

sources were projected by classifying state user-tax revenues into four basic sources: 1) revenues derived from motor vehicle registrations, 2) revenues derived from license fees, 3) revenues derived from state taxes on motor fuel and, 4) revenues derived from miscellaneous user sources.

Projected Motor Vehicle Registrations

Registration projections were made under the following assumptions:

1. Motorcycle registrations, bus registrations, and single-unit truck registrations (which are comprised mainly of privately owned pickups and vans) will be proportional to future auto registrations.
2. Combination truck registrations will be independent of auto registrations and influenced by prevailing economic conditions.

Auto Registration Projections

Although the DRI macroeconomic forecasts provided nationwide auto ownership projections, the Indiana auto ownership estimates could not be made as a proportion to national auto ownership, because of differential growth rates observed in historical data (1). As a result, a separate procedure was developed to predict automobile registrations in Indiana.

In an attempt to develop an appropriate regression equation the problem of multi-collinearity among independent variables made the task of isolating causal determinants impossible. Previous researchers (25) have developed regression equations to predict auto

ownership using real disposable income as the independent variable. Although pre-1974 data would appear to substantiate these equations; the data of recent years renders the validity of such an approach questionable as the observed decrease in real disposable income has had virtually no effect on auto ownership trends (1). It is therefore reasonable to suggest that auto ownership is determined by a far more complex behavioral choice process than the simple income model.

Due to the absence of data necessary to simulate the actual behavioral choice process that determines auto ownership, an alternative technique was adopted. This technique, utilized in a number of previous studies (2,15,26) assumes that an automobile saturation will be reached at which time the number of vehicles per capita will stabilize. This assumption seems reasonable since the current rate of increase in per capita ownership cannot be expected to continue indefinitely. However, establishing the point at which per capita ownership will stabilize was somewhat subjective as there was little evidence of such stabilization trends in existing data. The saturation value of .6 autos (in use) per capita to be achieved in the year 2000 was used in the present analysis. This value is comparable to the values selected by other researchers (2,26).

Once the saturation value was established, a power curve was fitted to the original data so that annual estimates of per capita auto ownership could be made. The equation used assumes the following form:

$$Y = S + K(100 - X)^P \quad (5.1)$$

where

Y = projected persons per auto in a given year.

S = projected saturation point for the year 2000.

K = constant determined through curve fitting.

X = last two digits of a given year.

P = exponent determined through curve fitting.

Once the number of persons per auto is established from the above equation, estimates of future Indiana auto registrations can be readily calculated providing statewide population projections are made.

Statewide Population Projections

In this study, the cohort survival method was used to project statewide population. This method accounts for births, deaths, and adjusts for migration. The projection was achieved by dividing the total population into 16 male and female age groups considered in five year increments. The initial number in each of the five year cohorts was obtained from data presented in the 1970 U.S. Census.

The future survival rates, which are defined as the probability of a cohort member surviving to the succeeding cohort, were taken directly from the estimates presented by the Bureau of the Census (27). The bureau also provides low, intermediate and high estimates of future cohort fertility rates. The future fertility rates used in this study (see Table 9) were assumed to be between the low and intermediate estimates so as to be consistent with recent fertility rate trends.

Indiana has experienced a relatively high net outward migration in recent years. Since the exodus of industry and population to the

sunbelt states is expected to continue well into the future, net outward migration can be assumed to persist over the time period of this analysis. However, the magnitude of this outward migration was projected to decrease over time, due to the fact that economic conditions in Indiana are expected to compare favorably to those of other industrial states. The estimated migration rates are presented in Table 10.

Population projections using five year cohorts can be made only at five year intervals, therefore, linear extrapolation was used to obtain intermediate annual estimates. Table 11 presents the results of the cohort method using the survival, fertility, and migration rates described above. These results tend to be lower than those estimated by other studies (2,3,28). This is due largely to the fact that previous studies have under-estimated the actual net outward migration in Indiana from 1970-1975.

The number of registered autos in any given year can be estimated simply by dividing the appropriate annual state population by the corresponding persons per auto determined from Equation 5.1. The results obtained for the state using the saturation procedure used in this study were observed to be consistent with the DRI national auto ownership projections.

Truck, Bus, and Motorcycle Registrations

Projections of single-unit truck registrations and bus registrations were made by multiplying auto registrations by an appropriate factor which was derived from recent registration data. Growth rates

TABLE 9. ESTIMATED ANNUAL FERTILITY RATES PER 1000 WOMEN OF CHILD-BEARING AGE (15-49) IN INDIANA.

YEARS	FERTILITY RATE
1970-1975	71.5
1975-1980	70.0
1980-1985	69.1
1985-1990	67.1

TABLE 10. ESTIMATED NET MIGRATION FOR INDIANA (IN PERCENT OF POPULATION).

YEARS	MALE	FEMALE
1970-1975	-1.90	-1.71
1975-1980	-2.21	-2.00
1980-1985	-0.95	-0.86
1985-1990	-0.53	-0.48

TABLE 11. INDIANA POPULATION PROJECTIONS TO 1990.

YEAR	FEMALE	MALE	TOTAL
1976	2721213	2583408	5304622
1977	2724349	2585777	5310128
1978	2734861	2595147	5330011
1979	2753609	2612330	5365943
1980	2776940	2633871	5410811
1981	2794016	2650734	5444751
1982	2811092	2667597	5478691
1983	2828168	2684460	5512631
1984	2845244	2701323	5546571
1985	2862323	2718189	5580512
1986	2880076	2736110	5616187
1987	2897829	2754031	5651862
1988	2915582	2771952	5687537
1989	2933335	2789873	5723212
1990	2951091	2807798	5758889

for these factors were applied to single-unit truck registrations (.5 percent per annum) and bus registrations (.05 percent per annum). These growth rates were determined from observed trends in state registration data (1). The projection equation assumed the following form:

$$XREG = PRP_{base} * (1 + GRP)^i * AREG \quad (5.2)$$

where

XREG = the registration estimate by vehicle type in the desired year.

PRP_{base} = the ratio of registration by vehicle type to auto registration in the base year.

GRP = the assumed growth rate in the ratio described above.

AREG = total auto registration in the desired year.

Motorcycle registrations were assumed to remain at the same proportion to auto registration (i.e., GRP = 0) over the time period of this analysis. Table 12 summarizes the registration projections achieved using the above techniques.

The number of combination trucks being registered in any given year is dependent, to some extent, upon economic conditions, since combination trucks are used almost exclusively for commercial purposes. Problems of multicollinearity among independent variables precluded the use of a regression analysis involving a detailed evaluation of the causal variables. Future combination truck registrations were estimated by assuming a growth rate and an elasticity of demand for registrations with respect to the business

TABLE 12. SUMMARY OF INDIANA MOTOR VEHICLE REGISTRATION PROJECTIONS.

YEAR	AUTO REGISTRATIONS	SINGLE UNIT TRUCK REGISTRATIONS	BUS REGISTRATIONS	MOTORCYCLE REGISTRATIONS
1976	2652311	719703	14860	145877
1977	2713495	739987	15210	149242
1978	2759177	756207	15474	151754
1979	2803721	772258	15732	154204
1980	2847795	788320	15987	156628
1981	2882846	802012	16192	158556
1982	2915602	815181	16384	160358
1983	2946675	827988	16567	162067
1984	2976460	840538	16743	163705
1985	3005231	852907	16913	165288
1986	3034119	865406	17084	166876
1987	3062337	877823	17251	168428
1988	3089993	885750	17416	169949
1989	3117173	898009	17578	171445
1990	3143945	910249	17738	172917

index (which is a measure of industrial production and a strong indicator of economic conditions). The following equation was used to project combination truck registrations:

$$CTR = CTR_{base} (1+GR)^i * (1+EP * \frac{(BI-BI_{base})}{BI_{base}}) \quad (5.3)$$

where

CTR = combination truck registrations in the desired year.

GR = assumed growth rate in combination truck registrations.

i = number of years beyond the base year.

EP = elasticity of demand for registrations with respect to the business index.

BI = business index (1967 = 100).

The elasticity of the demand for registrations with respect to the business index was determined to be +.24. This value was derived from a number of multiple time series regressions, which were run using data from the past 15 years (1). A growth rate of 1.5 percent per annum was chosen for the time period of this analysis. This growth rate was determined by discounting the observed Indiana combination truck registration growth rate trends, which have averaged 2.5 percent annually over the past 15 years.

Review of the Current Indiana Motor

Vehicle Registration Fee Structure

The current registration fees in Indiana are \$12 for passenger cars, \$16 for school and church buses, and \$6 for motorcycles. Truck registration fees are assessed on the basis of gross vehicle weight.

It was assumed in the present study that the Indiana gross vehicle weight distributions of trucks would remain constant over the time period of this analysis and would equal the observed 1975 Indiana weight distributions of trucks. The only exception to this assumption occurs when an increase in permissible truck weight limits is considered; the effects of this consideration will be described in Chapter 8. The 1975 Indiana truck weight distributions, obtained from the 1975 Highway Statistics (1) are summarized in Table 13.

The current fee structure for trucks and private buses is outlined in Table 14.

Projected Number of Licensed Drivers

Projections of the number of licensed drivers were performed by estimating the ratio of licensed drivers per 1,000 driving age population (15 years and over). The driving age population was obtained from the cohort population projection described earlier.

The Indiana ratio of licensed drivers per 1,000 driving age population has increased steadily until the late 1960's from which time fluctuations have been evidenced with a general upward trend. It can be expected that the growth in this ratio would be small over the time period of this analysis. This decreased growth can be attributed to 1) the anticipated increase in auto costs, 2) the decreased growth rate in per capita auto ownership, and 3) the anticipated increase in transit usage.

Table 15 presents past and projected ratios of licensed drivers per 1,000 driving age population.

TABLE 13. INDIANA PERCENTAGE OF TOTAL TRUCKS BY TRUCK TYPE AND WEIGHT CATEGORY.

GROSS WEIGHT NOT EXCEEDING (LBS)	SINGLE UNIT TRUCKS	TRACTOR TRUCKS
<hr/>		
7000	78.0	0.0
9000	3.1	0.0
11000	5.2	0.0
16000	4.1	0.0
20000	2.6	1.5
26000	5.0	0.8
30000	1.1	1.3
36000	0.3	1.9
42000	0.5	3.9
48000	0.5	3.0
54000	0.2	5.6
60000	0.0	12.8
66000	0.1	2.1
72000	1/ 0.3	11.4
72000 AND OVER	-	55.7

1/ INCLUDES ALL VEHICLES WITH WEIGHTS OF 66,001 POUNDS AND OVER

SOURCE: REFERENCE 1.

TABLE 14. INDIANA MOTOR TRUCK REGISTRATION FEES (IN DOLLARS)

GROSS WEIGHT NOT EXCEEDING (LBS)	SINGLE UNIT TRUCKS AND BUSES	TRACTOR TRUCKS W/ SEMITRAILERS
7000	16	-
9000	24	-
11000	40	-
16000	65	-
20000	100	110
26000	120	190
30000	175	235
36000	225	285
42000	275	310
48000	325	360
54000	375	385
60000	400	410
66000	425	435
72000	1/ 450	485
72000 AND OVER	-	500

1/ INCLUDES ALL VEHICLES WITH WEIGHTS OF 66,001 POUNDS AND OVER

SOURCE: REFERENCE 3.

TABLE 15. SUMMARY OF RATIOS OF LICENSED DRIVERS PER 1000 DRIVING AGE POPULATION.

YEAR	LICENSED DRIVERS PER 1000 DRIVING AGE POPULATION
1950	583
1955	699
1960	720
1965	807
1970	735
1975	851
1980	860
1985	868
1990	877

Projected Net Tax Revenues From Motor Fuel Consumption

The motor fuel consumption model, discussed earlier, provides estimates of annual motor fuel consumption from which gross fuel tax revenues can be calculated simply by multiplying the total gallonage of fuel consumed by a given fuel tax rate. The net fuel tax revenues can then be computed by subtracting motor fuel refunds (originating from such sources as evaporation, spillage, and non-highway use tax compensation) from the gross fuel tax revenues. These refunds have historically averaged 3 percent of the gross fuel tax revenues and, for projection purposes, it was assumed that this value would apply over the time period of this analysis. The following equation was then used to calculate net fuel tax revenues.

$$\text{NFR} = 0.97 * \text{MFC} * \text{TR}$$

where

NFR = net fuel tax revenues

MFC = total motor fuel consumption

TR = given tax rate.

Projections of Revenue from Miscellaneous Sources

Miscellaneous sources include such items as chauffeur licenses, distributor licenses, and a variety of other motor fuel and vehicle sources. The individual projection of such sources would be a difficult and tedious task. Fortunately, the amount of revenue derived from miscellaneous sources has remained almost constant, in recent years, at 8 percent of the total state user tax revenues.

Therefore, for projection purposes, revenues from miscellaneous sources were accounted for by adding 8 percent to the sum of the revenues derived from motor fuel taxes, vehicle registrations, and driver licenses. The same approach was used by McCarthy in an earlier study (2).

CHAPTER 6

HIGHWAY PERFORMANCE

In this study, the relative performance of highway sections was considered by functional classification (e.g. interstate, arterial, collector, and so on) and it was measured in terms of a "condition index". The condition indices were scaled from 0 to 100 and they are derived by appropriately weighting relevant highway characteristics. The characteristics used to determine such an index are components of the following elements:

1. Condition - this element reflects the structural status of the roadway and is determined by such factors as the type of pavement and the pavement condition.
2. Service - the service element is a measure of traffic congestion during peak periods and is an indicator of the level of service provided by the roadway under such conditions. Highway characteristics such as peak-hour volume/capacity ratios and peak-hour operating speeds are used to evaluate this element.
3. Safety - this element is an assessment of the accident potential of the roadway. An estimate of this index is made on the basis of features such as lane widths and right shoulder widths.

The initial values of the condition indices were approximated indirectly using statewide data provided in the 1976 National Highway Inventory and Performance Study (NHIPS) (5). Tables 16 through 18 summarize the Indiana data available from this source. It should be noted that the 1976 NHIPS data is categorized by rural, urban, and small urban highway functional classifications due to the inherent variability in design standards and travel characteristics between such systems.

Descriptions of the functional systems, as defined by the FHWA publication, "Highway Functional Classification, concepts, criteria, and Procedures" (29) are as follows:

1) Principal Arterial System -- In rural areas, a network of routes that primarily serves travel of statewide or interstate significance; serves virtually all urban areas over 50,000 population; provides high overall travel speed with minimum interference to through activity; serves the highest traffic volume corridors and the longest trip lengths; and carries a high proportion of urban area travel.

The principal arterial system is substratified as follows:

1) interstate; 2) other freeways and expressways (in urban areas only); and 3) other principal arterials.

2) Minor Arterial System -- In rural areas, a network of routes which provides access to principal arterial routes, and in conjunction with principal arterials, forms a network which links cities and larger towns to facilitate interstate and intercounty service.

In urban areas, this system provides service to trips of moderate length at a somewhat lower level of travel mobility. Such routes interconnect with and augment the principal arterial system. They may carry local bus routes and provide intra community connectivity.

3) Collector Systems -- In rural areas, a network of routes which generally serves travel of a more localized nature rather than statewide importance and on which predominant travel distances are shorter than on arterial routes. The collector system is stratified as follows: 1) major collectors - serving county seats and other traffic generators not directly served by arterial routes; and 2) minor collectors - linking locally important traffic generators with smaller communities.

TABLE 16. 1975 RURAL HIGHWAY SUMMARY BY FUNCTIONAL CLASSIFICATION.

(IN PERCENTS):

PAVEMENT TYPE:	INTERSTATE		OTHER PRIN ART		MINOR ARTERIAL		MAJOR COLLECTOR		MINOR COLLECTOR	
	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL
HIGH	100	100	100	100	100	100	48	70	7	15
INTERM	0	0	0	0	0	0	42	25	74	72
LOW	0	0	0	0	0	0	9	5	19	13
PAVEMENT CONDITION: 1/										
POOR	1	1	1	1	0	0	4	6	7	5
FAIR	20	18	29	31	38	43	47	45	66	59
GOOD	80	82	69	67	61	57	49	49	27	37
VOL/CAP RATIOS: 2/										
< .31	55	37	71	73	75	58	98	92	100	97
.31 - .80	45	63	28	23	25	41	2	8	0	3
> .80	0	0	1	3	0	1	0	0	0	0
LANE WIDTH (FT):										
< 10	0	0	0	0	0	0	30	20	64	56
10 - 11	0	0	17	17	36	32	58	59	34	38
> 11	100	100	83	83	64	68	12	21	2	6

1/ POOR - PSR <2.0 (<2.5 PRINCIPAL ARTERIAL): FAIR - PSR 2.0 TO 3.4: GOOD - PSR >3.4.

2/ TRAVEL IS FOR PEAK HOUR. ONE DIRECTION ONLY.

SOURCE: REFERENCE 5.

TABLE 17. 1975 URBAN HIGHWAY SUMMARY BY FUNCTIONAL CLASSIFICATION.

(IN PERCENTS)

PAVEMENT TYPE:	INTERSTATE		OTH FWY & EXPY		OTHER PRIN ART		MINOR ARTERIAL		COLLECTOR	
	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL
HIGH	100	100	100	100	86	85	38	51	17	15
INTERM	0	0	0	0	14	15	62	49	81	85
LOW	0	0	0	0	0	0	0	0	1	1
PAVEMENT CONDITION: 1/										
POOR	0	0	0	0	1	1	2	2	7	6
FAIR	10	5	6	9	50	49	42	43	44	40
GOOD	90	95	94	91	49	50	56	55	49	54
UDL/CAP RATIOS: 2/										
< .31	21	8	73	59	27	15	35	24	75	55
.31 - .90	69	71	24	41	49	44	48	47	21	37
> .90	10	20	3	0	24	41	17	29	4	8
LANE WIDTH (FT):										
< 10	0	0	0	0	8	8	13	14	23	15
10 - 11	0	0	5	9	27	29	44	44	48	62
> 11	100	100	95	91	64	63	43	43	28	24
1/ POOR - PSR < 2.0 (< 2.5 PRINCIPAL ARTERIAL): FAIR - PSR 2.0 TO 3.4: GOOD - PSR > 3.4.										
2/ TRAVEL IS FOR PEAK HOUR. ONE DIRECTION ONLY.										

SOURCE: REFERENCE 5.

TABLE 18. 1975 SMALL URBAN HIGHWAY SUMMARY BY FUNCTIONAL CLASSIFICATION.

(IN PERCENTS)

	INTERSTATE		OTH FHY & EXPY		OTHER PRIN ART		MINOR ARTERIAL		COLLECTOR	
	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL
PAVEMENT TYPE:										
HIGH	100	100	100	100	96	95	42	50	21	29
INTERM	0	0	0	0	4	5	58	50	77	69
LOW	0	0	0	0	0	0	0	0	3	3
PAVEMENT CONDITION: 1/										
POOR	0	0	0	0	0	0	6	4	9	9
FAIR	0	0	8	10	54	53	49	45	51	45
GOOD	100	100	92	90	46	46	45	51	40	46
VOL/CAP RATIOS: 2/										
< .31	17	9	78	77	29	19	48	36	90	85
.31 - .90	83	91	22	23	63	67	42	53	10	15
> .90	0	0	0	0	9	13	10	11	0	0
LANE WIDTH (FT):										
< 10	0	0	0	0	11	13	15	11	31	23
10 - 11	0	0	0	0	22	22	40	42	33	36
> 11	100	100	100	100	67	66	45	47	36	41

1/ POOR - PSR < 2.0 (< 2.5 PRINCIPAL ARTERIAL); FAIR - PSR 2.0 TO 3.4; GOOD - PSR > 3.4.

2/ TRAVEL IS FOR PEAK HOUR. ONE DIRECTION ONLY.

SOURCE: REFERENCE 5.

In urban areas, such routes distribute trips to and from the arterials to their ultimate destinations. Such routes provide for local traffic movement within residential neighborhoods, commercial areas, and industrial areas.

The highway functional classifications described above have been standardized since the early 1970's and they provide a practical level of aggregation for the purpose of system analysis.

The highway characteristics used in the present study to evaluate the condition, service, and safety elements are: 1) pavement type, 2) pavement condition, 3) peak-hour volume/capacity ratio and, 4) lane width. The impact that the above characteristics have on the condition index vary according to rural and urban systems and functional classifications. The weights assigned to the three elements and their components were derived from the 1976 NHIPS and are shown in Table 19.

The variation in the condition index weights reflects the difference between service oriented high volume facilities and condition oriented high speed facilities. In most cases the safety element, represented by lane widths, is given equal importance, and subsequently, was assigned the same weighting regardless of the type of facility.

Regretably, the highway characteristic data provided by the 1976 NHIPS (Tables 16-18) is not nearly detailed enough to be used as a basis for projecting highway condition indices, and therefore, it was necessary to devise a procedure that would provide the level of aggregation necessary for such projections.

Procedure to Estimate Present Highway Performance

A Monte Carlo sampling technique was used to create a sample of roadway sections which were categorized by highway functional classification.

TABLE 19. URBAN AND RURAL CONDITION INDEX WEIGHTS BY FUNCTIONAL CLASSIFICATION.

URBAN WEIGHTS			
	PRINCIPAL ARTERIALS	MINOR ARTERIALS	COLLECTORS
CONDITION:			
PAVEMENT TYPE	10	10	10
PAVEMENT COND.	30	35	40
SERVICE:			
VOL/CAP RATIO	40	30	20
SAFETY:			
LANE WIDTH	20	25	30
RURAL WEIGHTS			
	PRINCIPAL ARTERIALS	MINOR ARTERIALS	COLLECTORS
CONDITION:			
PAVEMENT TYPE	10	10	10
PAVEMENT COND.	30	40	50
SERVICE:			
VOL/CAP RATIO	40	30	20
SAFETY:			
LANE WIDTH	20	20	20

Each of the roadway sections was assigned a set of attributes which were then used to project the four basic determinants of the condition index: pavement type, pavement condition, volume/capacity ratio, and lane width. The section attributes were: 1) section length, 2) traffic volume, 3) number of lanes, 4) pavement thickness, 5) pavement condition, 6) peak-hour volume/capacity ratio and 7) lane width. An explanation as to how these attributes were assigned is given below.

Section Lengths - Highway section lengths are used to determine future maintenance and construction costs which are estimated on a per mile basis. The number of section lengths assigned are governed, in most cases, by computer memory limitations which restrict the number of sections to 100 for each functional classification. The minimum section length was chosen to be 2 miles, since it was felt that smaller lengths would provide an unrealistic variation in highway attributes among functional classifications with small mileages. Therefore, in most instances, the section length is determined by dividing the functional classification system mileage by 100. However, in those cases when the resultant value is less than 2 miles, the section length is set at 2 miles and the number of sections representing that functional classification is reduced accordingly. Table 20 summarizes the 1975 Indiana system mileage and daily vehicle miles traveled by functional classification.

Traffic Volumes - Traffic volumes are used to project peak-hour volume/capacity ratios and pavement conditions. Section traffic volumes were determined by assuming that the average daily traffic (ADT) volumes can be approximated by a normal distribution within each

TABLE 20. 1975 INDIANA HIGHWAY SYSTEM MILEAGE AND DAILY UMT.

	MILEAGE	DAILY-UMT (THOUSANDS)
-----	-----	-----
RURAL:		

INTERSTATE	827	11330
OTHER PRIN ART	1048	4972
MINOR ARTERIALS	3032	13131
MAJOR COLLECTORS	8724	8829
MINOR COLLECTORS	11332	2572
URBAN:		

INTERSTATE	210	7718
OTH FWY & EXPWY	67	946
OTHER PRIN ART	761	11182
MINOR ARTERIALS	1526	9500
COLLECTORS	1183	2794
SMALL URBAN:		

INTERSTATE	27	608
OTH FWY & EXPWY	52	173
OTHER PRIN ART	512	4284
MINOR ARTERIALS	733	3291
COLLECTORS	614	959

SOURCE: REFERENCE 5.

functional classification. The average ADT's and their corresponding standard deviations were estimated from the 1975 traffic map of Indiana which was prepared by the Division of Planning of the Indiana State Highway Commission. Table 21 summarizes the average 1975 ADT's and their standard deviations for each functional classification.

Once the average ADT's and their attendant standard deviations have been established, the traffic volume on each randomly sampled roadway section was assigned by generating a series of normally distributed random numbers with the specified mean and standard deviation. Minimum volumes were set to prevent the possibility of negative or unrealistically low values.

Number of Lanes - This attribute will influence future pavement conditions and peak-hour volume/capacity ratios. The number of lanes assigned to each roadway section was determined by first, assuming an appropriate peak-hour factor (as shown in Table 24) which when multiplied by the average daily traffic volume provides an approximation of one direction peak-hour volumes, and second, estimating the maximum per lane hourly capacity (30). Once the above estimations are made, the number of lanes in each direction is simply equal to the resultant of the one direction peak-hour volume divided by the lane capacity. This value is appropriately rounded off to provide an integer value.

Pavement Thickness - Pavement thickness is used directly to represent the pavement structure quality, which is a significant component of the condition index. In this analysis, pavements were classified as high type (all rigid pavements or flexible pavements

TABLE 21. 1975 INDIANA AVERAGE ADT'S AND STANDARD DEVIATIONS BY FUNCTIONAL CLASSIFICATION.

	AVERAGE ADT	STANDARD DEVIATION
	-----	-----
<u>RURAL:</u>		
INTERSTATE	16400	6650
OTHER PRIN ART	5700	3500
MINOR ARTERIALS	5200	3300
MAJOR COLLECTORS	1200	600
MINOR COLLECTORS	600	230
 <u>URBAN:</u>		
INTERSTATE	44000	16000
OTH FWY & EXPWY	16900	7200
OTHER PRIN ART	17200	7500
MINOR ARTERIALS	7460	3100
COLLECTORS	2830	1700
 <u>SMALL URBAN:</u>		
INTERSTATE	27020	10800
OTH FWY & EXPWY	4000	1800
OTHER PRIN ART	10000	5100
MINOR ARTERIALS	5400	3000
COLLECTORS	1870	1000

with a thickness index greater than 3.1 inches), intermediate type (flexible pavements with a thickness index greater than 2.6 inches and less than 3.1 inches), and low type (flexible pavements with a thickness index less than 2.6 inches or unpaved facilities). This classification was done only to simplify the computer model output, and the actual thickness indices or slab thicknesses (in the case of rigid pavements) were used in the condition index computations.

The thickness index for flexible pavements was defined by the following equation.

$$TI = .44D_1 + .14D_2 + .11D_3 \quad (6.1)$$

where

TI = thickness index

D_1 = surfacing thickness, inches

D_2 = base thickness, inches

D_3 = subbase thickness, inches

For rigid pavements, the slab thickness alone was used and these values were estimated by utilizing the summary of Indiana rigid pavement depths presented in reference 31.

The values for flexible pavement thickness indices were determined using daily truck volumes as a criterion. The truck volumes on each roadway section were calculated using data available from the 1975 national truck characteristics report (24) in which ratios of the truck volume to total vehicle volume are presented and categorized by highway functional classification. Once the truck volumes on each roadway section were established, an appropriate thickness index was

selected using a procedure similar to the group-index method, which is widely used in flexible pavement design (31).

Pavement Condition - The present pavement conditions will directly affect future pavement conditions since the present conditions along with the pavement thickness determine the number of additional axial loads the pavement can sustain. Pavement conditions are measured by using the present serviceability rating (PSR). The PSR values range from 5.0 for new pavements to 0.0 for completely deteriorated pavements. The 1976 NHIPS data categorizes pavement conditions into good (PSR=3.4 to 5.0), fair (PSR=2.5 to 3.4 for principal arterials and PSR=2.0 to 3.4 for other classifications), and poor (PSR<2.5 for principal arterials and PSR<2.0 for other classifications). It was assumed that such values are uniformly distributed within each of the three categories of pavement condition. The assignment of PSR values then was made by generating a series of uniformly distributed random numbers which in turn was used to; 1) select good, fair, or poor categories with the probability of selection equal to the proportion of mileage in each category and, 2) select a specific PSR value with equal probability within each category.

Peak-Hour Volume/Capacity Ratios - The peak-hour volume/capacity ratios (V/C) are used exclusively to measure the service element, and subsequently, play an important role in the determination of the condition index. The 1976 NHIPS data provides three broad categories of peak-hour V/C ratios. The assignment of V/C ratios to individual roadway sections is done assuming that the V/C ratios are uniformly distributed within each category. However in this case, there exists

the fact that high volume sections are more likely to have high V/C ratios than low volume sections and, therefore, the probability of selecting a V/C category was assumed to be a function of the ratio, percent mileage/percent volume, for each category. The selection of specific V/C ratios within each category was done with uniform probability as was the case with pavement conditions.

Lane Widths - The lane widths are used to represent the safety element of the roadway. The 1976 NHIPS data categorizes lane widths into; 1) less than 10 feet, 2) 10 to 11 feet, and 3) greater than 11 feet. It was assumed that lane widths would be uniformly distributed within each of the above categories. A minimum lane width of 9 feet and a maximum lane width of 12 feet were applied to the first and third categories respectively. Individual lane widths were then determined using the same random sampling approach as that used for the assignment of pavement conditions. The interstate systems were excluded from the approach described above as all of these facilities exclusively have 12 feet lane widths and were so assigned.

Estimation of Future Highway Performance

Future highway performance was estimated simply by projecting the seven attributes assigned to each roadway section. Attributes such as the number of lanes, pavement thickness, and lane widths will remain constant unless appropriate construction is performed on the roadway section. If no reconstruction is performed on a given section, the attributes that will change in the future are: 1) section length, 2) traffic volume, 3) peak-hour volume/capacity ratio, and 4) pavement condition.

Projection of Section Lengths - From year to year there are changes in the system mileages of each functional classification. These changes are induced by urban growth which results in the transfer of mileage from rural to urban systems, the upgrading of facilities to higher classifications, and the growth in total highway mileage. The estimation of the extent of annual fluctuations in functional classification system mileage is achieved by approximating 1990 system mileages and assuming a uniform annual growth rate between 1975 and 1990. The 1990 system mileages were derived using a number of sources (3, 32, 33), and are presented along with the annual growth rates in Table 22. Once the growth rates are known, the annual system mileages are calculated and the section lengths of each functional classification are increased or decreased such that the summation of the section lengths is equal to the calculated classification mileages.

Projections of Traffic Volumes - Future traffic volumes were estimated under the assumption that the growth in traffic volume would be proportional to the growth in the vehicle-miles of travel (VMT) per mile of highway. This assumption is illustrated by the following equation:

$$PGRV = \frac{\frac{FVMT}{FSM} - \frac{FVMT_{-1}}{FSM_{-1}}}{\frac{FVMT_{-1}}{FSM_{-1}}} \times 100 \quad (6.2)$$

where

PGRV = percent growth in functional system volumes.

FVMT = functional system VMT in desired year.

FVMT₋₁ = functional system VMT in preceding year.

TABLE 22. 1990 INDIANA HIGHWAY SYSTEM MILEAGE AND TOTAL 1975 TO 1990 MILEAGE GROWTH RATES

	MILEAGE	MILEAGE GROWTH RATE (PERCENT)
<hr/>		
RURAL:		
<hr/>		
INTERSTATE	869	5.0
OTHER PRIN ART	1170	11.6
MINOR ARTERIALS	3100	2.2
MAJOR COLLECTORS	8700	-0.3
MINOR COLLECTORS	11250	-0.7
URBAN:		
<hr/>		
INTERSTATE	225	7.1
OTH FWY & EXPWY	119	77.6
OTHER PRIN ART	897	14.9
MINOR ARTERIALS	1635	7.1
COLLECTORS	1225	3.6
SMALL URBAN:		
<hr/>		
INTERSTATE	35	29.7
OTH FWY & EXPWY	77	48.1
OTHER PRIN ART	609	18.9
MINOR ARTERIALS	839	14.5
COLLECTORS	656	6.8

FSM = functional system mileage in desired year.

FSM₋₁ = functional system mileage in preceding year.

The functional system mileages are known during each year from the uniform annual growth rate assumption made earlier (see Table 22). However, it was necessary to develop a technique to determine VMT values by functional classification (FVMT in Equation 6.2).

Since the growth in the total highway system VMT can be obtained from the VMT equation used in the fuel consumption model, a logical solution to the problem of determining functional system VMT values is to apply a proportion of individual functional system VMT growth to total system VMT growth. These proportions were developed by using the 1976 NHIPS estimates of 1990 VMT by functional classification to calculate annual VMT growth rates from 1975 to 1990 (assuming uniform growth) on each functional classification. The division of these growth rates by the average annual growth rate of the entire system mileage resulted in the desired growth rate proportions. These values are presented in Table 23.

Once these proportions are known, the VMT of each functional classification can be determined by applying the following equation:

$$FVMT = FVMT_{-1} * (PR * \frac{\Delta TVMT}{TVMT_{-1}} + 1) \quad (6.3)$$

where

FVMT = functional system VMT in desired year.

FVMT₋₁ = functional system VMT in preceding year.

PR = proportion of functional system VMT growth to total VMT growth.

TABLE 23. UMT GROWTH RATE PROPORTIONS BY FUNCTIONAL CLASSIFICATION.

	GROWTH RATE PROPORTION
<hr/>	
RURAL:	

INTERSTATE	0.80
OTHER PRIN ART	1.00
MINOR ARTERIALS	0.72
MAJOR COLLECTORS	0.64
MINOR COLLECTORS	0.64
URBAN:	

INTERSTATE	1.32
OTH FWY & EXPWY	2.16
OTHER PRIN ART	1.12
MINOR ARTERIALS	1.12
COLLECTORS	1.02
SMALL URBAN:	

INTERSTATE	1.00
OTH FWY & EXPWY	1.24
OTHER PRIN ART	1.00
MINOR ARTERIALS	1.02
COLLECTORS	1.02

$\Delta TVMT$ = change in total system VMT.

$TVMT_{-1}$ = total system VMT in preceding year.

Should there be a case where the system VMT values decline, the reciprocals of the growth rate proportions shown in Table 23 would be used as PR in Equation 6.3. This assures that high growth systems will have lower loss rates should such a situation arise.

The traffic volume growth rates on each functional classification are now known from Equation 6.2. The only remaining task is to determine the volume growth rates on individual highway sections within each functional classification. This was done by generating a series of normally distributed random numbers with a mean of 0.0 and a standard deviation of 1.5 percent and adding these numbers to the volume growth rates of each functional classification. This procedure provides a distribution of growth rates that is compatible with historical growth rate distributions (30). The standard deviation value of 1.5 percent was chosen to be consistent with the 3.3 percent growth rate used in the VMT equation discussed earlier.

Projection of Peak-Hour Volume/Capacity Ratios - Although the peak-hour volume/capacity ratios (V/C) can be assigned to roadway sections using the technique previously described, an estimation of peak-hour volumes and hourly capacities are necessary for the projection of V/C ratios.

Peak-hour volumes were approximated using the percentage of average daily volumes occurring in the peak-hour as a basis. The initial values of this percentage are shown in Table 24 (30). It must be realized that the values shown in Table 24 are generalized

TABLE 24. PERCENTAGE OF THE AVERAGE DAILY VOLUME IN PEAK HOUR.

TYPE OF FACILITY -----	PERCENTAGE IN PEAK HOUR (ONE DIRECTION) -----
RURAL: -----	
FREEWAY	23.6
EXPRESSWAY	21.5
HIGHWAY WITH MORE THAN 2 LANES	21.2
2 LANE TWO WAY HIGHWAY	23.0
URBAN: -----	
FREEWAY	15.0
EXPRESSWAY	14.6
STREET WITH MORE THAN 2 LANES	13.8
2 LANE TWO WAY STREET	14.8

and the actual values will naturally vary between roadway sections within the same functional classification. Consequently, an adjustment was necessary to account for this variation, and it is discussed later in this section.

The hourly capacity estimates were made on a volume per lane basis. The per lane hourly capacities were initially assumed to be: 2000 vehicles per hour (VPH) for interstates; 1600 VPH for freeways, expressways, and other principal rural arterials; 1400 VPH for other principal urban arterials and minor rural arterials; and 1000 VPH for all other classifications. These capacities also will vary between sections of the same functional classification. This variation is caused by such factors as lane widths, signal timings, and turning movements.

The problem of accounting for the variations in peak-hour percentages and per lane capacities between roadway sections was resolved by utilizing an adjusting factor. This factor was calculated from the following equation:

$$K = \frac{IVC}{\frac{PH * IADT}{100 * NL * CAP}} \quad (6.4)$$

where:

K = adjusting factor.

IVC = initial section V/C ratio.

PH = peak-hour percentages (Table 24).

IADT = initial section average daily volume.

NL = number of lanes (one direction) in the section.

CAP = estimated hourly capacity per lane.

The initial V/C ratios, number of lanes, and initial average daily volumes are known from the simulation procedure described earlier. Hence the adjusting factor can be readily calculated.

This adjusting factor is merely a ratio of peak-hour percentage correction to the hourly capacity correction. Once the adjusting factor is known, future volume/capacity ratios can be determined from Equation 6.5.

$$VC = K * \frac{\frac{PH}{100} * AV}{NL * CAP} \quad (6.5)$$

where

VC = volume/capacity ratio in the desired year.

AV = daily volume in the desired year.

All other variables are same as in Equation 6.4.

Items such as the addition of lanes, increased lane width, and assumptions regarding peaking characteristics will affect future V/C ratios and the adjustment factors. The impacts that such items will have on V/C ratio projections are discussed in the next chapter.

Projection of Pavement Conditions - The AASHO Road Test performance equations were used as a basis to estimate future pavement conditions since the results provided by these equations are consistent with pavement life experience in Indiana (3). The AASHO Road performance equations assume the following forms:

$$P = C_0 - (C_0 - C_1) \left(\frac{W}{\rho} \right)^\beta \quad (6.6)$$

where

P = the present serviceability rating (PSR)

C_0 = the initial serviceability rating

C_1 = the serviceability rating below which the pavement is
considered to be out of service

W = the accumulated axle load applications at the time when P
is to be determined.

β and ρ are functions of design and load and are determined from
the following equations:

$$\beta = 0.4 + \frac{0.81 (L_1+L_2)^{3.23}}{(D_1+1)^{5.19} L_2^{3.23}} \quad (6.7)$$

$$\rho = \frac{10^{5.93} (D_1+1)^{9.35} L_2^{4.33}}{(L_1+L_2)^{4.79}} \quad (6.8)$$

For rigid pavements:

$$\beta = 1.0 + \frac{3.63 (L_1+L_2)^{5.2}}{(D_2+1)^{8.46} L_2^{3.52}} \quad (6.9)$$

$$\rho = \frac{10^{5.85} (D_2+1)^{7.35} L_2^{3.28}}{(L_1+L_2)^{4.62}} \quad (6.10)$$

where

ρ and β = design and load functions.

L_1 = nominal axle weight in kips.

L_2 = 1 for single axle vehicles

2 for tandem axle vehicles

D_1 = thickness index (described earlier)

D_2 = slab thickness, inches

The initial serviceability rating (C_0 in Equation 6.6) is known from the assignments of pavement conditions. The serviceability ratings below which the pavement can be considered to be out of service (C_1 in Equation 6.6) were determined to be 2.0 for principal arterials and 1.5 for minor arterials and collectors using the values presented in the National Highway Functional Classification and Needs Study Manual (34) as a basis.

In Equations 6.7-6.10, the thickness indices and slab thicknesses are already known from the pavement type assigned to a particular section as discussed earlier. Therefore, to calculate ρ and β , it is necessary only to determine the nominal axle weights (L_1) and establish whether these weights are from single or tandem axles (L_2).

The basic approach used to determine L_1 and L_2 was to simulate a representative sample of vehicles and their associated axle weights, and then to translate these axle weights into 18 kip single axle weight equivalents.

Vehicle Axle Weight Sampling - Three categories of vehicles are considered in the axle weight analysis; automobiles, single unit trucks and combination trucks. The axle weight analysis was achieved by simulating a random sample of 1000 vehicles in each of the three categories mentioned above. Details of this sampling procedure are presented in the following paragraphs.

When considering the relative impact on pavement deterioration, the axle weights of automobiles are insignificant when compared with

truck axle weights, however, for the sake of completeness, automobile axle weights were also considered.

The estimation of auto axle weights was made by assuming that auto weights are normally distributed. A mean value of 3,300 pounds and a standard deviation of 800 pounds was chosen on the basis of findings in literature (35). It was assumed that the front axle would carry 60 percent of the total vehicle weight and the rear axle would carry the balance. A minimum value of 1,200 pounds was applied since it was not considered likely that an auto would weigh less than this amount.

Three sub-categories of single unit trucks were considered due to the high variation in loading characteristics. These sub-categories are: 1) 2-axle vehicles with 4 tires, 2) 2-axle vehicles with 6 tires, and 3) vehicles with 3 axles or more. It was assumed that the weights of loaded and empty vehicles in each sub-category would be normally distributed. This assumption was made on the basis of the truck weight distribution summaries presented in the 1975 National Truck Characteristic Report (NTCR) (24). The percentages of loaded and empty vehicles were also determined from this report and the values used were 50.6% and 49.4%, respectively.

Similarly, combination trucks were divided into 3 sub-categories; 3 axle vehicles, 4 axle vehicles, and vehicles with 5 axles or more. Once again the loaded and empty weight distributions within each sub-category were assumed to be normal. The percentages of loaded and empty vehicles were estimated to be 69.8 and 31.2 respectively.

The percent of vehicles in each sub-category, the means, standard deviations, and the fractions of load on each axle, for each sub-category of single unit and combination trucks, are presented in Table 25. This table was derived from the data provided in the 1975 NTCR (24).

The procedure implemented to establish the weight of each truck sample vehicle within each category (single unit or combination) consisted of the following steps: 1) selecting the sub-category by generating uniformly distributed random numbers and using the percent of trucks by truck type as the probability of selection; 2) determining whether the vehicle was loaded or empty by generating uniformly distributed random numbers using the percent of loaded and empty trucks as the probability; 3) estimating the vehicle weight by generating normally distributed random numbers using the appropriate mean and standard deviation. Once the weight of each sample truck is known, the weight is distributed to the axles using the fractions of weights by axle shown in Table 25.

These resultant axle loads (both automobile and trucks) are translated into 18 kip single axle equivalent loads (SAEL) by using Equations 6.11, 6.12 and 6.13 which were derived from the AASHO Road Tests (36).

For single axles:

$$18 \text{ SAEL} = 6.213 * 10^{-6} * AL^{4.16} \quad (6.11)$$

For tandem axles, flexible pavements:

$$18 \text{ SAEL} = 4.711 * 10^{-7} * AL^{4.16} \quad (6.12)$$

TABLE 25. TRUCK WEIGHT MEANS, STANDARD DEVIATIONS, AND PERCENTAGE OF WEIGHTS BY AXLE.

VEHICLE TYPE 1/ -----	PERCENT OF TRUCKS BY TYPE -----	MEAN WEIGHT (IN KIPS) -----	STANDARD DEVIATION (IN KIPS) -----	WEIGHTS BY AXLE 2/ -----		
				1 ---	2 ---	3 ---
EMPTY -----						
SINGLE UNIT -----						
2 AX 4 TIRE	77.0	5.5	2.0	.42	.58	-
2 AX 6 TIRE	19.0	10.5	4.0	.44	.56	-
3 AX OR MORE	4.0	17.0	7.0	.38	.62T	-
COMBINATION -----						
3 AXLE	5.0	22.0	7.0	.31	.37	.32
4 AXLE	15.0	25.0	8.0	.25	.25	.50T
5 AXLE OR MORE	80.0	30.0	4.0	.26	.40T	.34T
LOADED -----						
SINGLE UNIT -----						
2 AX 4 TIRE	77.0	6.2	2.6	.31	.69	-
2 AX 6 TIRE	19.0	14.7	6.0	.37	.63	-
3 AX OR MORE	4.0	34.0	14.0	.28	.72T	-
COMBINATION -----						
3 AXLE	5.0	30.0	5.0	.27	.40	.33
4 AXLE	15.0	39.0	12.0	.18	.34	.48T
5 AXLE OR MORE	80.0	60.0	14.0	.15	.42T	.43T

T = TANDEM AXLES
1/ TANDEM AXLES COUNTED AS TWO AXLES
2/ TANDEM AXLES COUNTED AS ONE AXLE

T = TANDEM AXLES

1/ TANDEM AXLES COUNTED AS TWO AXLES

2/ TANDEM AXLES COUNTED AS ONE AXLE

For tandem axles, rigid pavements:

$$18 \text{ SAEL} = 9.07 * 10^{-7} * AL^{4.12} \quad (6.13)$$

where

18 SAEL = 18 kip single axle equivalent load.

AL = nominal axle load in kips.

The summation of all of the 18 kip SAEL's within each of the three categories (auto, single unit, and combination trucks) provides the equivalent axle loads per 1000 vehicles by vehicle category. For projective purposes and ultimately estimating accumulated axle load applications (W in Equation 6.6), it is desirable to transform the above results into 18 kip SAEL's per 1000 vehicles, irrespective of vehicle category. This was accomplished by approximating the percentage of vehicle categories operating on each functional classification. These percentages were derived from the 1975 NTCR and are summarized in Table 26. Hence, the number of 18 kip SAEL's per 1000 vehicles operating on each functional classification can be determined simply by multiplying the percentages in Table 26 by the corresponding summation of 18 kip SAEL's derived from each of the three 1000 vehicle samples.

Referring back to Equations 6.7-6.10, ρ and β can be readily calculated for all vehicles, now that L_1 is known to be 18 kips and L_2 is one (since all tandem loads are now single axle equivalents). The only remaining requirement, to project the pavement condition, is the estimation of the number of axle load applications during a specified time period (W in Equation 6.6). In the present analysis,

TABLE 26. 1975 VEHICLE TYPES AS A PERCENT OF ALL VEHICLES (BY FUNCTIONAL CLASSIFICATION).

	AUTOS	SINGLE UNIT TRUCKS	COMBINATION TRUCKS
	-----	-----	-----
RURAL:			

INTERSTATE	70.0	14.7	15.3
OTHER PRIN ART	70.0	20.3	9.7
MINOR ARTERIALS	72.0	20.3	7.7
MAJOR COLLECTORS	72.0	23.5	4.5
MINOR COLLECTORS	72.0	23.5	4.5
ALL URBAN:			

INTERSTATE	80.0	11.0	9.0
OTH FWY & EXPWY	80.0	14.0	6.0
OTHER PRIN ART	80.0	16.0	4.0
MINOR ARTERIALS	75.0	23.0	2.0
COLLECTORS	75.0	23.0	2.0

pavement conditions are calculated annually; the number of annual load applications on a given roadway section is determined by the following equation:

$$LA = \frac{ADT}{1000} * 365 * ELPTV \quad (6.14)$$

where

LA = the number of annual load applications.

ADT = daily traffic volume on the section.

ELPTV = number of 18 kip SAEL's per 1000 vehicles operating on the system.

As the above equation indicates, the number of load applications in any given year will be a function of the daily volume (the projection of which was described earlier) and the 18 kip equivalent loads per 1000 vehicles. The future values of ELPTV will be influenced by: 1) shifts in the percent of vehicle type using each functional classification, 2) changes in the weight distributions of trucks and autos, and 3) fluctuations in the percentage of loaded trucks. The sampling technique devised for the present analysis allows an evaluation of the impacts of changing weight distributions and variations in the percentage of loaded trucks. However, it can be assumed, on the basis of recent trends, that the above two factors will be essentially constant over the time period of this analysis provided that the maximum axle weight laws are not revised.

Shifts in the percent of vehicle types using each functional classification were determined by asserting that the increase in the 18 kip ELPTV's would be proportional to the increase in commercial

truck VMT relative to the increase in total VMT. This technique is valid since an overwhelming percentage of the total 18 kip ELPTV is determined by commercial vehicles. Therefore, future 18 kip ELPTV's are estimated on each functional classification by applying the following equation:

$$ELPTV = \frac{1 + \frac{PICV}{100}}{1 + \frac{PITV}{100}} * ELPTV_{-1} \quad (6.15)$$

where

ELPTV = 18 kip equivalent axle loads per 1000 vehicles in desired year.

PICV = percent increase in commercial VMT from the preceding year.

PITV = percent increase in total VMT from the preceding year.

$ELPTV_{-1}$ = ELPTV in preceding year.

Once the ELPTV is known, the number of annual load applications may be calculated using Equation 6.14 and the summation of these annual load applications is used in Equation 6.6 (as W) from which the pavement condition can be determined annually.

The only remaining factor affecting future pavement conditions is the possible repair or resurfacing of a roadway section, and this item is discussed in the next chapter.

Computation of Condition Index Values

Once the pavement type, pavement condition, peak-hour volume/capacity (V/C) ratios, and lane width of each section are known; the appropriate condition indices can be readily calculated. This calculation is performed by using the following set of equations:

For pavement type;

$$CI_1 = ((D - 1.6) * CW_1)/8.4 \quad (6.16)$$

where

CI_1 = the portion of the condition index determined by pavement type.

D = the slab thickness for rigid pavements or the thickness index for flexible pavements.

CW_1 = the condition index weight for pavement type (Table 19).

Pavements with a "D" of 10 inches or more are given total points (i.e. $CI_1 = CW_1$) and those pavements with a "D" of 1.6 inches or less are given no points ($CI_1 = 0$).

For pavement condition;

$$CI_2 = ((PC - 1.) * CW_2)/4 \quad (6.17)$$

where

CI_2 = the portion of the condition index determined by pavement condition.

PC = the present serviceability rating (PSR) of the pavement 0 to 5).

CW_2 = the condition index weight for pavement condition (see Table 19).

Sections with a PSR of one or less are given no points ($CI_2 = 0$).

For peak-hour V/C ratios;

$$CI_3 = ((1. - PVC) * CW_3)/.6 \quad (6.18)$$

where

CI_3 = the portion of the condition index determined by the peak-hour V/C ratios.

PVC = the peak-hour V/C ratio of the section.

CW_3 = the condition index weight for V/C ratios (see Table 19).

Volume/capacity ratios of 0.4 or less are given total points

$(CI_3 = CW_3)$.

For lane widths;

$$CI_4 = ((LW - 9.) * CW_4)/3 \quad (6.19)$$

where

CI_4 = the portion of the condition index determined by the lane widths.

LW = the lane widths of the section in feet.

CW_4 = the condition index weight for lane widths (Table 19).

Sections with a lane width of 12 feet or more are given total points

$(CI_4 = CW_4)$ and those with lane width of 9 feet or less are given no points $(CI_4 = 0)$.

The condition index of any roadway section can then be determined simply by adding the results of Equations 6.16 to 6.19.

In the present study, the condition index of any given functional classification is equal to the average of the classification's individual section condition indices weighted by the corresponding section traffic volumes. This is illustrated by the following equation:

$$SCI = \frac{\sum_{i=1}^n (CI_i * V_i)}{\sum_{i=1}^n V_i} \quad (6.20)$$

where

SCI = total functional classification system condition index.

CI_i = the condition index of section i.

V_i = the traffic volume of section i.

n = the total number of sections comprising the specified functional classification.

The condition indices determined in this chapter are used as 1) a measurement of highway performance and 2) a basis to distribute the funds available for highway repair among the roadway sections comprising each functional classification. The details of the technique utilized to distribute funds to roadway sections are discussed in the next chapter.

CHAPTER 7

ALLOCATION OF CAPITAL FUNDS

The allocation of capital funds was performed in two steps. First, capital funds were distributed to individual highway functional classifications, and second, the capital funds distributed to such functional classifications were allocated to specific roadway sections within each functional classification. The former step will be discussed in the next chapter and the present chapter is concerned only with the allocation of funds to roadway sections.

Allocation of Capital Funds to Roadway Sections

Since it is highly improbable that sufficient capital improvement funds will be available to repair all deficiencies on every roadway section; it is necessary to apply a priority setting technique whereby the available funds can be allocated to those sections with the most critical deficiencies. The method used in the present study establishes funding priority on the basis of two equally weighted factors. The first factor gives priority to the roadway sections with low condition indices. The second factor gives priority to roadway sections with the most cost-effective improvement. Thus the procedure is to allocate half of the funds on the basis of condition indices and the remainder on the basis of cost-effectiveness factors.

The determination of the first factor is simple, since the condition indices of each roadway section are known from the procedures discussed in the previous chapter. The cost-effectiveness of an improvement, which is used as a basis for the application of the second priority factor, is defined by the following equation:

$$CE_i = \frac{(CI_N - CI_I) * V}{Cost_i} \quad (7.1)$$

where

CE_i = the cost-effectiveness of improvement type i in a specified year for a given section

CI_N = the condition index after the implementation of improvement type i.

CI_I = the initial condition index of the roadway section in the specified year

V = the traffic volume on the roadway section in the specified year

$Cost_i$ = the cost of implementing improvement type i in the specified year on the given section.

The traffic volume (V) and the Initial Condition Index (CI_I) are known in any given year from the procedures discussed in the preceding chapter. It is therefore necessary to establish; 1) the types of needed improvements, 2) the effects that such improvements will have on section condition indices and 3) the costs of such improvements in any given year.

Improvement Types

In this analysis, as is the case with most major studies in this subject area (3,5,6,32), capital improvements are categorized into eight major improvement types. These categories, along with their definitions are as follows:

1. New location - complete construction of the roadway on a new alignment.
2. Reconstruction - reconstruction of the roadway on essentially the same alignment.
3. Isolated reconstruction - reconstruction of some portion of the roadway to correct a particular deficiency such as a dangerous curve.
4. Major widening - addition of lanes to the roadway section.
5. Minor widening - provides for additional lane width.
6. Resurfacing - overlaying of the existing pavement.
7. Resurfacing and shoulder improvements - in addition to the overlaying of existing pavements, provisions for the widening of shoulders are made.
8. Structures - the rehabilitation or replacement of deficient structures.

Data limitations necessitated the allocation of a constant percentage of capital funds to structure improvements, and hence, such improvements are excluded from further discussion in this chapter.

The type of improvement needed on a specific roadway section was determined by applying data available in the 1972 National Highway Needs Report (32) in which national estimates of needed capital

improvements (presented in Tables IV-5, IV-15, and IV-16) from 1970 to 1990 by improvement type and functional classification are provided. These estimates were applied to Indiana and used to establish the relative probability of a specific capital improvement type being assigned to any given roadway section within each functional classification.

Effects of Improvements on the Condition Index

After the assignment of the improvement type to each roadway section is made through a random sampling technique the condition index of the section resulting from the improvement (CI_N in Equation 7.1) can be determined. This determination is made by evaluating the effects that each improvement type will have on the four basic components of the condition index. These effects are outlined below.

1. Pavement Type - All improvement types may potentially change this component. The pavement type is appropriately re-determined on the basis of the current truck volume (and its estimated growth rate) using the technique for pavement thickness estimation described in the preceding chapter.
2. Pavement Condition - Once again, all improvement types will affect this component. The present serviceability rating (PSR) is assigned maximum value, which was estimated to be 4.8 for principal arterials and 4.4 for all other classifications, and the accumulated axle loads are re-initialized.

3. Peak-Hour Volume/Capacity Ratios - Only lane widths and lane additions were considered to affect V/C ratios. Therefore the major widening, minor widening, new location, and reconstruction improvements were considered to affect this component. The V/C ratios are recalculated by estimating the increased capacity resulting from the addition of lanes and/or increases in lane widths. The 1965 Highway Capacity Manual (30) was used as a basis for such calculations.
4. Lane Widths - Major widening, minor widening, new location and reconstruction will affect this component. It is assumed that the lane widths will be raised to the current design standard of 12 feet when any of the above improvement types are implemented.

After the values of the condition index components are determined, after the implementation of a specified improvement type, the CI_N value in Equation 7.1 can be readily calculated.

Improvement Costs

The costs associated with each capital improvement type ($Cost_i$ in Equation 7.1) were estimated by developing an average cost per mile using the national data provided in the 1972 National Highway Needs Report and applying these values to Indiana. The resultant costs (1969 prices) are presented in Table 27. To evaluate the impact that economic conditions will have on these costs, annual projections were made by; 1) transforming the 1969 unit costs to 1975 unit costs using the cost indices provided in the 1975 Highway Statistics (1) and 2) using the deflators for capital improvement presented in Figure 16.

TABLE 27. 1969 ESTIMATIONS OF COSTS PER MILE BY CAPITAL IMPROVEMENT TYPE (IN THOUSANDS OF 1969 DOLLARS).

FUNCTIONAL CLASSIFICATION	NEW LOCATION	RECONST.	ISOLATED RECONST.	MAJOR WIDENING	MINOR WIDENING	RESURF. & SHLDR. IMP.	RESURF.
RURAL:							
INTERSTATE	363	1722	126	631	326	173	98
OTHER PRIN ART	1042	607	153	581	177	128	67
MINOR ARTERIAL	664	358	91	565	145	86	41
MAJOR COLLECTOR	283	231	54	584	120	51	22
MINOR COLLECTOR	161	145	35	185	89	40	18
URBAN:							
INTERSTATE	8244	3929	5311	2021	1233	658	223
OTH FWY & EXPWY	5385	3864	758	2826	1305	574	207
OTHER PRIN ART	2387	1452	414	1481	740	225	139
MINOR ARTERIALS	1095	942	231	1004	502	128	116
COLLECTORS	632	587	123	705	350	115	68
SMALL URBAN:							
INTERSTATE	-	-	-	764	800	273	155
OTH FWY & EXPWY	2442	2016	1087	921	877	403	172
OTHER PRIN ART	1575	987	249	905	605	149	96
MINOR ARTERIALS	795	598	196	619	419	138	66
COLLECTORS	582	472	721	506	306	107	49

FIGURE 16. SUMMARY OF DRI DEFLATORS FOR HIGHWAY CAPITAL IMPROVEMENTS

SOURCE: REFERENCE 7.

Equation 7.1 can now be applied to determine the cost effectiveness of a capital expenditure on each roadway section. Subsequently, the priority of expenditures can now be established.

Improvement Assignment

The approach described thus far is similar to that used by the 1976 National Highway Inventory and Performance Study, however unlike the 1976 NHIPS, which utilized a deterministic approach in priority setting, the present study's approach is probabilistic. Two major arguments can be raised against the application of a purely deterministic approach to set priorities for capital expenditures. First, since the condition index requires a considerable amount of subjective input, it is ill-advised to use it as an absolute basis. The second argument relates to the impact of political decisions which tend to make the programming process highly probabilistic.

As a result of the deficiencies inherent in the deterministic approach in priority programming, a dual threshold analysis technique (which is probabilistic by nature) was developed for use in this study. This technique assumes that all roadway sections with a condition index below a specified threshold or a cost effectiveness value above a specified threshold have an equal probability of selection. The thresholds used in this study are simply the average condition index and the average cost-effectiveness factor of the roadway sections which comprise each functional classification. Therefore, the priority setting of capital improvements was achieved by the application of the following steps:

1. Roadway sections are selected randomly and compared to the average condition index of the functional classification.
2. When a roadway section is found to have a condition index less than the average, the section is assigned the appropriate improvement and both the condition index and cost effectiveness factor are revised to reflect the impact of that improvement. The cost of the improvement is calculated by multiplying the section lengths with the costs per mile derived from the values presented in Table 27.
3. Roadway sections are selected randomly and compared to the average cost effectiveness factor of the roadway sections comprising a particular functional classification.
4. When a roadway section is found to have a cost effectiveness factor above the average, the same procedure described in step 2 is implemented.
5. Steps 1 through 4 are repeated until the total capital improvement funds allocated to the specific functional classification during a particular year are exhausted.

This dual threshold analysis technique provides projections of condition indices by functional classification which are only slightly affected by the order in which individual roadway sections are selected for threshold comparisons. It is felt that the consistency of condition index projections as well as the theoretical basis of this approach makes the dual threshold analysis technique an appropriate procedure instead of the deterministic approaches used in the past.

Stopgap Repairs

In addition to capital improvements, provisions were made for stopgap repairs. Stopgap repairs are defined as those repairs necessary to keep a roadway section in usable condition. These repairs, which include such activities as isolated resurfacing, were made only when insufficient funding is available to perform the needed capital improvement.

In this study, stopgap repairs were considered only on roadway sections with severely deteriorated pavements. The cost of such repairs is assumed to be 15% of the resurfacing costs (3). These repairs were assumed to add, in general, three to five years of service life to the roadway section.

CHAPTER 8

MODEL RESULTS

A listing of the computer model that eventually evolved is presented in Appendix A. Before the model could be applied it was necessary to establish the validity of the model results. The 1975 highway performance data, which was used as the basis for the estimation of highway performance in this study, was the only complete performance data available, and therefore, it was not possible to validate the model by comparing model results with more recent data. Subsequently, the model was validated by 1) carefully monitoring the values of model variables at various stages of the computational process in terms of their consistency, and 2) comparing the model results for 1990 with those obtained by the 1976 National Highway Inventory and Performance Study which is the only other study to provide detailed projections of future highway performance. The results of the present study were found to be compatible with those obtained in the 1976 NHIPS, although a direct comparison was not possible since the 1976 study provides highway performance on a national basis, while the present study projects highway performance for the state of Indiana.

Model Application

A number of scenarios was considered to analyze the effects that legislative policy options, changes in future travel characteristics and a relaxation of present improvement standards may have on the performance of the Indiana highway system. In discussing the results in this chapter, the scenarios tested are identified by a letter and number coding system. The letter denotes the macroeconomic model used to provide economic data for the scenario run. For example, T indicates that the TRENDLONG data was used, C the CYCLELONG data, and P the PESSIMLONG data. The number which follows the letter in the scenario coding system refers to a specific option of possible legislative alternatives along with other attendant assumptions.

It was assumed, in all scenarios tested, that legislative policy options would have no effect on the macroeconomic data used as input. The only exception to the assumption was the gasoline price deflator which would be influenced by changes in fuel taxing rates. This assumption is reasonable since a recent study observed that a probable range of highway funding options have negligible impacts on economic conditions (5).

Revenue Assumptions

Revenues from federal agencies, state general fund appropriations, and other non-state road-user tax sources, were estimated by assuming that such revenues would be proportional to the revenues collected from state road-user taxes. This assumption was based on 1) an analysis of past data, which revealed that revenues from non-state

road-user sources have historically constituted a relatively constant share of total highway revenues (see Figure 17) and 2) consideration of the taxing effort, which is a measure of a state's taxing policies relative to other states, and is an important factor in determining the amount of federal aid allocated to states, and therefore, revenues from federal sources can be expected to be proportional to changes in state road-user tax revenues (37).

Disbursement Assumptions

In this study, highway disbursements are categorized into four broad classifications: 1) local capital outlays which include all expenditures for capital improvements on the local road functional classification, 2) non-local capital outlays which include all expenditures for capital improvements on non-local functional classifications (e.g. interstates, arterials, and collectors), 3) structure costs which include funds allocated for the rehabilitation of roadway structures, and 4) routine maintenance, administration, and all others. It was assumed that the last group of expenditures would increase at an annual rate that is proportional to the annual increase in the price deflator for capital outlays. Hence the disbursements for this group were determined from the following equation:

$$DMA = DMA_{-1} * (1. + DCO * PR) \quad (8.1)$$

where

DMA = the annual disbursement for maintenance, administration,
and all others.

FIGURE 17. PERCENT OF TOTAL HIGHWAY RECEIPTS FROM SOURCES OTHER THAN STATE ROAD-USER TAXES FOR INDIANA

SOURCE: REFERENCE 1.

DMA_{-1} = the disbursement for maintenance, and so on in the
preceding year,
 DCO = the price deflator for capital outlays,
 PR = the assumed proportion of DMA increase relative to DCO
increase.

The above equation is based on an analysis of recent trends which revealed an approximate equality between maintenance and operation cost increases and increases in capital outlay costs (1). The proportion (PR in Equation 8.1) was introduced to reflect the ability of the highway agencies to reduce low priority routine maintenance and administration programs, thereby permitting more funds to be directed to needed capital improvement projects. A value of .25 was used in all scenarios for this proportion. This value reflects a considerable effort by the agencies to limit such disbursements, and this value is consistent with recent Indiana highway disbursement trends (1).

Once the disbursements for maintenance, administration, and others have been calculated, a fixed percentage of the remaining funds is allocated to structures, local and non-local capital outlays. It was assumed for all scenarios that 33 percent of the funds would be allocated to local road capital improvement projects, 3 percent of the funds would be allocated to structures, and the remaining 64 percent to non-local capital improvements. These values were estimated using historical data and the values estimated by previous studies (3,5,32).

Distribution of Non-Local Capital Funds

Among Functional Classifications

Two alternate funding distributions were developed using, as a basis, the funding distributions presented in the 1976 National Highway Inventory and Performance Study (5) and the estimation of future Indiana capital improvement needs made for the 1972 National Highway Needs Study (32). The first funding distribution (series I) was used for all scenarios which assume that the highway performance standards and the travel characteristics would remain unchanged over the time period of the present study. The series I distribution allocates a relatively large percentage of capital improvement funds to high volume facilities (see Table 28). This distribution reflects state preference for maintaining the condition of high volume facilities as opposed to low volume facilities which are given a lower priority particularly when funding levels are not sufficient to meet highway needs.

The second funding distribution (series II) was used for scenarios that assumed changes in highway performance standards or in travel characteristics. These assumed changes result in a considerable reduction in the need for capital improvements on high volume facilities. Subsequently, the series II distribution (see Table 29) allocates more funding to low volume facilities than does the series I distribution.

Discussion of Options

Table 30 summarizes the assumptions made for the seven options used in this analysis. Appendix B presents a sample computer output

TABLE 28. SERIES I PERCENT OF TOTAL CAPITAL IMPROVEMENT FUNDS ALLOTTED TO EACH FUNCTIONAL CLASSIFICATION.

SYSTEM	DISTRIBUTION OF FUNDS (PERCENT)
RURAL:	
INTERSTATE	8.0
OTHER PRIN ART	9.5
MINOR ARTERIALS	16.5
MAJOR COLLECTORS	6.0
MINOR COLLECTORS	6.0
URBAN:	
INTERSTATE	18.0
OTH FWY & EXPWY	7.0
OTHER PRIN ART	12.0
MINOR ARTERIALS	5.5
COLLECTORS	3.0
SMALL URBAN:	
INTERSTATE	0.5
OTH FWY & EXPWY	1.0
OTHER PRIN ART	3.0
MINOR ARTERIALS	2.0
COLLECTORS	2.0

TABLE 29. SERIES II REVISED PERCENT OF TOTAL CAPITAL IMPROVEMENT FUNDS ALLOTTED TO EACH FUNCTIONAL CLASSIFICATION.

SYSTEM	DISTRIBUTION OF FUNDS (PERCENT)
<hr/>	
RURAL:	

INTERSTATE	5.5
OTHER PRIN ART	6.0
MINOR ARTERIALS	14.0
MAJOR COLLECTORS	10.0
MINOR COLLECTORS	10.5
URBAN:	

INTERSTATE	12.5
OTH FWY & EXPWY	8.0
OTHER PRIN ART	11.0
MINOR ARTERIALS	8.5
COLLECTORS	3.5
SMALL URBAN:	

INTERSTATE	0.1
OTH FWY & EXPWY	0.5
OTHER PRIN ART	1.9
MINOR ARTERIALS	3.0
COLLECTORS	3.0
<hr/>	

TABLE 30. SUMMARY OF OPTION ASSUMPTIONS.

	OPTION						
	1	2	3	4	5	6	7
STATE ROAD-USER TAX RATES	SAME AS 1979	\$.11 GAS TAX	\$.11 GAS TAX	20 PERCENT AD VALOREM TAX	SAME AS 1979	\$.11 GAS TAX	\$.11 GAS TAX
FRACTION OF TOTAL REVENUES OBTAINED FROM NON-STATE ROAD-USER TAX SOURCES	.45	.45	.55	.45	.45	.45	.45
DISTRIBUTION OF CAPITAL FUNDS TO FUNCTIONAL CLASSIFICATIONS	SERIES 1	SERIES 1	SERIES 1	SERIES 1	SERIES 1	SERIES 2	SERIES 2
OTHER ASSUMPTIONS	NONE	NONE	NONE	NONE	INCREASE IN PERMISSIBLE AXLE LOADS.	RELAXED IM- PROVEMENT STANDARDS.	REDUCE PEAK- ING BY 20 PERCENT.

of a typical option model run. The results of all seven options tested are discussed in the following paragraphs.

Option 1

This option was designed to analyze the effects that a continuation of present Indiana highway taxing policies will have on future Indiana highway performance. It was examined in terms of all three macroeconomic forecasts so that the full impacts of varying national economic conditions could be assessed. Table 31 summarizes the 1990 values of select model parameters using the TRENDLONG, CYCLELONG, and PESSIMLONG macroeconomic forecasts. As might be expected, when comparing the three model run parameters presented in this table, the high inflation rates and lower industrial productions of the CYCLELONG and PESSIMLONG model runs result in lower VMT values, lower fleet fuel efficiencies, higher gasoline prices, and lower highway revenues which have less buying power per dollar.

The effects that economic conditions have on highway performance are shown in Table 32. This table summarizes the percent change in the condition indices of each functional classification between 1976 and 1990 under Option 1. It is apparent that if current highway taxing policies are continued, a considerable deterioration is expected in Indiana highway performance, particularly on lower volume facilities. This loss in highway performance arises from an overall decline in system pavement conditions and increased congestion.

As for the impacts of economic conditions, in this option the more pessimistic economic assumptions result in less highway performance

TABLE 31. SUMMARY OF THE 1990 VALUES OF SELECT MODEL PARAMETERS UNDER SCENARIOS T-1, C-1, P-1.

PARAMETER	SCENARIO		
	T-1	C-1	P-1
TOTAL UMT (MILLIONS)	53399	51594	49920
COMBINATION UMT (MILLIONS)	3115	2873	2917
TOTAL FLEET EFFICIENCY (MPG)	18.56	18.51	18.45
RETAIL GAS PRICE (DOLLARS)	1.31	1.48	1.65
TOTAL REVENUES (THOUSANDS OF DOLLARS)	586272	570112	550827
NON-LOCAL CAPITAL OUTLAYS (THOUSANDS OF DOLLARS)	182056	167843	153113
PRICE DEFULATOR FOR CAPITAL OUTLAYS (1975=1.00)	2.75	2.92	3.38
OTHER NON-CAPITAL DISBURSEMENTS (THOUSANDS OF DOLLARS)	314546	319599	332299

TABLE 32. SUMMARY OF THE PERCENT CHANGE IN CONDITION INDICES (1976-1990) UNDER SCENARIOS T-1, C-1, AND P-1.

SCENARIO			
FUNCTIONAL CLASSIFICATION	T-1	C-1	P-1
RURAL: -----			
INTERSTATE	-11.2	-9.8	-8.9
OTHER PRINCIPAL ARTERIALS	-5.8	-4.1	-3.6
MINOR ARTERIALS	-9.6	-7.6	-7.4
MAJOR COLLECTORS	-22.5	-19.3	-18.7
MINOR COLLECTORS	-29.6	-25.6	-25.4
URBAN: -----			
INTERSTATE	-13.5	-12.5	-12.1
OTHER FREEWAYS AND EXPRESSWAYS	-14.4	-13.2	-10.9
OTHER PRINCIPAL ARTERIALS	-10.4	-10.3	-9.6
MINOR ARTERIALS	-19.3	-19.1	-17.9
COLLECTORS	-18.5	-18.5	-16.4

loss. This is due to the fact that pessimistic economic assumptions result in 1) less congestion as total VMT growth rates are restrained, and 2) less axle load accumulations as the growth in intercity ton-mileage takes place only on a moderate level. For this option, the above two factors offset the effects of decreasing highway revenues and reductions in per dollar buying power. The result is that a less reduction in highway performance is observed.

It must be pointed out, however, that in no way can it be concluded that more pessimistic economic assumptions will necessarily result in less deterioration in highway performance. In some cases, as will be shown later, revised highway performance standards and travel characteristics result, on certain functional classifications, in less reduction in highway performance, even under more optimistic economic scenarios. This is due to the fact that highway performance is the result of the interaction of economic conditions, the performance criteria used, the travel characteristics assumed, and the physical attributes of each functional classification.

Option 2

Option 2 has essentially the same assumptions as Option 1, however this option implements an 11 cents per gallon gasoline tax in 1980 which is a 3 cent increase over current gasoline tax rates. The increase in gasoline tax, which is also accompanied by increases in funds from other non-state road-user revenue sources, results in a 27 percent increase in total highway revenues in calendar year 1980 (see Table 34) using the TRENDLONG macroeconomic data. The impact

that the additional revenue has on the Indiana highway performance is summarized in Table 33. When comparing scenarios T-1 and T-2 it is evident that the increased revenue results in only moderate improvement in highway performance after a certain threshold level. This is due to the fact that the capital investment/performance curve for each functional classification is asymptotic (see Figure 18), and therefore, a large increase in capital investment may result in only modest increases in the condition index.

Option 3

Option 3 assumes a 3 cents per gallon increase in the gas tax in 1980 accompanied by an increase in the proportion of federal aid, general fund appropriations, and other revenue shares such that these revenue sources constitute 55 percent of the total highway budget as opposed to the 45 percent used in previous options. The above assumptions result in total 1980 highway revenues which are 22 percent and 36 percent greater than the Option 2 and Option 1 1980 revenues respectively, using the TRENDLONG macroeconomic data (see Table 34). Table 33 summarizes the changes in highway performance under scenarios T-1, T-2, and T-3. Once again, the additional revenue results in only moderate reductions in highway performance loss.

Option 4

Option 4 assumes that a 20 percent per gallon ad valorem gasoline tax is implemented in 1980 in an attempt to keep pace with the inflationary pressures which push capital improvement costs up by 275 percent, between 1975 and 1990, under the TRENDLONG macroeconomic

FIGURE 18. GENERALIZED SHAPE OF THE HIGHWAY INVESTMENT / PERFORMANCE CURVE (ONE FOR EACH FUNCTIONAL CLASSIFICATION)

SOURCE: REFERENCE 5.

TABLE 33. SUMMARY OF THE PERCENT CHANGE IN CONDITION INDICES (1976-1990) UNDER SCENARIOS T-1, T-2, AND T-3.

SCENARIO			
FUNCTIONAL CLASSIFICATION	T-1	T-2	T-3
RURAL:			
INTERSTATE	-11.2	-10.0	-7.7
OTHER PRINCIPAL ARTERIALS	-5.8	-3.1	-0.8
MINOR ARTERIALS	-9.6	-5.8	-4.4
MAJOR COLLECTORS	-22.5	-18.6	-12.6
MINOR COLLECTORS	-29.6	-27.0	-23.8
URBAN:			
INTERSTATE	-13.5	-10.7	-7.3
OTHER FREEWAYS AND EXPRESSWAYS	-14.4	-12.5	-10.1
OTHER PRINCIPAL ARTERIALS	-10.4	-9.7	-7.5
MINOR ARTERIALS	-19.3	-18.8	-16.5
COLLECTORS	-18.5	-15.6	-13.7

assumptions. Table 34 summarizes total highway revenues generated by the four options discussed thus far. The ad valorem tax obviously generates the most revenue. This is particularly evident in the mid-1980's when decreasing fuel consumption actually reduces the total revenues collected from the other three options.

Although the highway performance in scenario T-4 is noticeably improved over scenario T-1 (see Table 36), it is evident that, despite a considerable increase in revenues, the highway performance still declines on most functional classifications. This indicates that the generated revenue is still not sufficient to perform the capital improvements necessary to maintain 1975 highway performance. There are essentially two reasons for this. First, the asymptotic shape of the investment/performance curve provides less improvement than would be expected if a linear relationship existed. Second, the ad valorem tax is indexed to the price of fuel, which in the TRENDLONG macro-economic forecast, increases at a rate which is less than the rate of increase in the cost for capital improvements, and therefore, inflation continues to erode highway dollars but to a lesser extent than previous options.

Option 5

Option 5 was designed to evaluate the impacts that an increase in the permissible axle loads would have on Indiana highway performance. Currently Indiana weight limits are 18 kips for single axles, 32 kips for tandem axles, and 73.28 kips for total gross weight. There has been considerable pressure on the Indiana state legislature to raise

TABLE 34. SUMMARY OF TOTAL HIGHWAY REVENUES GENERATED BY SCENARIOS
T-1, T-2, T-3, AND T-4 (IN THOUSANDS OF DOLLARS).

YEAR	SCENARIO			
	T-1	T-2	T-3	T-4
1976	587716	587716	587716	587716
1977	593720	593720	593720	593720
1978	597849	597849	597849	597849
1979	598809	598809	598809	598809
1980	598065	761765	930108	884334
1981	596759	758872	926507	921084
1982	593267	753158	919515	957142
1983	590975	748962	914378	991797
1984	587528	743186	907310	1037210
1985	583165	736284	898908	1082107
1986	580312	731508	893022	1128559
1987	579679	729465	890520	1181416
1988	580814	730018	891190	1242025
1989	583106	732149	893790	1309155
1990	586272	735529	897942	1380767

these limits to conform with the weight limits of most other states which are; 20 kips, 32 kips, and 80 kips for single axle, tandem axle, and gross weight respectively. This option implements these higher weight limits at the beginning of 1980. The other assumptions are the same as in Option 1.

The increase in permissible weight limits will have the following impacts on Indiana truck characteristics:

1. The average weight of a loaded truck will increase.
2. The average weight of an empty truck will increase as additional structural support will be required to carry the increase in loads.
3. The commercial VMT will decrease as less truck trips are required to transport the same amount of tonnage.

Estimations of the increases in the mean weights of empty and loaded trucks (see Table 35) were developed from the 1975 National Truck Characteristic Report and other appropriate studies (24,38,39). The standard deviations, weight distributions by axle, and percent of trucks by type, were assumed to be unchanged as the data available to estimate these changes was inconclusive; however, since the increase in the permissible weight limits is relatively small, such an assumption will not cause any significant errors.

The measurement of the decrease in commercial VMT is achieved by estimating the average load carried index (ALCI) described earlier in Chapter 4. The factor was estimated by applying the following equation:

TABLE 3S. REVISED TRUCK WEIGHT MEANS, STANDARD DEVIATIONS, AND PERCENTAGE OF WEIGHTS BY AXLE.

VEHICLE TYPE 1/ -----	PERCENT OF TRUCKS BY TYPE -----	MEAN WEIGHT (IN KIPS) -----	STANDARD DEVIATION (IN KIPS) -----	WEIGHTS BY AXLE 2/ 1 2 3 -----
EMPTY -----				
SINGLE UNIT -----				
2 AX 4 TIRE	77.0	5.5	2.0	.42 .58 -
2 AX 6 TIRE	19.0	10.9	4.0	.44 .56 -
3 AX OR MORE	4.0	17.5	7.0	.38 .62T -
COMBINATION -----				
3 AXLE	5.0	23.0	7.0	.31 .37 .32
4 AXLE	15.0	27.0	8.0	.25 .25 .50T
5 AXLE OR MORE	80.0	31.2	4.0	.26 .40T .34T
LOADED -----				
SINGLE UNIT -----				
2 AX 4 TIRE	77.0	7.0	2.6	.31 .69 -
2 AX 6 TIRE	19.0	16.4	6.0	.37 .63 -
3 AX OR MORE	4.0	36.5	14.0	.28 .72T -
COMBINATION -----				
3 AXLE	5.0	34.5	5.0	.27 .40 .33
4 AXLE	15.0	43.0	12.0	.18 .34 .48T
5 AXLE OR MORE	80.0	63.0	14.0	.15 .42T .43T

T = TANDEM AXLES
 1/ TANDEM AXLES COUNTED AS TWO AXLES
 2/ TANDEM AXLES COUNTED AS ONE AXLE

$$ALCI = \frac{\sum_{i=1}^6 PT_i * (NMLW_i - NMEW_i)}{\sum_{i=1}^6 PT_i * (IMLW_i - IMEW_i)} \quad (8.2)$$

where

ALCI = the average load carried index.

i = the truck type (single unit 2 axle 4 tire, and so on).

PT_i = truck type i as a percent of all truck types.

NMLW_i = new mean loaded weight of truck type i.

NMEW_i = new mean empty weight of truck type i.

IMLW_i = 1975 mean loaded weight of truck type i.

IMEW_i = 1975 mean empty weight of truck type i.

A value of 1.09 was calculated from the above equation indicating a 9 percent average increase in load carried per vehicle. This value was then used in equation 4.2 to calculate the change in commercial VMT.

The resulting changes in highway performance are summarized in Table 36. In comparing scenarios T-1 and T-5 it is evident that the increasing of the axle weight limits has only a small adverse effect on the performance of the principal arterial systems, however, the increase has a significant adverse impact on the lower volume facilities. This is due to the fact that lower volume facilities generally have lighter pavement designs which are more sensitive to increases in axle loads (36), and subsequently, the collector systems will tend to suffer the most from increasing weight limits.

TABLE 36. SUMMARY OF THE PERCENT CHANGE IN CONDITION INDICES (1976-1990) UNDER SCENARIOS T-1, T-4, AND T-5.

SCENARIO				

FUNCTIONAL CLASSIFICATION				
	T-1	T-4	T-5	

RURAL:				

INTERSTATE	-11.2	-4.2	-11.1	
OTHER PRINCIPAL ARTERIALS	-5.8	+1.8	-5.9	
MINOR ARTERIALS	-9.6	-1.1	-10.3	
MAJOR COLLECTORS	-22.5	-8.4	-27.7	
MINOR COLLECTORS	-29.6	-17.7	-33.4	
URBAN:				

INTERSTATE	-13.5	-4.4	-15.0	
OTHER FREEWAYS AND EXPRESSWAYS	-14.4	-9.5	-15.3	
OTHER PRINCIPAL ARTERIALS	-10.4	-6.7	-11.9	
MINOR ARTERIALS	-19.3	-15.6	-22.4	
COLLECTORS	-18.5	-10.3	-22.9	

Option 6

The purpose of this option was to evaluate the effects that a relaxation of present highway performance standards will have on future Indiana highway performance. This relaxation was achieved by attaching more importance to pavement conditions and less importance to volume/capacity ratios and lane widths. Table 37 presents a summary of the weighting values resulting from relaxed performance standards. Such a relaxation in standards would permit the state to concentrate more of its capital funds on pavement rehabilitation and less funds on costly widening improvements.

This option also included the assumption of the 1980 implementation of an 11 cent per gallon gas tax. It was further assumed that non-local capital funds would be distributed among functional classifications by the series II distribution which allocates a greater share of capital funds to lower volume facilities. The resulting impacts on Indiana highway performance are summarized in Table 38. In comparing scenarios T-2 and T-6 it is apparent that there is a general improvement in the performance deterioration of the latter. The relaxation of standards enables the performance losses of the T-6 high volume facilities to be comparable to the T-2 losses on such facilities despite the fact that less funds were allocated to these facilities under the series II distribution. Overall, the pavement conditions are improved considerably under this option; as it can be expected. However, the volume/capacity ratios generally are higher indicating a greater service loss.

TABLE 37. REVISED URBAN AND RURAL CONDITION INDEX WEIGHTS BY FUNCTIONAL CLASSIFICATION.

URBAN WEIGHTS			
	PRINCIPAL ARTERIALS	MINOR ARTERIALS	COLLECTORS
	-----	-----	-----
CONDITION:			
PAVEMENT TYPE	10	10	10
PAVEMENT COND.	45	55	55
SERVICE:			
VOL/CAP RATIO	30	20	20
SAFETY:			
LANE WIDTH	15	15	15
RURAL WEIGHTS			
	PRINCIPAL ARTERIALS	MINOR ARTERIALS	COLLECTORS
	-----	-----	-----
CONDITION:			
PAVEMENT TYPE	10	10	10
PAVEMENT COND.	45	55	65
SERVICE:			
VOL/CAP RATIO	30	20	10
SAFETY:			
LANE WIDTH	15	15	15

TABLE 38. SUMMARY OF THE PERCENT CHANGE IN CONDITION INDICES (1976-1990) UNDER SCENARIOS T-2, T-6, AND P-6.

SCENARIO			
FUNCTIONAL CLASSIFICATION	T-2	T-6	P-6
RURAL:			
INTERSTATE	-10.0	-4.5	-2.5
OTHER PRINCIPAL ARTERIALS	-3.1	-5.7	-4.9
MINOR ARTERIALS	-5.8	-6.5	-5.4
MAJOR COLLECTORS	-18.6	-9.4	-8.1
MINOR COLLECTORS	-27.0	-19.8	-21.2
URBAN:			
INTERSTATE	-10.7	-11.3	-10.1
OTHER FREEWAYS AND EXPRESSWAYS	-12.5	-13.0	-9.2
OTHER PRINCIPAL ARTERIALS	-9.7	-9.9	-7.7
MINOR ARTERIALS	-18.8	-16.6	-14.3
COLLECTORS	-15.6	-6.5	-4.4

This option was also run with the PESSIMLONG macroeconomic model to evaluate economic impacts under the revised performance standards. The economic impact results for high volume facilities were much the same as the results observed in Option 1. This indicates that the reduced volume/capacity ratios and commercial VMT values associated with the PESSIMLONG model offset the effects of decreases in capital investments. However, in the lower volume facilities, which generally require more frequent resurfacing, the additional funds allocated to resurfacing improvements with the TRENDLONG model result in significantly improved pavement conditions. This, when considering the increased emphasis on pavement conditions in the series II performance criteria, offsets the lower volume/capacity ratios and commercial VMT values observed with the PESSIMLONG model to a greater degree than was the case with the higher volume facilities. Consequently, the difference in the performance impacts of the two economic models is less conclusive on lower volume facilities. In the case of rural minor collectors, for example, scenario T-6 resulted in better overall pavement condition than those in scenario P-6 and, although the volume/capacity ratios were higher in the former, the overall adverse effect on highway performance was less.

Option 7

This option was intended to evaluate the impacts that a reduction in the present peaking characteristics would have on Indiana highway performance. Such reductions can result from car/van pooling,

staggered working hours and so on. It was assumed in this option that the eleven cent per gallon gas tax would be implemented in 1980, the initial performance standards would be in use, and the series II capital outlay distribution would be utilized. In addition, from 1976 to 1990 a 20 percent reduction in the percent of the average daily travel (ADT) occurring during peak periods was applied.

This option resulted in an improved highway performance; the performance levels were considerably higher than those obtained under scenario T-2 which assumed a continuation of present peaking characteristics. This improvement results from the obvious reductions in volume/capacity ratios and the improvement in pavement conditions as more funds were allocated to pavement rehabilitation as the need for widening diminished (see Table 39).

The increased emphasis on pavement rehabilitation resulted in better pavement conditions under scenario T-7 than those in scenario P-7 despite the lower axle load accumulations in the latter. However, the higher volume/capacity ratios of scenario T-7 and their relative importance in estimating highway performance, offsets the improved pavement conditions, and subsequently, highway performance losses were generally less under scenario P-7.

Implications of the Results

It is apparent from the options tested in this chapter, that a general decline in Indiana highway performance can be expected in the future. Alternatives other than additional revenue generation such as the relaxations of performance standards and reductions in peaking

TABLE 39. SUMMARY OF THE PERCENT CHANGE IN CONDITION INDICES (1976-1990) UNDER SCENARIOS T-2, T-7, AND P-7.

SCENARIO			
FUNCTIONAL CLASSIFICATION	T-2	T-7	P-7
RURAL:-----			
INTERSTATE	-10.0	-2.8	-1.1
OTHER PRINCIPAL ARTERIALS	-3.1	-2.6	-1.0
MINOR ARTERIALS	-5.8	-1.8	-0.6
MAJOR COLLECTORS	-18.6	-6.5	-8.1
MINOR COLLECTORS	-27.0	-14.9	-10.9
URBAN:-----			
INTERSTATE	-10.7	-8.0	-6.2
OTHER FREEWAYS AND EXPRESSWAYS	-12.5	-6.0	-4.4
OTHER PRINCIPAL ARTERIALS	-9.7	-5.3	-3.8
MINOR ARTERIALS	-18.8	-12.4	-9.3
COLLECTORS	-15.6	-8.1	-2.7

characteristics can minimize future highway performance losses as options six and seven indicate. Realistically, a combination of increased taxes and other non-revenue generating alternatives will likely provide the most acceptable solution to the highway financing problem. This combination will be dependent upon public willingness to accept additional taxation and public tolerance to additional highway performance loss.

Insofar as taxation is concerned, the 20 percent ad valorem gas tax is the most promising option tested in this study, as it neutralizes much of the inflationary pressure afflicting highway disbursements. Regretably, administrative problems and public resistance to an apparently high taxing level may make the implementation of such a tax difficult. An increase in the conventional eight cent per gallon gas tax is a more likely source of additional revenue.

The determination of what the public considers to be a tolerable level of highway performance is difficult, if not impossible to assess. It, therefore, can be argued that the relaxation of performance standards considered in option six, which significantly reduced highway performance loss, may be quite acceptable to the public. There is obviously the need for additional research to determine public willingness to accept trade-offs between the safety, service, and condition attributes of highway performance. Other policies such as the reduction in peaking characteristics, through an effective car/van pool program and other such measures, require public cooperation which will be influenced to a certain extent by government incentives.

In conclusion, although highway performance is likely to decrease in the future, appropriate highway policy decisions can assure that an acceptable level of highway performance is achieved.

CHAPTER 9

SUMMARY AND CONCLUSIONS

This research has considered the interaction between factors such as energy, national economic conditions, fuel efficiency, fuel consumption, population, and legislative options in an effort to evaluate their ultimate impact on the highway financing process in Indiana. This evaluation was achieved by the development of a computer model which utilized the national energy and economic forecasts provided by Data Resources Inc. along with various assumptions relating to legislative options to project a probable range of highway performance in Indiana. The results of the application of this model indicate that the level of Indiana highway performance is likely to decline over the next decade as the funds required to sustain highway performance are staggering. However, appropriate legislative action can limit this decline and assure that an acceptable level of highway performance is realized in the future.

On the basis of the results of the present study the following conclusions can be made.

1. Additional highway revenues must be acquired soon as the continued deferment of needed capital improvement projects will seriously compound future highway problems in Indiana. Such additional revenues can be generated from a number of

sources including additional appropriations from general funds and increases in current fuel tax rates or the enactment of an ad valorem fuel tax.

2. Serious efforts should be made to limit the growth in all non-capital highway disbursements.
3. It is necessary to determine the acceptable trade-offs between highway performance components and the capital funding effort should be adjusted accordingly. For example, public outcry over the condition of pavements may seem to indicate the need for more emphasis on pavement rehabilitation. However, if this is to be done, less resources will be available for widening and other such upgrading improvements causing more congested highways. Therefore, careful evaluation must be made of the appropriate trade-offs such that capital improvement funds can be optimally utilized.
4. Attention should be given on statewide promotion of car/van pooling, public transit, and staggered working hours since the effective implementation of these measures may significantly reduce highway congestion in urban areas. This would allow the capital improvement funds normally spent to increase highway capacity to be allocated to pavement rehabilitation and other less costly improvements.
5. Future increases in permissible axle loads should not be considered unless accompanied by significant increases in truck registration fees, since there is evidence that pavement deterioration rates increase measurably under the higher axle load limits.

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LIST OF REFERENCES

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APPENDICES

APPENDIX A

Program Listing of the HIPERFORM Computer Model

		HPM	1
		HPM	2
		HPM	3
		HPM	4
		HPM	5
		HPM	6
		HPM	7
		HPM	8
		HPM	9
		HPM	10
		HPM	11
		HPM	12
		HPM	13
		HPM	14
		HPM	15
		HPM	16
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		HPM	24
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		HPM	27
		HPM	28
		HPM	29
		HPM	30
		HPM	31
		HPM	32
		HPM	33
		HPM	34
		HPM	35
1000	FORMAT(I6,1X,I2)	HPM	36
	DO 1979 I=1,KSEED	HPM	37
1979	SEED=RANF(0)	HPM	38
	READ(5,503) (AID(I),I=1,15)	HPM	39
503	FORMAT(15F4.2)	HPM	40
	READ(5,501) (WSIN(I),I=1,15)	HPM	41
501	FORMAT(15F5.1)	HPM	42
	READ(5,1010) (RV1(I),I=1,15)	HPM	43
	READ(5,1010) (RV2(I),I=1,15)	HPM	44
1010	FORMAT(15F4.2)	HPM	45
	DO 3000 N1=1,KCOW	HPM	46
	KBARR=N1	HPM	47
	IF(N1.EQ.KCOW) KSSF=2	HPM	48
	IF(N1.GT.1) KSFLAG=2	HPM	49
	CALL PRESCO	HPM	50
	IF(N1.GT.1) GO TO 510	HPM	51
	CALL IPPM	HPM	52
	CALL USACO	HPM	53
	CALL UMPRO	HPM	54
	CALL REUGEN	HPM	55
510	CALL PAUAGE	HPM	56
3000	CONTINUE	HPM	57
	STOP	HPM	58
	END	HPM	59
		HPM	60

```

C
C
C
C
C      SUBROUTINE IPPM
C *****
C
C      THIS SUBROUTINE PROJECTS THE INDIANA POPULATION TO THE
C      TARGET YEAR.
C
C      DIMENSION MAL(18),MFE(18),SUM1(18),SUM2(18),SUF1(18),SUF2(18),
C      1SF(6),SUMM(18),SUFM(18),SUM3(6,18),SUF3(6,18),RMIG(6),MAL1(18),
C      2MFE1(18),N1(6),MMA(30),MMF(30),MIN(30),RINC(15),SINC(15),TOMG(15)
C      3,BI(15),GPI(15),WMIG(4),MP15(30),ITGAS(15),IRECO(15),
C      4IRESU(15),IREMO(15),IREA(15),RV1(15),RV2(15),HG4(3,5,105)
C      5,HG5(3,6,105),HGWY(3,6,105),HG2(3,6,105),ML1(3,6),HG3(3,5,105)
C      6,GRATE1(16),GRATE2(16),ITREV(16),AID(15),WSIN(16),TAX(15)
C      COMMON RINC,SINC,TOMG,BI,MIN,GPI,NYEAR,SAT1,B9,TAX,
C      1MP15,ITGAS,IRECO,IRESU,IREMO,IREA,RV1,RV2,IUOL,GRATE1,GRATE2,ITREV
C      2,HG5,HGWY,HG2,ML1,HG3,HG4,KCOW,KSSF,KSFLAG,KBARR,AID,WSIN
C
C      **** READ SERIES
C
C      READ(5,9999) IUOL,NYEAR,SAT1
C      9999 FORMAT(I1,1X,I2,1X,F4.2)
C
C      **** INITIAL COHORTS
C
C      DATA(MAL1(I),I=1,18)/232479,268759,278959,253127,195629,171449,
C      A144834,136324,148231,147852,132652,118207,98179,74348,55881,
C      B38238,22028,13594/
C      DATA(MFE1(I),I=1,18)/223197,260265,266944,249113,219095,174413,
C      A148775,143141,154703,156684,141669,125775,109405,92145,76349,
C      B57775,37124,25927/
C
C      **** INPUT SURVIVAL RATES
C
C      DATA(SUM1(I),I=1,18)/.980568,.996687,.998061,.995056,.990373,
C      A.989901,.990559,.988505,.983123,.972836,.957040,.933383,.899862,
C      B.852301,.790463,.710259,.605016,.406879/
C      DATA(SUM2(I),I=1,18)/.98475,.996936,.998191,.995322,.99081,.99056
C      A6,.991379,.98968,.985007,.975772,.961179,.938696,.906192,.859358,
C      B.797309,.719784,.621615,.42339/
C      DATA(SUF1(I),I=1,18)/.984689,.997442,.998523,.997784,.996683,
C      A.996368,.995455,.993414,.989939,.984169,.976437,.965977,.95087,
C      B.930779,.855951,.832189,.733118,.496489/
C      DATA(SUF2(I),I=1,18)/.987952,.997738,.99866,.998019,.997054,
C      A.996834,.996032,.994246,.991076,.995895,.978952,.969318,.955584,
C      B.937323,.905365,.847452,.754904,.508305/
C
C      **** FERTILITY RATES
C
C      DATA(SF(I),I=1,6)/71.5,70.,69.1,67.1,64.7,60.1/
C
C      **** ESTIMATED MIGRATION RATES
C
C      DATA(RMIG(I),I=1,6)/-.018,-.021,-.009,-.005,-.005,-.005/
C
C      **** DETERMINE SURVIVAL RATE INCREASE
C
C      DO 7070 I=1,18
C      SUMM(I)=(SUM2(I)-SUM1(I))/4
C      7070 SUFM(I)=(SUF2(I)-SUF1(I))/4
C      DO 7077 I=1,2
C      DO 7077 N=1,18
C      SUM3(I,N)=SUM1(N)
C      7077 SUF3(I,N)=SUF1(N)
C      DO 7078 I=3,6

```


DO 7078 N=1,18	HPM	131
SUM3(I,N)=SUM1(N)+((I-2)*SUMM(N))	HPM	132
7078 SUF3(I,N)=SUF1(N)+((I-2)*SUFM(N))	HPM	133
C	HPM	134
C **** START OF YEARLY PROJECTIONS	HPM	135
C	HPM	136
DO 8182 I=1,18	HPM	137
MAL(I)=MAL1(I)	HPM	138
8182 MFE(I)=MFE1(I)	HPM	139
DO 8080 L=1,6	HPM	140
IYEAR=1975+(L-1)*5	HPM	141
N1(L)=5*L	HPM	142
C	HPM	143
C **** BIRTH CALCULATIONS	HPM	144
C	HPM	145
FER2=0	HPM	146
DO 7071 I=4,9	HPM	147
FER1=FLOAT(MFE(I)/1000)*SF(L)	HPM	148
7071 FER2=FER2+FER1	HPM	149
FER2=FER2*5	HPM	150
C	HPM	151
C **** SURVIVAL CALCULATIONS	HPM	152
C	HPM	153
DO 7072 I=1,18	HPM	154
MAL(I)=IFIX(FLOAT(MAL(I))*SUM3(L,I))	HPM	155
7072 MFE(I)=IFIX(FLOAT(MFE(I))*SUF3(L,I))	HPM	156
C	HPM	157
C **** COHORT ADVANCE	HPM	158
C	HPM	159
MALU=MAL(18)	HPM	160
MFEU=MFE(18)	HPM	161
DO 7073 I=1,17	HPM	162
J=18-I	HPM	163
MAL(J+1)=MAL(J)	HPM	164
7073 MFE(J+1)=MFE(J)	HPM	165
MAL(18)=MAL(18)+MALU	HPM	166
MFE(18)=MFE(18)+MFEU	HPM	167
MAL(1)=IFIX(.515*FER2)	HPM	168
MFE(1)=IFIX(.485*FER2)	HPM	169
C	HPM	170
C **** MIGRATION CALCULATIONS	HPM	171
C	HPM	172
DO 7075 I=1,18	HPM	173
MAL(I)=IFIX(FLOAT(MAL(I))*1.05*RMIG(L))+MAL(I)	HPM	174
7075 MFE(I)=IFIX(FLOAT(MFE(I))*1.95*RMIG(L))+MFE(I)	HPM	175
MALT=0	HPM	176
MFET=0	HPM	177
DO 7074 I=1,18	HPM	178
MALT=MALT+MAL(I)	HPM	179
MFET=MFET+MFE(I)	HPM	180
7074 IF(I.GE.4) MP15(N1(L))=MP15(N1(L))+MAL(I)+MFE(I)	HPM	181
INPOP=MALT+MFET	HPM	182
MMA(N1(L))=MALT	HPM	183
MMF(N1(L))=MFET	HPM	184
MIN(N1(L))=INPOP	HPM	185
IF(L.EQ.1) GO TO 8080	HPM	186
MACO=(MMA(N1(L))-MMA(N1(L-1)))/5	HPM	187
MFCO=(MMF(N1(L))-MMF(N1(L-1)))/5	HPM	188
INCO=(MIN(N1(L))-MIN(N1(L-1)))/5	HPM	189
IF(L.NE.2) GO TO 90	HPM	190
WMIG(1)=.995	HPM	191
WMIG(2)=.9973	HPM	192
WMIG(3)=1.	HPM	193
WMIG(4)=1.003	HPM	194
GO TO 92	HPM	195
90 DO 91 I=1,4	HPM	196
91 WMIG(I)=1.	HPM	197
92 DO 1900 I=1,4	HPM	198
J=N1(L-1)+I	HPM	199
MMA(J)=(MACO*MMA(J-1))*WMIG(I)	HPM	200

MMF(J)=(MFCO+MMF(J-1))*WMIG(I)	HPM	201
1900 MIN(J)=(INCO+MIN(J-1))*WMIG(I)	HPM	202
8080 CONTINUE	HPM	203
WRITE(6,1000)	HPM	204
1000 FORMAT('1',1X,25('* '),1X,'INDIANA POPULATION ESTIMATES',1X,25('*	HPM	205
A'),////,31X,71('-'),//,31X'YEAR',15X,'FEMALE',16X,'MALE',	HPM	206
B16X,'TOTAL',/,31X,71('-'),/)	HPM	207
NDO=NYEAR+5	HPM	208
DO 1901 I=6,NDO	HPM	209
J=I-5	HPM	210
IYEAR=1975+J	HPM	211
WRITE(6,1001) IYEAR,MMF(I),MMA(I),MIN(I)	HPM	212
1001 FORMAT(31X,I4,3(12X,I9),/)	HPM	213
1901 CONTINUE	HPM	214
WRITE(6,1002)	HPM	215
1002 FORMAT(31X,71('-'))	HPM	216
RETURN	HPM	217
END	HPM	218
C	HPM	219
C	HPM	220
C	HPM	221
C	HPM	222
C	HPM	223
SUBROUTINE USACO	HPM	224
C *****	HPM	225
C	HPM	226
C	HPM	227
C	HPM	228
C	HPM	229
C	HPM	230
C	HPM	231
DIMENSION PSR(25),ACOR(12),SURV(12),RMPG(12),FMPG(15),	HPM	232
1UNEM(15),RGNP(15),RINC(15),ZNC(15),TOMG(15),	HPM	233
2NCB(15),BCOR(12),BI(15),TUT(15),PERV(15),MP15(30),	HPM	234
3MIN(30),SINC(15),GPI(15),RU1(15),RU2(15),TAX(15),	HPM	235
4ITGAS(15),IRECO(15),IRESU(15),IREMO(15),IREA(15),GRATE1(16),	HPM	236
5GRATE2(16),ITREV(16),HG4(3,5,105),GPI(15),AID(15),WSIN(16)	HPM	237
6,HG5(3,6,105),HG6(3,6,105),HG2(3,6,105),ML1(3,6),HG3(3,5,105)	HPM	238
COMMON RINC,SINC,TOMG,BI,MIN,GPI,NYEAR,SAT1,B9,TAX,	HPM	239
1MP15,ITGAS,IRECO,IRESU,IREMO,IREA,RU1,RU2,IVOL,GRATE1,GRATE2,ITREV	HPM	240
2,HG5,HG6,HG2,ML1,HG3,HG4,KCOW,KSSF,KSFLAG,KBARR,AID,WSIN	HPM	241
INTEGER ACOR,BCOR,NCB,TAUTO,PDIFF,BACOR,CACOR,TUT,PSIX,RACOR	HPM	242
1,UAUTO	HPM	243
C	HPM	244
C	HPM	245
C	HPM	246
**** READ INPUT DATA	HPM	247
READ(5,1001) (RINC(I),I=1,NYEAR)	HPM	248
READ(5,1001) (GPI(I),I=1,NYEAR)	HPM	249
READ(5,1002) (RGNP(I),I=1,NYEAR)	HPM	250
READ(5,1002) (BI(I),I=1,NYEAR)	HPM	251
READ(5,1002) (SINC(I),I=1,NYEAR)	HPM	252
1001 FORMAT (15(F5.1))	HPM	253
1002 FORMAT (15(F6.1))	HPM	254
DATA(PSR(I),I=1,25)/213.5,215.12,216.75,218.44,220.23,222.16,	HPM	255
A224.21,226.34,229.51,230.69,232.88,235.06,237.23,239.36,241.46,	HPM	256
B243.51,245.5,247.43,249.28,251.05,252.75,254.38,255.95,257.56,	HPM	257
C258.93/	HPM	258
DATA(ACOR(I),I=1,12)/4684,9763,11332,10098,8549,8341,8339,7556,	HPM	259
A6113,5796,4825,9824/	HPM	260
DATA(SURV(I),I=1,12)/1.52,1.,.995,.992,.982,.968,.953,.923,.887,	HPM	261
A.845,.713,.80/	HPM	262
DATA(RMPG(I),I=1,12)/14.5,13.,.12.8,13.0,13.3,13.4,13.5,13.7	HPM	263
A,13.9,14.2,14.3,14.3/	HPM	264
DATA(FMPG(I),I=1,10)/15.5,17.,.18.,.19.,.20.,.21.5,23.,.24.5,26.,	HPM	265
A27.5/	HPM	266
B9=(2.0-SAT1)/ALOG(25.)	HPM	267
C	HPM	268
C	HPM	269
C	HPM	270
**** INITIAL PARAMETER VALUES	HPM	271
USIN=169.7	HPM	272

UV2=.51	HPM	271
C	HPM	272
C **** PROJECTIONS OF ECONOMIC PARAMETERS	HPM	273
C	HPM	274
DO 1800 I=1,NYEAR	HPM	275
IF(IVOL.EQ.2) GO TO 400	HPM	276
UV1=UV2*(1.+GPI1(I)/100.)*RV1(I)	HPM	277
UV2=UV1-RV1(I)	HPM	278
401 GPI(I)=UV1*USIN/.59	HPM	279
GO TO 1800	HPM	280
400 UV1=(UV2-.04)*(1.+GPI1(I)/100.)*(1.+RV2(I))+.04	HPM	281
UV2=UV1-((UV2-.04)*(1.+GPI1(I)/100.)*(RV2(I)))	HPM	282
TAX(I)=(UV2-.04)*(1.+GPI1(I)/100.)*RV2(I)	HPM	283
GO TO 401	HPM	284
1800 CONTINUE	HPM	285
DO 1903 N=1,NYEAR	HPM	286
TACOR=0	HPM	287
DO 1901 I=1,12	HPM	288
1901 TACOR=TACOR+ACOR(I)	HPM	289
C	HPM	290
C **** ESTIMATION OF NUMBER OF NEW CARS PURCHASED	HPM	291
C	HPM	292
NCB(N)=IFIX(RINC(N)*1000./1.55)	HPM	293
C	HPM	294
C **** SURVIVAL RATE CALCULATIONS	HPM	295
C	HPM	296
DO 1904 I=1,12	HPM	297
1904 BCOR(I)=ACOR(I)*SURV(I)	HPM	298
CACOR=BCOR(12)	HPM	299
C	HPM	300
C **** SURVIVAL RATE ADJUSTMENTS	HPM	301
C	HPM	302
UAUTO=IFIX(RGNP(N)*1000.)	HPM	303
IAUTO=0	HPM	304
DO 2003 I=1,12	HPM	305
2003 IAUTO=BCOR(I)+IAUTO	HPM	306
IVARZ=IAUTO+NCB(N)	HPM	307
C	HPM	308
C **** ESTIMATING SURVIVAL RATE CHANGES	HPM	309
C	HPM	310
PDIFF=UAUTO-IVARZ	HPM	311
ICOUNT=0	HPM	312
INT=0	HPM	313
IF(PDIFF.LT.0) GO TO 2017	HPM	314
ISTAB=1	HPM	315
2005 ION=ISTAB	HPM	316
R1=RAUF(0)	HPM	317
ICOUNT=ICOUNT+1	HPM	318
IF(ICOUNT.NE.7) GO TO 2002	HPM	319
ION=-ISTAB	HPM	320
ICOUNT=0	HPM	321
2002 IF(R1.LE.0.15) BCOR(1)=BCOR(1)+ION	HPM	322
IF(R1.GT.0.15.AND.R1.LE.0.2) BCOR(2)=BCOR(2)+ION	HPM	323
IF(R1.GT.0.2.AND.R1.LE.0.225) BCOR(3)=BCOR(3)+ION	HPM	324
IF(R1.GT.0.225.AND.R1.LE.0.252) BCOR(4)=BCOR(4)+ION	HPM	325
IF(R1.GT.0.252.AND.R1.LE.0.286) BCOR(5)=BCOR(5)+ION	HPM	326
IF(R1.GT.0.286.AND.R1.LE.0.329) BCOR(6)=BCOR(6)+ION	HPM	327
IF(R1.GT.0.329.AND.R1.LE.0.383) BCOR(7)=BCOR(7)+ION	HPM	328
IF(R1.GT.0.383.AND.R1.LE.0.455) BCOR(8)=BCOR(8)+ION	HPM	329
IF(R1.GT.0.455.AND.R1.LE.0.549) BCOR(9)=BCOR(9)+ION	HPM	330
IF(R1.GT.0.549.AND.R1.LE.0.67) BCOR(10)=BCOR(10)+ION	HPM	331
IF(R1.GT.0.67.AND.R1.LE.0.805) BCOR(11)=BCOR(11)+ION	HPM	332
IF(R1.GT.0.805) BCOR(12)=BCOR(12)+ION	HPM	333
INT=INT+ION	HPM	334
IAM=IABS(INT-PDIFF)	HPM	335
IF(IAM.LE.1) GO TO 2004	HPM	336
GO TO 2005	HPM	337
2017 ISTAB=-1	HPM	338
GO TO 2005	HPM	339
2004 DO 2011 I=1,12	HPM	340

2011	SURV(I)=FLOAT(BCOR(I))/FLOAT(ACOR(I))	HPM	341
C		HPM	342
C	**** COHORT ADVANCE	HPM	343
C		HPM	344
	DO 1905 I=1,11	HPM	345
	J=12-I	HPM	346
1905	BCOR(J+1)=BCOR(J)	HPM	347
	BACOR=BCOR(12)	HPM	348
	BCOR(1)=NCB(N)	HPM	349
	BCOR(12)=BACOR+CACOR	HPM	350
	TAUTO=0	HPM	351
	DO 1992 I=1,12	HPM	352
1992	TAUTO=TAUTO+BCOR(I)	HPM	353
	TUT(N)=TAUTO	HPM	354
	DO 1910 I=1,12	HPM	355
1910	ACOR(I)=BCOR(I)	HPM	356
C		HPM	357
C	**** FLEET MILEAGE CALCULATIONS	HPM	358
C		HPM	359
	RMFG(12)=(FLOAT(BACOR)*RMFG(11)+FLOAT(CACOR)*RMFG(12))/FLOAT(BCOR(	HPM	360
	A12))	HPM	361
	DO 1911 I=2,11	HPM	362
	J=12-I	HPM	363
1911	RMFG(J+1)=RMFG(J)	HPM	364
	IF(N.GT.10) FMFG(N)=27.5	HPM	365
	RMFG(1)=FMFG(N)	HPM	366
	TMFG=0	HPM	367
	TTG1=0	HPM	368
	DO 1912 I=1,12	HPM	369
	C1=FLOAT(I+1)	HPM	370
	R7=1.8535-.48126*ALOG(C1)	HPM	371
	IF(I.EQ.1) R7=.9	HPM	372
	TTG1=FLOAT(BCOR(I))*R7+TTG1	HPM	373
1912	TMFG=TMFG+(FLOAT(BCOR(I))*RMFG(I)*R7)	HPM	374
	TOMG(N)=TMFG/TTG1	HPM	375
	PPUL=PSR(N+1)*1000/FLOAT(TUT(N))	HPM	376
	PERU(N)=PPUL	HPM	377
1903	CONTINUE	HPM	378
C		HPM	379
C	**** OUTPUT STATEMENTS	HPM	380
C		HPM	381
	WRITE(6,101)	HPM	382
101	FORMAT('1',1X,24('* '),1X,'U.S. AUTO EFFICIENCY PROJECTIONS',1X,	HPM	383
	A24('* '),///,16X,96('-'),/,35X,'NEW CAR',14X,'TOTAL NUMBER',14X,	HPM	384
	B'FLEET',15X,'PERSONS',/,16X,'YEAR',15X,'SALES 1/',14X,'OFTAUTOS 1/	HPM	385
	C',15X,'MPG',15X,'PER AUTO',/,16X,96('-'),/)	HPM	386
	DO 1913 I=1,NYEAR	HPM	387
	NOY=1975+I	HPM	388
	NSIN=IFIX(RINC(I)*1000.)	HPM	389
	WRITE(6,102) NOY,NSIN,TUT(I),TOMG(I),PERU(I)	HPM	390
102	FORMAT(16X,14,15X,16,17X,17,17X,F5.2,15X,F5.2,/)	HPM	391
1913	CONTINUE	HPM	392
	WRITE(6,103)	HPM	393
103	FORMAT(16X,96('-'))	HPM	394
	WRITE(6,104)	HPM	395
104	FORMAT(/,16X,'1/ IN THOUSANDS')	HPM	396
	RETURN	HPM	397
	END	HPM	398
C		HPM	399
C		HPM	400
C		HPM	401
C		HPM	402
C		HPM	403
	SUBROUTINE UMPRO	HPM	404
C	*****	HPM	405
C		HPM	406
C		HPM	407
C	THIS SUBROUTINE PROJECTS VEHICLE MILES OF TRAVEL IN	HPM	408
C	INDIANA BY VEHICLE TYPE.	HPM	409
C		HPM	410

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C          DIMENSION SPRO(15),AITM(15),AIUM(15),ZMPG(15),SUMG(15),      HPM 411
1BMUG(15),ZMPG1(15),TUMT(15),TGAS(15),                                HPM 412
3IAIUM(15),IAIUM(15),ITUMT(15),REAUT(15),                              HPM 413
4RECOM(15),RESU(15),REBUS(15),REMO(15),PPU(15),REGT(15),IREA(15),      HPM 414
5IRESU(15),IRECO(15),IREGT(15),IREMO(15),RINC(15),SINC(15),TOMG(15)    HPM 415
6,BI(15),MIN(30),ITGAS(15),IAITM(15),GPI(15)                          HPM 416
7,ZUAR(15),MP15(30),RV1(15),RV2(15),GRATE1(16),GRATE2(16)             HPM 417
8,ITREU(16),HG4(3,5,105),AID(15),WSIN(16),TAX(15)                    HPM 418
9,HG5(3,6,105),HGUY(3,6,105),HG2(3,6,105),ML1(3,6),HG3(3,5,105)      HPM 419
COMMON RINC,SINC,TOMG,BI,MIN,GPI,NYEAR,SAT1,B9,TAX,                    HPM 420
1MP15,ITGAS,IRECO,IRESU,IREMO,IREA,RV1,RV2,IUOL,GRATE1,GRATE2,ITREU    HPM 421
2,HG5,HGUY,HG2,ML1,HG3,HG4,KCOW,KSSF,KSFLAG,KBARR,AID,WSIN            HPM 422
C          HPM 423
C          HPM 424
C          HPM 425
C ***** STEEL PRODUCTION ESTIMATES                                    HPM 426
C          HPM 427
C          DO 2000 I=1,NYEAR                                             HPM 428
          SPRO(I)=1.22*SINC(I)/100.*17.61                               HPM 429
C          HPM 430
C ***** INTERCITY TON-MILE ESTIMATES                                  HPM 431
C          HPM 432
          AITM(I)=-51.4764+8.95205*ALOG(BI(I))+8.72447*ALOG(SPRO(I))    HPM 433
2000  IAITM(I)=IFIX(AITM(I)*1000.)                                       HPM 434
          TUM4=37359.                                                    HPM 435
          TUM3=35459.                                                    HPM 436
          AIUM4=1900.                                                    HPM 437
C          HPM 438
C ***** VEHICLE MILE CALCULATIONS                                     HPM 439
C          HPM 440
          DO 2002 I=1,NYEAR                                             HPM 441
          AIUM(I)=1900.*AITM(I)/17.22                                    HPM 442
          GRATE1(I)=(AIUM(I)-AIUM4)/AIUM4                                HPM 443
          AIUM4=AIUM(I)                                                  HPM 444
          ZMPG1(I)=AIUM(I)/(5.69*((1.018)**I))                          HPM 445
          SUMG(I)=10.01*((1.008**I))                                     HPM 446
          BMUG(I)=5.28*((1.005**I))                                       HPM 447
          XX1=.17*((1.005**I))                                           HPM 448
          XX2=.004*((1.005**I))                                           HPM 449
          XX3=1.-(.017+XX1+XX2)                                           HPM 450
          BUAR=XX1/SUMG(I)+XX3/TOMG(I)+XX2/BMUG(I)+.017/50.             HPM 451
          DELGP=-1.+GPI(I)/169.7                                           HPM 452
          TUMT(I)=TUM4*(1.033)**I*(1-.10*DELGP)                         HPM 453
          GRATE2(I)=((TUMT(I)-AIUM(I))-TUM3)/TUM3                       HPM 454
          TUM3=TUMT(I)-AIUM(I)                                             HPM 455
          ZMPG(I)=TUMT(I)/(ZMPG1(I)+(TUMT(I)-AIUM(I))*BUAR)             HPM 456
C          HPM 457
C ***** FUEL CONSUMPTION CALCULATIONS                                HPM 458
C          HPM 459
          ZUAR(I)=TUMT(I)-AIUM(I)                                         HPM 460
          TGAS(I)=(TUMT(I)/ZMPG(I))                                       HPM 461
C          HPM 462
C ***** CONVERSION OF REAL ARRAYS TO INTEGER ARRAYS                 HPM 463
C          HPM 464
          IAIUM(I)=IFIX(XX3*ZUAR(I))                                       HPM 465
          IAIUM(I)=IFIX(AIUM(I))                                           HPM 466
          ITUMT(I)=IFIX(TUMT(I))                                           HPM 467
2002  ITGAS(I)=IFIX(TGAS(I))*1000                                         HPM 468
C          HPM 469
C ***** REGISTRATION ESTIMATIONS                                     HPM 470
C          HPM 471
          DO 2003 I=1,NYEAR                                             HPM 472
          REAUT(I)=FLOAT(MIN(I+5))/(2.0-B9*ALOG(FLOAT(I)))              HPM 473
          RECOM(I)=38543.*(1.015)**I*(1+.21*(BI(I)/117.8-1))            HPM 474
          PC2=.27*((1.005**I))                                           HPM 475
          PC3=.0056*((1.0005**I))                                         HPM 476
          RESU(I)=REAUT(I)*PC2                                             HPM 477
          REBUS(I)=PC3*REAUT(I)                                           HPM 478
          REMO(I)=.055*REAUT(I)                                           HPM 479
          PPU(I)=FLOAT(MIN(I+5))/(RESU(I)+REBUS(I)+RECOM(I)+REAUT(I))    HPM 480

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REGT(I)=REAUT(I)+RECOM(I)+RESU(I)+REBUS(I)	HPM	481
C	HPM	482
C **** CONVERSION OF REAL ARRAYS TO INTEGER ARRAYS	HPM	483
C	HPM	484
IREA(I)=IFIX(REAUT(I))	HPM	485
IRESU(I)=IFIX(RESU(I))	HPM	486
IRECO(I)=IFIX(RECOM(I))	HPM	487
IREGT(I)=IFIX(REGT(I))	HPM	488
2003 IREMO(I)=IFIX(REMO(I))	HPM	489
C	HPM	490
C **** OUTPUT STATEMENTS	HPM	491
C	HPM	492
WRITE(6,1)	HPM	493
1 FORMAT('1',1X,29('* '), 'UMT PROJECTIONS',1X,29('* '),/////,	HPM	494
A21X,90('-'),/,40X,'AUTO',14X,'COMBINATION',12X,'TOTAL',16X,	HPM	495
B'FLEET',/,21X,'YEAR',14X,'UMT 1/',15X,'UMT 1/',14X,'UMT 1/',17X,	HPM	496
C'MPG',/,21X,90('-'),/)	HPM	497
NFLAG=1	HPM	498
9 DO 2010 I=1,NYEAR	HPM	499
NOY=1975+I	HPM	500
DEL=(GPI(I)-169.7)*.59	HPM	501
IF(NFLAG.EQ.2) GO TO 7	HPM	502
IF(NFLAG.EQ.3) GO TO 17	HPM	503
WRITE(6,2) NOY,IAUUM(I),IAIUM(I),ITUMT(I),ZMPG(I)	HPM	504
2 FORMAT(21X,I4,14X,I5,2(16X,I5),16X,F5.2,/)	HPM	505
GO TO 2010	HPM	506
7 WRITE(6,4) NOY,IREA(I),IRESU(I),IRECO(I),IREGT(I),PPU(I)	HPM	507
4 FORMAT(11X,I4,15X,I7,14X,I6,15X,I5,14X,I7,15X,F5.2,/)	HPM	508
GO TO 2010	HPM	509
17 WRITE(6,19) NOY,DEL,ITGAS(I),IAITM(I)	HPM	510
19 FORMAT(30X,I4,15X,F4.2,17X,I7,17X,I5,/)	HPM	511
2010 CONTINUE	HPM	512
IF(NFLAG.EQ.1) WRITE(6,31)	HPM	513
31 FORMAT(21X,90('-'))	HPM	514
IF(NFLAG.EQ.1) WRITE(6,40)	HPM	515
40 FORMAT(//,21X,'1/ IN MILLIONS OF VEHICLE MILES TRAVELED')	HPM	516
IF(NFLAG.EQ.2) WRITE(6,32)	HPM	517
32 FORMAT(11X,110('-'))	HPM	518
IF(NFLAG.EQ.3) WRITE(6,33)	HPM	519
33 FORMAT(30X,72('-'))	HPM	520
IF(NFLAG.EQ.3) WRITE(6,41)	HPM	521
41 FORMAT(//,33X,'1/ IN THOUSANDS OF GALLONS')	HPM	522
IF(NFLAG.EQ.3) WRITE(6,42)	HPM	523
42 FORMAT(/,33X,'2/ IN MILLIONS')	HPM	524
IF(NFLAG.EQ.3) GO TO 10	HPM	525
IF(NFLAG.EQ.2) GO TO 18	HPM	526
WRITE(6,3)	HPM	527
3 FORMAT('1',1X,26('* '), 'REGISTRATION PROJECTIONS',1X,27('* '),	HPM	528
A/////,11X,110('-'),/,61X,'TRUCKS',/,31X,'AUTO',13X,'SINGLE UNIT ',	HPM	529
B9X,'COMBINATION ',12X,'TOTAL',14X,'PERSONS',/,11X,'YEAR',	HPM	530
C11X,'REGISTRATIONS',3(8X,'REGISTRATIONS'),8X,'PER VEHICLE',	HPM	531
D/,11X,110('-'),/)	HPM	532
NFLAG=2	HPM	533
GO TO 9	HPM	534
18 WRITE(6,20)	HPM	535
20 FORMAT('1',1X,23('* '), 'FUEL CONSUMPTION AND TON-MILE ESTIMATES '	HPM	536
A,23('* '),/////,30X,72('-'),/,46X,'RETAIL GAS',13X,'MOTOR FUEL',	HPM	537
B13X,'INTERCITY',/,30X,'YEAR',15X,'PRICE',13X,'CONSUMPTION 1/',9X,	HPM	538
C'TON-MILES 2/',/,30X,72('-'),/)	HPM	539
NFLAG=3	HPM	540
GO TO 9	HPM	541
10 RETURN	HPM	542
END	HPM	543
C	HPM	544
C	HPM	545
C	HPM	546
C	HPM	547
C	HPM	548
SUBROUTINE REUGEN	HPM	549
C *****	HPM	550

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C
C
C      THIS SUBROUTINE ESTIMATES ALL INDIANA STATE ROAD-USER
C      TAX REVENUES.
C
C      DIMENSION MP15(30),ITGAS(15),IRECO(15),IRESU(15),IREMO(15),
AIREA(15),RIV1(15),RIV2(15),RIV3(15),RV1(15),RV2(15),RINC(15),
BSINC(15),TOMG(15),BI(15),GPI(15),MIN(30),N1(6),HG4(3,5,105)
C,IRLP(2,15),PCTT(2,15),GRATE1(16),GRATE2(16),ITREV(16),
DHG5(3,6,105),HGWY(3,6,105),HG2(3,6,105),ML1(3,6),HG3(3,5,105)
E,AID(15),WSIN(16),TAX(15)
COMMON RINC,SINC,TOMG,BI,MIN,GPI,NYEAR,SAT1,B9,TAX,
1MP15,ITGAS,IRECO,IRESU,IREMO,IREA,RV1,RV2,IVOL,GRATE1,GRATE2,ITREUHPM
2,HG5,HGWY,HG2,ML1,HG3,HG4,KCOW,KSSF,KSFLAG,KBARR,AID,WSIN
C
C ***** READ INPUT DATA
C
C      DATA((IRLP(I,J),J=1,15),I=1,2)/16,24,40,65,100,120,175,225,275,
A325,375,400,425,450,0,0,0,0,0,110,190,235,285,310,360,385,410,
B435,485,500/
C      DATA((PCTT(I,J),J=1,15),I=1,2)/.78,.03,.05,.04,.026,.05,.01,.003,
A.005,.005,.002,.0004,.0011,.0025,0.,0.,0.,0.,0.,.015,.008,.013,
B.019,.039,.03,.056,.128,.021,.114,.557/
C      READ(5,1010) (RIV1(I),I=1,NYEAR)
C      READ(5,1010) (RIV2(I),I=1,NYEAR)
C      READ(5,1010) (RIV3(I),I=1,NYEAR)
1010 FORMAT(15(F5.2))
C
C ***** CALCULATION OF POPULATION GREATER THAN 15 YEARS OLD
C
C      DO 900 L=1,6
N1(L)=5*L
IF(L.EQ.1) GO TO 900
MAI=(MP15(N1(L))-MP15(N1(L-1)))/5
DO 901 I=1,4
J=N1(L-1)+I
MP15(J)=MAI+MP15(J-1)
MP15(J-5)=MP15(J)
901 CONTINUE
900 CONTINUE
C
C ***** REVENUE CALCULATIONS
C
C      DO 420 I=1,NYEAR
ITR1=0
ITR2=0
DO 4002 L=1,2
DO 4002 L2=1,15
IF(L.EQ.1) ITR1=ITR1+IFIX(FLOAT(IRESU(I))*PCTT(1,L2)*FLOAT(IRLP
A(1,L2)))
IF(L.EQ.2) ITR2=ITR2+IFIX(FLOAT(IRECO(I))*PCTT(2,L2)*FLOAT(IRLP
A(2,L2)))
4002 CONTINUE
IMORE=IFIX(FLOAT(IREMO(I))*RIV1(I))/1000
IAURE=IFIX(FLOAT(IREA(I))*RIV2(I))/1000
ITR1=ITR1/1000
ITR2=ITR2/1000
RLISC=.85*FLOAT(MP15(I))
LIREV=IFIX(RIV3(I)*RLISC)/1000
RX=FLOAT(ITGAS(I)*1000)
IF(IVOL.EQ.2) GO TO 410
IGREV=(IFIX(RX*RV1(I))-IFIX(.03*(RX*RV1(I))))/1000
GO TO 411
410 IGREV=(IFIX(RX*TAX(I)-.03*RX*TAX(I)))/1000
411 IITOT=ITR1+ITR2+IMORE+IAURE
IADD=IFIX(AID(I)/(1.-AID(I))*FLOAT(IGREV+IITOT))+LIREV
ITREV(I)=IADD+IGREV+IITOT
NOY=1975+I
IF(I.GT.1) GO TO 40

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WRITE(6,11)
11 FORMAT('1',1X,26('* '), 'REVENUE PROJECTIONS 1/',1X,27('* '), '////', HPM 621
A16X,96(' '),/,32X, 'REGISTRATION',14X, 'FUEL TAX',16X, 'OTHER',16X, HPM 622
B'TOTAL',/,16X, 'YEAR',14X, 'REVENUES',16X, 'REVENUES',14X, 'REVENUES' HPM 623
C,13X, 'REVENUES',/,16X,96(' '),/) HPM 624
40 WRITE(6,12) NOY, I1TOT, IGREV, IADD, ITREV(I) HPM 625
12 FORMAT(16X,14,14X,16,18X,17,15X,16,16X,17,/) HPM 626
420 CONTINUE HPM 627
WRITE(6,13) HPM 628
13 FORMAT(16X,96(' ')) HPM 629
WRITE(6,14) HPM 630
14 FORMAT(/,16X, '1/ IN THOUSANDS OF DOLLARS') HPM 631
RETURN HPM 632
END HPM 633
HPM 634
C HPM 635
C HPM 636
C HPM 637
C HPM 638
C HPM 639
SUBROUTINE PRESCO HPM 640
C ***** HPM 641
C HPM 642
C HPM 643
C THIS SUBROUTINE SIMULATES PRESENT PAVEMENT CONDITIONS HPM 644
C BY CREATING A NUMBER OF SAMPLE ROADWAY SECTIONS. HPM 645
C HPM 646
C HPM 647
C DIMENSION MILE(3,6,6), UMM(3,2,6), UCR1(5,2,6), UCR2(5,2,6), HPM 648
1MAX(3,6), UCAN(6), HG2(3,6,105), HG3(3,5,105), HPM 649
2HG4(3,5,105), HG5(3,6,105), HG6(3,6,105), UCAN(6), UCR3(5,2,6) HPM 650
3, WLOH(3,6), ML1(3,6), HTO(3,6), GRATE1(16), GRATE2(16), ITREV(16) HPM 651
4, RINC(15), SINC(15), TOMG(15), BI(15), MIN(30), GPI(15), HPM 652
5, IMP15(30), ITGAS(15), IRECO(15), IRESU(15), IREMO(15), IREA(15), HPM 653
6, RU1(15), RU2(15), AID(15), WSIN(16), TAX(15) HPM 654
COMMON RINC, SINC, TOMG, BI, MIN, GPI, NYEAR, SAT1, B9, TAX, HPM 655
1, IMP15, ITGAS, IRECO, IRESU, IREMO, IREA, RU1, RU2, IVOL, GRATE1, GRATE2, ITREV HPM 656
2, HG5, HG6, HG2, ML1, HG3, HG4, KCOV, KSSF, KSFLAG, KBARR, AID, WSIN HPM 657
REAL MILE, MAX HPM 658
XARK=17171274321477413155B HPM 659
YARK=17171274321477413155B HPM 660
IF(KSFLAG.EQ.2) GO TO 4017 HPM 661
C HPM 662
C **** READING OF INITIAL DATA HPM 663
C HPM 664
C **** PAVEMENT CONDITIONS - PCT(RURAL) HPM 665
DATA(MILE(1,1,1), I=1,6)/79.,20.,1.,81.,18.,1./ HPM 666
DATA(MILE(1,2,1), I=1,6)/69.,30.,1.,67.,32.,1./ HPM 667
DATA(MILE(1,3,1), I=1,6)/61.,39.,0.,57.,43.,0./ HPM 668
DATA(MILE(1,4,1), I=1,6)/49.,47.,4.,49.,45.,6./ HPM 669
DATA(MILE(1,5,1), I=1,6)/27.,66.,7.,37.,58.,5./ HPM 670
DATA(MILE(1,6,1), I=1,6)/15.,70.,15.,20.,65.,15./ HPM 671
C **** PAVEMENT CONDITIONS - PCT(URBAN) HPM 672
DATA(MILE(2,1,1), I=1,6)/89.,11.,0.,94.,6.,0./ HPM 673
DATA(MILE(2,2,1), I=1,6)/96.,4.,0.,92.,8.,0./ HPM 674
DATA(MILE(2,3,1), I=1,6)/51.,48.,1.,51.,48.,1./ HPM 675
DATA(MILE(2,4,1), I=1,6)/60.,40.,0.,57.,43.,0./ HPM 676
DATA(MILE(2,5,1), I=1,6)/53.,41.,6.,55.,39.,6./ HPM 677
DATA(MILE(2,6,1), I=1,6)/48.,40.,12.,52.,38.,10./ HPM 678
C **** PAVEMENT CONDITIONS - PCT(SMALL URBAN) HPM 679
DATA(MILE(3,1,1), I=1,6)/100.,0.,0.,100.,0.,0./ HPM 680
DATA(MILE(3,2,1), I=1,6)/92.,8.,0.,90.,10.,0./ HPM 681
DATA(MILE(3,3,1), I=1,6)/46.,54.,0.,46.,54.,0./ HPM 682
DATA(MILE(3,4,1), I=1,6)/45.,49.,6.,51.,45.,4./ HPM 683
DATA(MILE(3,5,1), I=1,6)/40.,51.,9.,46.,45.,9./ HPM 684
DATA(MILE(3,6,1), I=1,6)/35.,55.,10.,40.,50.,10./ HPM 685
C HPM 686
C **** READING OF ADT MEANS AND STANDARD DEVIATIONS HPM 687
C HPM 688
DATA(UMM(1,J,K), K=1,6, J=1,2)/16.4,5.7,5.2,1.2,.6,.2,6.65,3.5, HPM 689
A3.3,.6,.23,.09/ HPM 690

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DATA((UMM(2,J,K),K=1,6),J=1,2)/44.00,16.90,17.2,7.46,2.83,.76,16.,HPM 691
A7.2,7.5,4.1,1.7,.4/HPM 692
DATA((UMM(3,J,K),K=1,6),J=1,2)/27.02,4.00,10.0,5.40,1.87,.560,10.8HPM 693
A,1.8,5.1,3.0,1.,.25/HPM 694
C HPM 695
C **** READING OF U/C RATIOS HPM 696
C HPM 697
C **** PCT(RURAL) HPM 698
DATA((UCR1(1,J,K),K=1,6),J=1,2)/0.,45.,55.,0.,63.,37.,100.,0.,HPM 699
A0.,100.,0.,0./HPM 700
DATA((UCR1(2,J,K),K=1,6),J=1,2)/1.,28.,71.,3.,24.,73.,83.,17.,HPM 701
A0.,83.,17.,0./HPM 702
DATA((UCR1(3,J,K),K=1,6),J=1,2)/1.,24.,75.,2.,40.,58.,64.,36.,HPM 703
A0.,68.,32.,0./HPM 704
DATA((UCR1(4,J,K),K=1,6),J=1,2)/0.,2.,98.,0.,8.,92.,12.,58.,30.,HPM 705
A21.,59.,20./HPM 706
DATA((UCR1(5,J,K),K=1,6),J=1,2)/0.,1.,99.,0.,3.,97.,2.,34.,64.,HPM 707
A6.,38.,56./HPM 708
C **** PCT(URBAN) HPM 709
DATA((UCR2(1,J,K),K=1,6),J=1,2)/11.,67.,22.,22.,70.,8.,100.,0.,HPM 710
A0.,100.,0.,0./HPM 711
DATA((UCR2(2,J,K),K=1,6),J=1,2)/4.,26.,70.,1.,49.,50.,92.,8.,0.,HPM 712
A88.,12.,0./HPM 713
DATA((UCR2(3,J,K),K=1,6),J=1,2)/33.,41.,26.,50.,36.,14.,62.,31.,HPM 714
A7.,62.,32.,5./HPM 715
DATA((UCR2(4,J,K),K=1,6),J=1,2)/21.,51.,28.,35.,45.,20.,42.,46.,HPM 716
A12.,42.,44.,14./HPM 717
DATA((UCR2(5,J,K),K=1,6),J=1,2)/6.,26.,68.,10.,42.,48.,25.,56.,HPM 718
A19.,20.,67.,13./HPM 719
C **** PCT(SMALL URBAN) HPM 720
DATA((UCR3(1,J,K),K=1,6),J=1,2)/0.,83.,17.,0.,91.,9.,100.,0.,0.,HPM 721
A100.,0.,0./HPM 722
DATA((UCR3(2,J,K),K=1,6),J=1,2)/0.,22.,78.,0.,23.,77.,100.,0.,0.,HPM 723
A100.,0.,0./HPM 724
DATA((UCR3(3,J,K),K=1,6),J=1,2)/8.,63.,29.,14.,67.,19.,67.,22.,HPM 725
A11.,66.,21.,13./HPM 726
DATA((UCR3(4,J,K),K=1,6),J=1,2)/10.,42.,48.,11.,53.,36.,45.,40.,HPM 727
A15.,47.,42.,11./HPM 728
DATA((UCR3(5,J,K),K=1,6),J=1,2)/0.,10.,90.,0.,15.,85.,36.,33.,31.,HPM 729
A41.,35.,25./HPM 730
C HPM 731
C **** READ TOTAL UMT HPM 732
C HPM 733
DATA(MAX(1,K),K=1,6)/11330.,4972.,13131.,8829.,2572.,7961./HPM 734
DATA(MAX(2,K),K=1,6)/7718.,946.,11182.,9500.,2794.,4057./HPM 735
DATA(MAX(3,K),K=1,6)/608.,173.,4284.,3291.,959.,1623./HPM 736
C HPM 737
C **** SIMULATION OF PRESENT HIGHWAY CONDITIONS HPM 738
C HPM 739
4017 DO 70 K=1,3 HPM 740
DO 70 N=1,6 HPM 741
WLOK(K,N)=MAX(K,N)/(UMM(K,1,N)/1.2*100.) HPM 742
IF(WLOK(K,N).LT.2.) WLOK(K,N)=2. HPM 743
70 HTO(K,N)=0. HPM 744
HTOT=0. HPM 745
DO 3000 I=1,3 HPM 746
DO 3000 J=1,6 HPM 747
ML=0 HPM 748
CONT=0. HPM 749
IF(J.EQ.6) GO TO 5010 HPM 750
C HPM 751
C **** ESTIMATION OF DAILY VOLUMES AND U/C RATIOS HPM 752
C HPM 753
DO 3002 I1=1,6 HPM 754
IF(I.EQ.1) UCAN(I1)=UCR1(J,1,I1) HPM 755
IF(I.EQ.2) UCAN(I1)=UCR2(J,1,I1) HPM 756
3002 IF(I.EQ.3) UCAN(I1)=UCR3(J,1,I1) HPM 757
IF(UCAN(1).NE.0.) GO TO 3007 HPM 758
U1=0. HPM 759
GO TO 3008 HPM 760

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3007	U1=(VCAN(4)/VCAN(1))	HPM	761
3008	U2=VCAN(5)/VCAN(2)	HPM	762
	U3=VCAN(6)/VCAN(3)	HPM	763
	U4=U1*UMM(I,1,J)	HPM	764
	U5=U2*UMM(I,1,J)	HPM	765
	U6=U3*UMM(I,1,J)	HPM	766
	IF(U1.GT.1) U1=1/U1	HPM	767
	IF(U2.GT.1) U2=1/U2	HPM	768
	IF(U3.GT.1) U3=1/U3	HPM	769
	S1=U1*UMM(I,2,J)	HPM	770
	S2=U2*UMM(I,2,J)	HPM	771
	S3=U3*UMM(I,2,J)	HPM	772
4000	ML=ML+1	HPM	773
	IF(I.EQ.1) A2=.8	HPM	774
	IF(I.GT.1) A2=.9	HPM	775
	H1=(.95-A2)*RANF(0)+A2	HPM	776
	H2=(A2-.31)*RANF(0)+.31	HPM	777
	H3=(.31-.2)*RANF(0)+.2	HPM	778
	R3=RANF(0)	HPM	779
	R3=R3*100.	HPM	780
	IF(VCAN(6).GE.VCAN(5).AND.VCAN(5).GE.VCAN(4)) GO TO 3021	HPM	781
	IF(VCAN(5).GE.VCAN(6).AND.VCAN(6).GE.VCAN(4)) GO TO 3022	HPM	782
	IF(VCAN(4).GE.VCAN(5).AND.VCAN(5).GE.VCAN(6)) GO TO 3023	HPM	783
	IF(VCAN(5).GE.VCAN(4).AND.VCAN(4).GE.VCAN(6)) GO TO 3024	HPM	784
3021	IF(R3.LE.VCAN(4)) GO TO 3040	HPM	785
	IF(R3.GT.VCAN(4).AND.R3.LE.(VCAN(5)+VCAN(4))) GO TO 3041	HPM	786
	GO TO 3042	HPM	787
3022	IF(R3.LE.VCAN(4)) GO TO 3040	HPM	788
	IF(R3.LE.(VCAN(6)+VCAN(4))) GO TO 3042	HPM	789
	GO TO 3041	HPM	790
3023	IF(R3.LE.VCAN(6)) GO TO 3042	HPM	791
	IF(R3.LE.(VCAN(6)+VCAN(5))) GO TO 3041	HPM	792
	GO TO 3040	HPM	793
3024	IF(R3.LE.VCAN(6)) GO TO 3042	HPM	794
	IF(R3.LE.(VCAN(6)+VCAN(4))) GO TO 3040	HPM	795
	GO TO 3041	HPM	796
5010	ML=ML+1	HPM	797
80	HGWY(I,J,ML)=GAUSS(UMM(I,2,J),UMM(I,1,J))	HPM	798
	NFLAG=1	HPM	799
	GO TO 3050	HPM	800
3040	HG3(I,J,ML)=H1	HPM	801
81	HGWY(I,J,ML)=GAUSS(S1,U4)	HPM	802
	NFLAG=2	HPM	803
	GO TO 3050	HPM	804
3041	HG3(I,J,ML)=H2	HPM	805
82	HGWY(I,J,ML)=GAUSS(S2,U5)	HPM	806
	NFLAG=3	HPM	807
	GO TO 3050	HPM	808
3042	HG3(I,J,ML)=H3	HPM	809
83	HGWY(I,J,ML)=GAUSS(S3,U6)	HPM	810
	NFLAG=4	HPM	811
C		HPM	812
C	**** ASSIGNMENT OF PAVEMENT CONDITIONS	HPM	813
C		HPM	814
3050	GO TO(1710,1712,1711) I	HPM	815
1710	IF(J.EQ.1.AND.HGWY(I,J,ML).LE.8.) GO TO 1713	HPM	816
	IF(J.EQ.2.AND.HGWY(I,J,ML).LE.2.) GO TO 1713	HPM	817
	IF(J.EQ.3.AND.HGWY(I,J,ML).LE.1.5) GO TO 1713	HPM	818
	IF(J.EQ.4.AND.HGWY(I,J,ML).LE.0.6) GO TO 1713	HPM	819
	IF(J.EQ.5.AND.HGWY(I,J,ML).LE.0.4) GO TO 1713	HPM	820
	GO TO 1714	HPM	821
1711	IF(J.EQ.1.AND.HGWY(I,J,ML).LE.12.) GO TO 1713	HPM	822
	IF(J.EQ.2.AND.HGWY(I,J,ML).LE.2.) GO TO 1713	HPM	823
	IF(J.EQ.3.AND.HGWY(I,J,ML).LE.4.) GO TO 1713	HPM	824
	IF(J.EQ.4.AND.HGWY(I,J,ML).LE.3.) GO TO 1713	HPM	825
	IF(J.EQ.5.AND.HGWY(I,J,ML).LE.0.7) GO TO 1713	HPM	826
	GO TO 1714	HPM	827
1712	IF(J.EQ.1.AND.HGWY(I,J,ML).LE.16.) GO TO 1713	HPM	828
	IF(J.EQ.2.AND.HGWY(I,J,ML).LE.9.) GO TO 1713	HPM	829
	IF(J.EQ.3.AND.HGWY(I,J,ML).LE.8.) GO TO 1713	HPM	830

IF(J.EQ.4.AND.HGWY(I,J,ML).LE.3.) GO TO 1713	HPM 831
IF(J.EQ.5.AND.HGWY(I,J,ML).LE.1.) GO TO 1713	HPM 832
GO TO 1714	HPM 833
1713 GO TO(80,81,82,83) NFLAG	HPM 834
1714 IF(HGWY(I,J,ML).LE.0.03) GO TO(80,81,82,83) NFLAG	HPM 835
DEVO=.75	HPM 836
IF(J.EQ.1) DEVO=1.3	HPM 837
IF(J.GT.1.AND.J.LE.3) DEVO=1.05	HPM 838
IF(I.EQ.1.AND.J.LE.2) GO TO 3051	HPM 839
IF(I.GE.2.AND.J.LE.3) GO TO 3051	HPM 840
A1=2.	HPM 841
B1=1.5	HPM 842
GO TO 3052	HPM 843
3051 A1=2.5	HPM 844
B1=2.	HPM 845
IF(I.EQ.1.AND.J.EQ.3) B1=1.8	HPM 846
3052 R2=RANF(0)	HPM 847
R2=R2*100.	HPM 848
IF(R2.LE.MILE(I,J,3)) HG2(I,J,ML)=(A1-B1)*RANF(0)+B1	HPM 849
IF(MILE(I,J,1).LE.MILE(I,J,2)) GO TO 3053	HPM 850
IF(R2.GT.MILE(I,J,3).AND.R2.LE.(MILE(I,J,3)+MILE(I,J,2))) HG2(I,J,ML)=(3.4-A1)*RANF(0)+A1	HPM 851
IF(R2.GT.(MILE(I,J,3)+MILE(I,J,2))) HG2(I,J,ML)=DEVO*RANF(0)+3.4	HPM 852
GO TO 3060	HPM 853
3053 IF(R2.GT.MILE(I,J,3).AND.R2.LE.(MILE(I,J,3)+MILE(I,J,1))) HG2(I,J,ML)=DEVO*RANF(0)+3.4	HPM 854
IF(R2.GT.(MILE(I,J,3)+MILE(I,J,1))) HG2(I,J,ML)=(3.4-A1)*RANF(0)	HPM 855
A+A1	HPM 856
	HPM 857
	HPM 858
C	HPM 859
C **** LANE WIDTH ASSIGNMENT	HPM 860
C	HPM 861
3060 IF(J.EQ.6) GO TO 3070	HPM 862
DO 3061 I1=1,6	HPM 863
IF(I.EQ.1) UCON(I1)=UCR1(J,2,I1)	HPM 864
IF(I.EQ.2) UCON(I1)=UCR2(J,2,I1)	HPM 865
3061 IF(I.EQ.3) UCON(I1)=UCR3(J,2,I1)	HPM 866
R4=RANF(0)	HPM 867
R4=R4*100.	HPM 868
IF(UCON(1).GE.UCON(2).AND.UCON(2).GE.UCON(3)) GO TO 3062	HPM 869
IF(UCON(2).GE.UCON(1).AND.UCON(1).GE.UCON(3)) GO TO 3063	HPM 870
IF(UCON(2).GE.UCON(3).AND.UCON(3).GE.UCON(1)) GO TO 3064	HPM 871
IF(UCON(3).GE.UCON(2).AND.UCON(2).GE.UCON(1)) GO TO 3065	HPM 872
3062 IF(R4.LT.UCON(3)) GO TO 3066	HPM 873
IF(R4.LT.(UCON(3)+UCON(2))) GO TO 3067	HPM 874
GO TO 3068	HPM 875
3063 IF(R4.LT.UCON(3)) GO TO 3066	HPM 876
IF(R4.LT.(UCON(3)+UCON(1))) GO TO 3068	HPM 877
GO TO 3067	HPM 878
3064 IF(R4.LT.UCON(1)) GO TO 3068	HPM 879
IF(R4.LT.(UCON(3)+UCON(1))) GO TO 3066	HPM 880
GO TO 3067	HPM 881
3065 IF(R4.LT.UCON(1)) GO TO 3068	HPM 882
IF(R4.LT.(UCON(1)+UCON(2))) GO TO 3067	HPM 883
GO TO 3066	HPM 884
3068 HG4(I,J,ML)=12.	HPM 885
GO TO 3070	HPM 886
3067 HG4(I,J,ML)=10.+RANF(0)	HPM 887
GO TO 3070	HPM 888
3066 HG4(I,J,ML)=9.+RANF(0)	HPM 889
C	HPM 890
C **** ASSIGNMENT OF PAVEMENT TYPES	HPM 891
C	HPM 892
3070 GO TO 3080	HPM 893
C	HPM 894
C **** OPTIONAL OUTPUT STATEMENTS	HPM 895
C	HPM 896
3081 DO 3082 ML=1,ML1(I,J)	HPM 897
HGWY(I,J,ML)=CHANG*HGWY(I,J,ML)	HPM 898
HTO(I,J)=HTO(I,J)+HGWY(I,J,ML)	HPM 899
HTOT=HTOT+HGWY(I,J,ML)	HPM 900


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DATA((COM(K,I,J),J=1,5),I=1,3),K=1,2)/22.,7.,.31.,.37.,.32,
A25.,8.,.25.,.25.,.5,30.,4.,.26.,4.,.34,30.,5.,.27.,4.,.33,39.,
B12.,.18.,.34.,.48,60.,14.,.15.,.42.,.43/
C ***** PCT. OF TRUCKS ON EACH HIGHWAY SYSTEM
DATA((UUL1(I,J,K),K=1,6),J=1,2),I=1,3)/.147.,.203.,.203.,.235,
A.235.,.021.,.153.,.097.,.077.,.045.,.045.,.009.,.11.,.14.,.16.,.23.,.23,
B.17.,.09.,.06.,.04.,.02.,.02.,.04.,.11.,.14.,.16.,.23.,.23.,.17.,.09.,.06,
C.04.,.02.,.02.,.04/
DATA((SD(I,J,K),K=1,6),J=1,2),I=1,3)/.03.,.04.,.04.,.06.,.06,
A.005.,.03.,.02.,.02.,.02.,.02.,.005.,.03.,.04.,.05.,.06.,.06.,.05.,.02,
B.02.,.01.,.005.,.005.,.01.,.03.,.03.,.04.,.06.,.06.,.05.,.02.,.02.,.01,
C.005.,.005.,.01/
C ***** PCT OF TRUCK TYPES
DATA((TYPE(J,K),K=1,3),J=1,2)/.77.,.19.,.04.,.80.,.15.,.05/
C ***** RELATIVE INCREASE IN HIGHWAY SYSTEM'S UMT
DATA((REL(I,J),J=1,6),I=1,3)/.8,1.,.72.,.64.,.64.,.64,1.32,2.16,
A1.12,1.12,1.02,1.48,1.,1.24,1.,1.02,1.02,1.32/
DATA((SAX(I,J),J=1,5),I=1,3)/11330.,4972.,13131.,8829.,2572.,
A7718.,946.,11182.,9500.,2794.,608.,173.,4284.,3291.,959./
DATA((PMIL(I,J),J=1,5),I=1,3)/.003.,.007.,.0015,-.0002,-.0005,
A.005.,.033.,.009.,.005.,.003.,.013.,.020.,.012.,.009.,.0044/
DO 749 I=1,3
DO 749 J=1,5
DRAPER(I,J)=SAX(I,J)
ERAPER(I,J)=SAX1(I,J)
FRAPER(I,J)=SAX(I,J)*UUL1(I,2,J)
DO 749 K=1,ML1(I,J)
RELIN(I,J,K)=GAUSS(0.0,.015)
749 CONTINUE
READ(5,502)((EFORT(I,J),J=1,5),I=1,3)
502 FORMAT(15(1X,F4.3))
4017 AAM=242780.
C
C ***** DETERMINATION OF TRAVEL TYPE
C
DO 500 I=1,3
DO 500 J=1,5
500 HUNT(I,J)=0.
MGFLAG=1
MKN=0
KCAR=1
DO 850 I=1,3
DO 850 J=1,5
850 IFAM(I,J)=0
DO 2912 NYEA=1,NYEAR+1
IF(NYEA.GE.2) KCAR=2
MKN=MKN+1
MG1FLAG=1
MRANK=1
MFLAG=1
IF(MGFLAG.EQ.2) GO TO 6754
MTOTAL=0
DO 2046 K=1,2
DO 2046 J=1,3
2046 EQUI(K,J)=0.
DO 8020 I=1,3
DO 8020 J=1,3
DO 8020 K=1,6
EQT1(I,J,K)=0.
8020 EQT2(I,J,K)=0.
KOUNT=0
GO TO 8001
8988 DO 6000 I=1,3
DO 6000 J=1,6
MTOTAL=MTOTAL+ML1(I,J)
C
C ***** SAMPLING TECHNIQUE TO DETERMINE AXLE LOADS
C
PCTS=UUL1(I,1,J)
PCTC=UUL1(I,2,J)

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HPM 971
 HPM 972
 HPM 973
 HPM 974
 HPM 975
 HPM 976
 HPM 977
 HPM 978
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 HPM 997
 HPM 998
 HPM 999
 HPM 1000
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 HPM 1024
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 HPM 1029
 HPM 1030
 HPM 1031
 HPM 1032
 HPM 1033
 HPM 1034
 HPM 1035
 HPM 1036
 HPM 1037
 HPM 1038
 HPM 1039
 HPM 1040

PCCA=1-(PCTS+PCTC)	HPM 1041
DO 87 K=1,2	HPM 1042
EQUIV(K,I,J)=PCTC*EQUI(K,1)+PCTS*EQUI(K,2)+PCCA*EQUI(K,3)	HPM 1043
IF(K.EQ.2) GO TO 86	HPM 1044
EQT1(1,I,J)=PCTC*EQUI(K,1)	HPM 1045
EQT1(2,I,J)=PCTS*EQUI(K,2)	HPM 1046
EQT1(3,I,J)=PCCA*EQUI(K,3)	HPM 1047
GO TO 87	HPM 1048
86 EQT2(1,I,J)=PCTC*EQUI(K,1)	HPM 1049
EQT2(2,I,J)=PCTS*EQUI(K,2)	HPM 1050
EQT2(3,I,J)=PCCA*EQUI(K,3)	HPM 1051
87 CONTINUE	HPM 1052
6000 CONTINUE	HPM 1053
GO TO 6754	HPM 1054
8001 WCARS=.8	HPM 1055
WCARM=3.3	HPM 1056
ICFLAG=1	HPM 1057
IFLAG=1	HPM 1058
X8=RANF(0)	HPM 1059
X9=RANF(0)	HPM 1060
KOUNT=KOUNT+1	HPM 1061
K1=1	HPM 1062
IF(KOUNT.LE.1000.) GO TO 6006	HPM 1063
IF(KOUNT.LE.2000.) GO TO 6007	HPM 1064
IF(KOUNT.LE.3000.) GO TO 6008	HPM 1065
GO TO 8988	HPM 1066
6006 IFFLAG=1	HPM 1067
IF(X9.LT.0.698) K1=2	HPM 1068
IF(X8.LE.TYPE(2,3)) GO TO 6010	HPM 1069
IF(X8.LE.(TYPE(2,3)+TYPE(2,2))) GO TO 6011	HPM 1070
GO TO 6012	HPM 1071
6007 IFFLAG=2	HPM 1072
IF(X9.LT.0.506) K1=2	HPM 1073
IF(X8.LE.TYPE(1,3)) GO TO 6013	HPM 1074
IF(X8.LE.(TYPE(1,3)+TYPE(1,2))) GO TO 6014	HPM 1075
GO TO 6015	HPM 1076
C	HPM 1077
C **** COMBINATION WEIGHTS	HPM 1078
C	HPM 1079
6010 WATE=GAUSS(COM(K1,1,2),COM(K1,1,1))	HPM 1080
IF(WATE.LT.2.5) GO TO 6010	HPM 1081
DO 10 I2=1,3	HPM 1082
10 W(I2)=WATE*COM(K1,1,I2+2)	HPM 1083
GO TO 7000	HPM 1084
6011 WATE=GAUSS(COM(K1,2,2),COM(K1,2,1))	HPM 1085
IF(WATE.LT.2.5) GO TO 6011	HPM 1086
DO 11 I2=1,3	HPM 1087
11 W(I2)=WATE*COM(K1,2,I2+2)	HPM 1088
IFLAG=2	HPM 1089
GO TO 7000	HPM 1090
6012 WATE=GAUSS(COM(K1,3,2),COM(K1,3,1))	HPM 1091
IF(WATE.LT.2.5) GO TO 6012	HPM 1092
DO 12 I2=1,3	HPM 1093
12 W(I2)=WATE*COM(K1,3,I2+2)	HPM 1094
IFLAG=3	HPM 1095
GO TO 7000	HPM 1095
C	HPM 1097
C **** SINGLE UNIT TRUCK WEIGHT ESTIMATES	HPM 1098
C	HPM 1099
6013 WATE=GAUSS(SU(K1,3,2),SU(K1,3,1))	HPM 1100
IF(WATE.LT.2.5) GO TO 6013	HPM 1101
W(1)=WATE*SU(K1,3,3)	HPM 1102
W(2)=WATE*SU(K1,3,4)	HPM 1103
IFLAG=4	HPM 1104
GO TO 7000	HPM 1105
6014 WATE=GAUSS(SU(K1,2,2),SU(K1,2,1))	HPM 1106
IF(WATE.LT.2.0) GO TO 6014	HPM 1107
W(1)=WATE*SU(K1,2,3)	HPM 1108
W(2)=WATE*SU(K1,2,4)	HPM 1109
GO TO 7000	HPM 1110

6015	WATE=GAUSS(SU(K1,1,2),SU(K1,1,1))	HPM	1111
	IF(WATE.LT.1.7) GO TO 6015	HPM	1112
	W(1)=WATE*SU(K1,1,3)	HPM	1113
	W(2)=WATE*SU(K1,1,4)	HPM	1114
	GO TO 7000	HPM	1115
C		HPM	1116
C	**** AUTO WEIGHT ESTIMATES	HPM	1117
C		HPM	1118
6008	IFFLAG=3	HPM	1119
	WATE=GAUSS(WCARS,WCARM)	HPM	1120
	IF(WATE.LT.1.2) GO TO 6008	HPM	1121
	W(1)=.6*WATE	HPM	1122
	W(2)=.4*WATE	HPM	1123
C		HPM	1124
C	**** CALCULATION OF 18K AXLE LOADS	HPM	1125
C		HPM	1126
7000	I7=2	HPM	1127
	IF(IFFLAG.EQ.1) I7=3	HPM	1128
9754	DO 7011 I2=1,I7	HPM	1129
	IF(ICFLAG.EQ.1) GO TO 7020	HPM	1130
	IF(I2.EQ.2) GO TO 7012	HPM	1131
	IF(I2.EQ.3) GO TO 7016	HPM	1132
7020	IF(I2.EQ.2) GO TO 7021	HPM	1133
	IF(I2.EQ.3) GO TO 7022	HPM	1134
7013	EQ1=.0000062125*(W(I2))*4.16	HPM	1135
	GO TO 7015	HPM	1136
7012	GO TO(7013,7013,7014,7014) IFLAG	HPM	1137
7016	GO TO(7013,7014,7014) IFLAG	HPM	1138
7021	GO TO(7013,7013,7017,7017) IFLAG	HPM	1139
7022	GO TO(7013,7017,7017) IFLAG	HPM	1140
7014	EQ1=.00000047110*(W(I2))*4.155	HPM	1141
	GO TO 7015	HPM	1142
7017	EQ1=.00000090701*(W(I2))*4.115	HPM	1143
7015	EQUI(ICFLAG,IFFLAG)=EQUI(ICFLAG,IFFLAG)+EQ1	HPM	1144
7011	CONTINUE	HPM	1145
	IF(ICFLAG.EQ.2) GO TO 8001	HPM	1146
	ICFLAG=2	HPM	1147
	GO TO 9754	HPM	1148
C		HPM	1149
C	**** CALCULATION OF PAVEMENT DETERIORATION	HPM	1150
C		HPM	1151
6754	HK2=0.	HPM	1152
	DO 250 I=1,3	HPM	1153
	HK1(I)=0.	HPM	1154
	DO 290 J=1,5	HPM	1155
	HK(I,J)=0.	HPM	1156
	CHANG1=RELP(I,J)*GRATE1(NYEA)	HPM	1157
	IF(GRATE1(NYEA).LT.0.) CHANG1=(1./RELP(I,J))*GRATE1(NYEA)	HPM	1158
	CHANG2=RELP(I,J)*GRATE2(NYEA)	HPM	1159
	IF(GRATE2(NYEA).LT.0.) CHANG2=(1./RELP(I,J))*GRATE2(NYEA)	HPM	1160
	CHANG2=((DRAPER(I,J)*(1.+CHANG2))/(ERAPER(I,J)*(1.+PMIL(I,J))))-	HPM	1161
	A(DRAPER(I,J)/ERAPER(I,J))/(DRAPER(I,J)/ERAPER(I,J))	HPM	1162
	CHANG1=((FRAPER(I,J)*(1.+CHANG1))/(ERAPER(I,J)*(1.+PMIL(I,J))))-	HPM	1163
	A(FRAPER(I,J)/ERAPER(I,J))/(FRAPER(I,J)/ERAPER(I,J))	HPM	1164
	DRAPER(I,J)=DRAPER(I,J)*(1.+CHANG2)	HPM	1165
	ERAPER(I,J)=ERAPER(I,J)*(1.+PMIL(I,J))	HPM	1166
	FRAPER(I,J)=FRAPER(I,J)*(1.+CHANG1)	HPM	1167
	IF(NYEA.EQ.16) GO TO 748	HPM	1168
748	ICAN=2	HPM	1169
	IF(J.EQ.1) ICAN=1	HPM	1170
	EQUIV(ICAN,I,J)=EQUIV(ICAN,I,J)*((1.+CHANG1)/(1.+CHANG2))	HPM	1171
	DO 290 K=1,ML1(I,J)	HPM	1172
	IF(MGFLAG.EQ.2) GO TO 9117	HPM	1173
	EQT(I,J,K)=0.	HPM	1174
	IF(I.EQ.1.AND.J.EQ.1) SAR=.183	HPM	1175
	IF(I.GT.1) SAR=.12	HPM	1176
	IF(I.EQ.1.AND.J.GT.1) SAR=.16	HPM	1177
	MMFLAG=1	HPM	1178
379	IF(J.EQ.1) CAP=2.0	HPM	1179
	IF(J.EQ.2) CAP=1.6	HPM	1180

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IF(J.EQ.3) CAP=1.4
IF(J.GT.3) CAP=1.
IF(MMFLAG.GE.2) GO TO 1492
VAR11=((HGWY(I,J,K)*5AR)/CAP)+.8
LANE(I,J,K)=IFIX(VAR11)
IF(LANE(I,J,K).LT.1) LANE(I,J,K)=1
IF(LANE(I,J,K).GT.5) LANE(I,J,K)=5
IF(LANE(I,J,K).GE.2) GO TO 4793
IF(J.EQ.1) LANE(I,J,K)=2
IF(I.EQ.2.AND.J.EQ.2) LANE(I,J,K)=2
4793 PEAK(I,J,K)=(HG3(I,J,K)*FLOAT(LANE(I,J,K))*CAP)/HGWY
A(I,J,K)
4792 ICAN=2
IF(J.EQ.1) ICAN=1
IF(ICAN.EQ.1) GO TO 3820
VAR1=(UUL1(I,2,J)*HGWY(I,J,K)+.25*UUL1(I,1,J)*HGWY(I,J,K))*1000.
IF(VAR1.GE.100.) HG5(I,J,K)=4.15
IF(VAR1.GE.200.) HG5(I,J,K)=4.4
IF(VAR1.GE.300.) HG5(I,J,K)=4.9
IF(VAR1.GE.500.) HG5(I,J,K)=5.2
IF(VAR1.GE.750.) HG5(I,J,K)=5.5
IF(VAR1.GE.1200.) HG5(I,J,K)=6.
IF(VAR1.LT.100.0.AND.VAR1.GE.75.) HG5(I,J,K)=3.95
IF(VAR1.LT.75.AND.VAR1.GE.50.) HG5(I,J,K)=3.7
IF(VAR1.LT.50.) GO TO 3830
GO TO 3840
3820 IF(J.EQ.1) HG5(I,J,K)=11.
GO TO 3840
3830 IF(VAR1.GT.5.) HG5(I,J,K)=3.1
IF(VAR1.GT.15.) HG5(I,J,K)=3.25
IF(VAR1.GT.25.) HG5(I,J,K)=3.45
IF(VAR1.GT.35.) HG5(I,J,K)=3.6
IF(VAR1.LE.5.) HG5(I,J,K)=2.7
3840 IF(MRANK.EQ.2) GO TO 190
9117 ICAN=2
IF(HG5(I,J,K).GT.9.) ICAN=1
REGAL=RELIN(I,J,K)
HGWY(I,J,K)=HGWY(I,J,K)*(1.+CHANG2+REGAL)
HK(I,J)=HK(I,J)+HGWY(I,J,K)
HK1(I)=HK1(I)+HGWY(I,J,K)
HK2=HK2+HGWY(I,J,K)
EQT9=EQUIV(ICAN,I,J)*(HGWY(I,J,K))*365.
IF(LANE(I,J,K).LT.2) YRU=2.
IF(LANE(I,J,K).GE.2) YRU=2.5
EQT(I,J,K)=EQT9/YRU+EQT(I,J,K)
IF(ICAN.EQ.1) GO TO 8111
BETA=.4+(.081*19.**3.23)/((HG5(I,J,K))**5.19)
ROW=10.**5.93*(HG5(I,J,K))**9.36/19.**4.79
8112 AF1=1.5
IF(J.LE.3) AF1=2.0
IF(I.EQ.1.AND.J.EQ.3) AF1=1.8
IF(KCAR.EQ.2) GO TO 1301
HLM=4.6
IF(J.EQ.1) HLM=4.8
IF(J.GT.3) HLM=4.2
EQT(I,J,K)=(EXP(ALOG(ROW)+(ALOG((HLM-HG2(I,J,K))/(HLM-AF1)))/BETA
A)))+EQT(I,J,K)
HG2(I,J,K)=HLM
1301 HG6(I,J,K)=HG2(I,J,K)-(HG2(I,J,K)-AF1)*(EQT(I,J,K)/ROW)**BETA
GO TO 290
8111 BETA=1.+3.63*(19.**5.2)/(HG5(I,J,K)**8.46)
ROW=10.**5.85*(HG5(I,J,K)**7.35)/(19.**4.62)
GO TO 8112
C
C ***** OPTIONAL OUTPUT STATEMENTS
C
5999 IF(K.EQ.1) PRINT,I,J,ML1(I,J)
WRITE(6,100) HG6(I,J,K),HG2(I,J,K),HGWY(I,J,K),HG3(I,J,K),HG5(
AI,J,K),LANE(I,J,K),PEAK(I,J,K),EQUIV(ICAN,I,J),HG4(I,J,K)
100 FORMAT(10X,F4.2,5X,F4.2,5X,F6.2,5X,F5.3,5X,F5.2,5X,I2,5X,F4.2,
HPM 1181
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HPM 1183
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HPM 1190
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HPM 1199
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HPM 1243
HPM 1244
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HPM 1246
HPM 1247
HPM 1248
HPM 1249
HPM 1250

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      ASX,F7.0,5X,F5.2)
290 CONTINUE
      IF(MGFLAG.EQ.2) GO TO 1956
      IF(KSFLAG.EQ.2) GO TO 1956
C
C **** READING OF INITIAL DATA
C
      DO 8016 N=1,16
      DO 8016 I=1,3
      DO 8016 J=1,5
      TM1(N,I,J)=0.
      IF(I.EQ.3) TM2(N,J)=0.
      IF(N.EQ.16) GO TO 8016
      RPAD(N,I,J)=0.
8016 CONTINUE
      DO 8015 N=1,3
      DO 8015 I=1,3
      DO 8015 J=1,5
8015 KFAM(N,I,J)=0
      DO 8017 J=1,3
      DO 8017 K=1,360
8017 KBEL(J,K)=0
C
C **** 1969 COST FOR IMPROVEMENTS
C
      DATA((CONRT(1,J,K),K=1,8),J=1,5)/363.,1722.,126.,631.,326.,173.,
      A98.,127.,1042.,607.,153.,581.,177.,128.,67.,331.,664.,358.,91.,
      B565.,145.,86.,41.,119.,283.,231.,54.,584.,120.,51.,22.,43.,161.,
      C145.,35.,185.,89.,40.,18.,18./
      DATA((CONRT(2,J,K),K=1,8),J=1,5)/8244.,3929.,5311.,2021.,1233.,
      A658.,223.,6796.,5385.,3864.,758.,2826.,1305.,574.,207.,3721.,
      B2387.,1452.,414.,1481.,740.,225.,139.,1355.,1095.,942.,231.,
      C1004.,502.,128.,116.,665.,632.,587.,123.,705.,350.,115.,68.,319./
      DATA((CONRT(3,J,K),K=1,8),J=1,5)/0.,0.,0.,764.,800.,273.,155.,
      A337.,2442.,2016.,1087.,921.,877.,403.,172.,510.,1575.,987.,249.,
      B905.,605.,149.,86.,645.,795.,598.,196.,619.,419.,138.,66.,349.,
      C582.,472.,121.,506.,306.,107.,49.,296./
C **** PROBABILITY OF REPAIR TYPE
C
      DATA(((PERC(I,J,K),K=1,4),J=1,5),I=1,3)/9.,2.,5.,84.,50.,12.,20.,
      A18.,50.,15.,18.,17.,44.,18.,11.,27.,55.,16.,8.,21.,12.,0.,12.,
      B76.,50.,4.,12.,34.,49.,5.,6.,40.,55.,4.,6.,35.,49.,3.,6.,42.,0.,
      C0.,11.,89.,42.,7.,8.,43.,37.,5.,8.,50.,53.,6.,7.,34.,49.,3.,7.,
      D41./
      DATA(((PERC1(I,J,K),K=1,2),J=1,5),I=1,3)/0.,100.,77.,23.,74.,26.,
      A85.,15.,97.,3.,0.,100.,85.,15.,28.,72.,40.,60.,37.,63.,0.,100.,86.,
      B14.,40.,60.,44.,56.,37.,63./
C
      DATA(((CONI(I,J,K),K=1,4),J=1,3),I=1,2)/30.,40.,20.,10.,40.,30.,
      A20.,10.,50.,20.,20.,10.,30.,40.,20.,10.,35.,30.,25.,10.,40.,20.,
      B30.,10./
C
C **** DETERMINATION OF INITIAL INDEXES
C
1956 DO 1955 I=1,3
      DO 1955 J=1,5
      DO 1955 K=1,8
      IF(MGFLAG.EQ.1) CONST(I,J,K)=1.57*CONRT(I,J,K)
      IF(MGFLAG.NE.1) CONST(I,J,K)=CONST(I,J,K)*(1.+WSIN(NYEA)/100.)
1955 CONTINUE
      MFLAG=1
      TFUND=FLOAT(ITREV(NYEA))
      DO 2000 I=1,3
      DO 2000 J=1,5
      SMCON1(I,J)=0.
370 IF(I.NE.1) GO TO 1200
      I1=2
      IF(J.LE.2) I2=1
      IF(J.EQ.3) I2=2
      IF(J.GT.3) I2=3

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HPM 1251
 HPM 1252
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GO TO 1201	HPM 1321
1200 I1=1	HPM 1322
IF(J.LE.3) I2=1	HPM 1323
IF(J.EQ.4) I2=2	HPM 1324
IF(J.EQ.5) I2=3	HPM 1325
1201 IF(MG1FLAG.EQ.2) GO TO 9001	HPM 1326
IF(MFLAG.EQ.2) GO TO 973	HPM 1327
DO 2000 K=1,ML1(I,J)	HPM 1328
973 MMFLAG=2	HPM 1329
GO TO 379	HPM 1330
1492 I22F=1	HPM 1331
IF(HG4(I,J,K).EQ.12.) GO TO 1493	HPM 1332
I22F=2	HPM 1333
IF(LANE(I,J,K).EQ.1) PTY1=1.-.24*((12.-HG4(I,J,K))/3.)	HPM 1334
IF(LANE(I,J,K).NE.1) PTY1=1.-.18*((12.-HG4(I,J,K))/3.)	HPM 1335
1493 DELCIC=(HGWI(I,J,K)*PEAK(I,J,K))/((FLOAT(LANE(I,J,K))+1)*CAP)	HPM 1336
IF(DELCIC.GT.1.) DELCIC=1.	HPM 1337
PLIE=3.6	HPM 1338
IF(J.EQ.1) PLIE=3.8	HPM 1339
IF(J.GT.3) PLIE=3.2	HPM 1340
HG3(I,J,K)=(HGWI(I,J,K)*PEAK(I,J,K))/(FLOAT(LANE(I,J,K))*CAP)	HPM 1341
CONI(I1,I2,5)=(1.-DELCIC)*(CONI(I1,I2,2)/.6)	HPM 1342
IF(DELCIC.LT.0.4) CONI(I1,I2,5)=CONI(I1,I2,2)	HPM 1343
PCON(1)=(HG3(I,J,K)-1.)*(CONI(I1,I2,1)/PLIE)	HPM 1344
IF(PCON(1).LT.0.) PCON(1)=0.	HPM 1345
HELP=HG3(I,J,K)	HPM 1346
IF(HG3(I,J,K).GT.1.) HG3(I,J,K)=1.	HPM 1347
PCON(2)=(1.-HG3(I,J,K))*(CONI(I1,I2,2)/.6)	HPM 1348
IF(HG3(I,J,K).LT.0.4) PCON(2)=CONI(I1,I2,2)	HPM 1349
PCON(3)=(HG4(I,J,K)-9.)*(CONI(I1,I2,3)/3.)	HPM 1350
PARA=HG5(I,J,K)	HPM 1351
IF(PARA.EQ.11.) PARA=7.	HPM 1352
PCON(5)=(PARA-2.6)*CONI(I1,I2,4)/4.4	HPM 1353
PCON(4)=PCON(2)	HPM 1354
IF(LANE(I,J,K).EQ.5) PCON(2)=CONI(I1,I2,2)	HPM 1355
IF(MFLAG.EQ.2) GO TO 371	HPM 1356
SMCI(I,J,K)=PCON(1)+PCON(2)+PCON(3)+PCON(5)	HPM 1357
SMCON1(I,J)=SMCON1(I,J)+(PCON(1)+PCON(3)+PCON(4)+PCON(5))*HGWI	HPM 1358
I(I,J,K)	HPM 1359
IF(NYEA.EQ.(NYEAR+1)) GO TO 2000	HPM 1360
C	HPM 1361
C **** DETERMINATION OF IMPROVEMENT TYPE	HPM 1362
C	HPM 1363
X70=RANF(0)*100.	HPM 1364
IF(PERC(I,J,4).GT.PERC(I,J,1).AND.PERC(I,J,1).GE.PERC(I,J,3))	HPM 1365
AGO TO 2010	HPM 1366
IF(PERC(I,J,1).GT.PERC(I,J,3).AND.PERC(I,J,3).GT.PERC(I,J,4))	HPM 1367
AGO TO 2011	HPM 1368
IF(PERC(I,J,1).GT.PERC(I,J,4).AND.PERC(I,J,2).GT.PERC(I,J,3))	HPM 1369
AGO TO 2012	HPM 1370
IF(PERC(I,J,4).GT.PERC(I,J,1)) GO TO 2013	HPM 1371
GO TO 2014	HPM 1372
C	HPM 1373
2010 IF(X70.LE.PERC(I,J,2)) GO TO 2020	HPM 1374
IF(X70.LE.(PERC(I,J,2)+PERC(I,J,3))) GO TO 2021	HPM 1375
IF(X70.LE.(PERC(I,J,2)+PERC(I,J,3)+PERC(I,J,1))) GO TO 2022	HPM 1376
GO TO 2023	HPM 1377
2011 IF(X70.LE.PERC(I,J,2)) GO TO 2020	HPM 1378
IF(X70.LE.(PERC(I,J,2)+PERC(I,J,4))) GO TO 2023	HPM 1379
IF(X70.LE.(PERC(I,J,2)+PERC(I,J,4)+PERC(I,J,3))) GO TO 2021	HPM 1380
GO TO 2020	HPM 1381
2012 IF(X70.LE.PERC(I,J,3)) GO TO 2021	HPM 1382
IF(X70.LE.(PERC(I,J,3)+PERC(I,J,2))) GO TO 2020	HPM 1383
IF(X70.LE.(PERC(I,J,3)+PERC(I,J,2)+PERC(I,J,4))) GO TO 2023	HPM 1384
GO TO 2022	HPM 1385
2013 IF(X70.LE.PERC(I,J,3)) GO TO 2021	HPM 1386
GO TO 2023	HPM 1387
2014 IF(X70.LE.PERC(I,J,2)) GO TO 2020	HPM 1388
IF(X70.LE.(PERC(I,J,2)+PERC(I,J,3))) GO TO 2021	HPM 1389
IF(X70.LE.(PERC(I,J,2)+PERC(I,J,3)+PERC(I,J,4))) GO TO 2023	HPM 1390

GO TO 2022	HPM 1391
2020 COST1(I,J,K)=CONST(I,J,3)	HPM 1392
GO TO 2030	HPM 1393
2021 COST1(I,J,K)=CONST(I,J,6)	HPM 1394
GO TO 2030	HPM 1395
2022 COST1(I,J,K)=CONST(I,J,2)	HPM 1396
GO TO 2030	HPM 1397
2023 COST1(I,J,K)=CONST(I,J,7)	HPM 1398
C	HPM 1399
C **** DETERMINATION OF WIDENING COSTS	HPM 1400
C	HPM 1401
2030 X71=РАНF(0)*100.	HPM 1402
IF(PERC1(I,J,2).GE.PERC1(I,J,1)) GO TO 2031	HPM 1403
GO TO 2032	HPM 1404
2031 IF(X71.LE.PERC1(I,J,1)) COST2(I,J,K)=CONST(I,J,1)	HPM 1405
IF(X71.GT.PERC1(I,J,1)) COST2(I,J,K)=CONST(I,J,4)	HPM 1406
GO TO 371	HPM 1407
2032 IF(X71.LE.PERC1(I,J,2)) COST2(I,J,K)=CONST(I,J,4)	HPM 1408
IF(X71.GT.PERC1(I,J,2)) COST2(I,J,K)=CONST(I,J,1)	HPM 1409
C	HPM 1410
C **** DETERMINATION OF COST-EFFECTIVENESS OF IMPROVEMENTS	HPM 1411
C	HPM 1412
371 PARK=4.6	HPM 1413
IF(J.EQ.1) PARK=4.8	HPM 1414
IF(J.GT.3) PARK=4.2	HPM 1415
REV=(PARK-1.)*(CONI(I1,I2,1)/PLIE)	HPM 1416
IF(I22F.EQ.2) DART=(1.-HG3(I,J,K)*PTY1)*(CONI(I1,I2,2)/.6)	HPM 1417
IF(I22F.EQ.2.AND.(HG3(I,J,K)*PTY1).LT.0.4) DART=CONI(I1,I2,2)	HPM 1418
PVAR(1)=((REV-PCON(1))*HGWI(I,J,K)*RELP(I,J))/COST1	HPM 1419
A(I,J,K)	HPM 1420
PVAR(2)=((CONI(I1,I2,5)-PCON(2)+REV-PCON(1)+CONI(I1,I2,3	HPM 1421
A)-PCON(3))*HGWI(I,J,K)*RELP(I,J))/COST2(I,J,K)	HPM 1422
PVAR(3)=((CONI(I1,I2,3)-PCON(3)+REV-PCON(1))*HGWI(I,J,K)*RELP	HPM 1423
A(I,J))/CONST(I,J,5)	HPM 1424
IF(I22F.EQ.2) PVAR(3)=((CONI(I1,I2,3)-PCON(3)+REV-PCON(1)-PCON	HPM 1425
A(2)+DART)*HGWI(I,J,K)*RELP(I,J))/CONST(I,J,5)	HPM 1426
PVAR(4)=PVAR(2)	HPM 1427
IF(LANE(I,J,K).EQ.5) PVAR(2)=0.	HPM 1428
IF(MFLAG.EQ.2) GO TO 372	HPM 1429
DELCI(I,J,K)=PVAR(1)+PVAR(2)+PVAR(3)	HPM 1430
2000 CONTINUE	HPM 1431
IF(NYEA.EQ.(NYEAR+1)) GO TO 710	HPM 1432
C	HPM 1433
C **** DETERMINATION OF MAINTAINANCE	HPM 1434
C	HPM 1435
AAM=AAM*(1.+WSIN(NYEA)/400.)	HPM 1436
TFUND2=((TFUND-AAM)*.67)/1.03	HPM 1437
FUND(NYEA)=AAM	HPM 1438
TFUND1(NYEA)=.33*(TFUND-AAM)	HPM 1439
ADMIN(NYEA)=TFUND2*1.03	HPM 1440
GO TO 2950	HPM 1441
7281 MFLAG=2	HPM 1442
DO 90 I=1,3	HPM 1443
DO 90 J=1,5	HPM 1444
K11=0	HPM 1445
TCOST=0.	HPM 1446
FUNDS(I,J)=EFORT(I,J)*TFUND2+HUNT(I,J)	HPM 1447
IFAM(I,J)=IFAM(I,J)+IFIX(FUNDS(I,J)-HUNT(I,J))	HPM 1448
IKONT=0	HPM 1449
JFLAG=1	HPM 1450
DO 1654 K=1,ML1(I,J)	HPM 1451
PMIN=1.2	HPM 1452
IF(J.LE.3) PMIN=1.5	HPM 1453
IF(I.EQ.1.AND.J.EQ.3.AND.HGWI(I,J,K).LT.6.) PMIN=1.3	HPM 1454
IF(HG6(I,J,K).GT.PMIN) GO TO 1654	HPM 1455
ICAN=2	HPM 1456
IF(HG5(I,J,K).GT.9.) ICAN=1	HPM 1457
IF(ICAN.EQ.1) GO TO 6100	HPM 1458
BETA=.4+(.081*19.**3.23)/((HG5(I,J,K))*5.19)	HPM 1459
ROW=10.**5.93*(HG5(I,J,K))*9.36/19.**4.79	HPM 1460

6101	AF1=1.5	HPM	1461
	IF(J.LE.3) AF1=2.	HPM	1462
	IF(I.EQ.1.AND.J.EQ.3) AF1=1.8	HPM	1463
	HLM=4.6	HPM	1464
	IF(J.EQ.1) HLM=4.8	HPM	1465
	IF(J.GT.3) HLM=4.2	HPM	1466
	PFLY=2.2	HPM	1467
	IF(J.LE.3) PFLY=2.6	HPM	1468
	IF(I.EQ.1.AND.J.EQ.3.AND.HGWY(I,J,K).LT.6.) PFLY=2.5	HPM	1469
	EQT(I,J,K)=EXP(ALOG(ROW)+(ALOG((HLM-PFLY)/(HLM-AF1))/BETA))	HPM	1470
	COSTA=CONST(I,J,7)*ERAPER(I,J)/FLOAT(ML1(I,J))	HPM	1471
	TCOST=.1*COSTA+TCOST	HPM	1472
	IF(J.LE.3) TCOST=.15*COSTA+TCOST	HPM	1473
	IF(I.EQ.1.AND.J.EQ.3.AND.HGWY(I,J,K).LT.6.) TCOST=.1*COSTA	HPM	1474
	A+TCOST	HPM	1475
	IF(TCOST.GT.FUNDS(I,J)) GO TO 381	HPM	1476
	PLIE=3.6	HPM	1477
	IF(J.EQ.1) PLIE=3.8	HPM	1478
	IF(J.GT.3) PLIE=3.2	HPM	1479
	MG1FLAG=2	HPM	1480
	GO TO 370	HPM	1481
9001	PCON(1)=(HG6(I,J,K)-1.)*(CONI(I1,I2,1)/PLIE)	HPM	1482
	IF(PCON(1).LT.0) PCON(1)=0.	HPM	1483
	REV=(PFLY-1.)*(CONI(I1,I2,1)/PLIE)	HPM	1484
	SMCI(I,J,K)=SMCI(I,J,K)-PCON(1)+REV	HPM	1485
	REV1=CONI(I1,I2,1)	HPM	1486
	DELCI(I,J,K)=DELCI(I,J,K)-(((REV1-PCON(1))*HGWI(I,J,K)*	HPM	1487
	ARELP(I,J))/COST1(I,J,K))+(((REV1-REV)*HGWI(I,J,K)*RELP	HPM	1488
	B(I,J))/COST1(I,J,K))	HPM	1489
	HG6(I,J,K)=PFLY	HPM	1490
	GO TO 1654	HPM	1491
6100	BETA=1.+3.63*(19.**5.2)/(HG5(I,J,K)**8.46)	HPM	1492
	ROW=10.**5.85*(HG5(I,J,K)**7.35)/(19.**4.62)	HPM	1493
	GO TO 6101	HPM	1494
1654	CONTINUE	HPM	1495
	DELCON(I,J)=0.	HPM	1496
	SMCON9(I,J)=0.	HPM	1497
	DO 2003 K=1,ML1(I,J)	HPM	1498
	SMCON9(I,J)=SMCON9(I,J)+SMCI(I,J,K)	HPM	1499
2003	DELCON(I,J)=DELCON(I,J)+DELCI(I,J,K)	HPM	1500
352	X91=RANF(0)*FLOAT(ML1(I,J))-0.01	HPM	1501
	MG1FLAG=1	HPM	1502
	IKONT=IKONT+1	HPM	1503
	IF(IKONT.GT.500) GO TO 700	HPM	1504
	K=IFIX(X91)+1	HPM	1505
	IF(JFLAG.EQ.2) GO TO 350	HPM	1506
	IF(DELCI(I,J,K).GT.(DELCON(I,J)/FLOAT(ML1(I,J)))) GO TO 351	HPM	1507
	GO TO 352	HPM	1508
351	JFLAG=2	HPM	1509
	GO TO 370	HPM	1510
C		HPM	1511
C	**** DETERMINING PRIORITIZATION ON THE BASIS OF COST-BENEFIT	HPM	1512
C		HPM	1513
372	TOP=0.	HPM	1514
	DO 373 N2=1,3	HPM	1515
	IF(PUAR(N2).LT.TOP) GO TO 373	HPM	1516
	TOP=PUAR(N2)	HPM	1517
	IR1=N2	HPM	1518
373	CONTINUE	HPM	1519
	IF(HELP.GE.1.2.AND.LANE(I,J,K).LT.5) IR1=2	HPM	1520
	IF(IR1.EQ.1) COSTA=COST1(I,J,K)*ERAPER(I,J)/FLOAT(ML1(I,J))	HPM	1521
	IF(IR1.EQ.2) COSTA=COST2(I,J,K)*ERAPER(I,J)/FLOAT(ML1(I,J))	HPM	1522
	IF(IR1.EQ.3) COSTA=CONST(I,J,5)*ERAPER(I,J)/FLOAT(ML1(I,J))	HPM	1523
	TCOST=TCOST+COSTA	HPM	1524
	IF(TCOST.GT.FUNDS(I,J)) GO TO 381	HPM	1525
	GO TO 380	HPM	1526
350	IF(SMCI(I,J,K).LT.(SMCON9(I,J)/FLOAT(ML1(I,J)))) GO TO 450	HPM	1527
	GO TO 352	HPM	1528
450	JFLAG=1	HPM	1529
	GO TO 370	HPM	1530


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C
C **** REVISION OF INDEXES AFTER MAINTENANCE
C
380 IF(IR1.EQ.2) GO TO 383
1818 IF(IR1.NE.2) DELCI(I,J,K)=DELICI(I,J,K)-PUAR(IR1)
      IF(IR1.EQ.2) DELCI(I,J,K)=DELICI(I,J,K)-PUAR(1)-PUAR(3)
      IF(IR1.EQ.1) SMCI(I,J,K)=SMCI(I,J,K)-PCON(1)+REV
      IF(IR1.EQ.3) SMCI(I,J,K)=SMCI(I,J,K)-PCON(1)-PCON(3)+CONI(I1,I2,
      A3)+REV
      IF(IR1.EQ.3.AND.I22F.EQ.2) SMCI(I,J,K)=SMCI(I,J,K)-PCON(2)+DART
      IF(IR1.EQ.2) SMCI(I,J,K)=SMCI(I,J,K)-PCON(1)+REV-
      APCON(3)+CONI(I1,I2,3)-PCON(2)+CONI(I1,I2,5)
      GO TO 1819
383 LANE(I,J,K)=LANE(I,J,K)+1
      D1=(HGWY(I,J,K)*PEAK(I,J,K))/((LANE(I,J,K)+1)*CAP)
      IF(D1.GT.1.) D1=1.
      D2=(1.-D1)*((CONI(I1,I2,2)/.6)
      IF(D1.LT.0.4) D2=CONI(I1,I2,2)
      DELCI(I,J,K)=DELICI(I,J,K)-PUAR(2)+(((D2-CONI(I1,I2,5))*HGWY(I,
      AJ,K)*RELPI(I,J))/COST2(I,J,K))
      GO TO 1818
1819 MRANK=2
      GO TO 4792
190 PARA=HG5(I,J,K)
      IF(PARA.EQ.11.) PARA=7.
      SMCI(I,J,K)=SMCI(I,J,K)-PCON(5)+((PARA-2.6)*CONI(I1,I2,4)/4.4)
      EQT(I,J,K)=0.
      IF(I22F.EQ.2) HG3(I,J,K)=PTY1*HG3(I,J,K)
      IF(I22F.EQ.2) PEAK(I,J,K)=PTY1*PEAK(I,J,K)
      IF(IR1.EQ.2) HG3(I,J,K)=DELCIC
      IF(IR1.GE.2) HG4(I,J,K)=12.
      HG6(I,J,K)=4.6
      IF(J.EQ.1) HG6(I,J,K)=4.8
      IF(J.GT.3) HG6(I,J,K)=4.2
      DELCON(I,J)=0.
      SMCON9(I,J)=0.
      DO 2002 MKE=1,ML1(I,J)
      SMCON9(I,J)=SMCON9(I,J)+SMCI(I,J,MKE)
2002 DELCON(I,J)=DELCN(I,J)+DELICI(I,J,MKE)
      GO TO 352
381 HUNT(I,J)=FUNDS(I,J)-(TCOST-COSTA)
      DO 9973 K=1,ML1(I,J)
      IF(J.LE.3) RINTO=2.6
      IF(I.EQ.1.AND.J.EQ.3.AND.HGWY(I,J,K).LT.6.) RINTO=2.1
      IF(J.GT.3) RINTO=2.1
      IF(HG6(I,J,K).LE.RINTO) K11=K11+1
9973 CONTINUE
      RPAD(NYEA,I,J)=FLOAT(K11)/FLOAT(ML1(I,J))+RPAD(NYEA,I,J)
90 CONTINUE
      IF(MKN.NE.0) GO TO 70
      NOY=1974+NYEA+1
      N=1
1985 IF(NOY.EQ.1980) KFK=1
      IF(NOY.EQ.1985) KFK=2
      IF(NOY.EQ.1990) KFK=3
      DO 1984 I=1,3
      DO 1984 J=1,5
      IA1(N,I,J)=0
      IA2(N,I,J)=0
      IA3(N,I,J)=0
      IB1(N,I,J)=0
      IB2(N,I,J)=0
      IB3(N,I,J)=0
      IC1(N,I,J)=0
      IC2(N,I,J)=0
      IC3(N,I,J)=0
      ID1(N,I,J)=0
      ID2(N,I,J)=0
      ID3(N,I,J)=0
      DO 1984 K=1,ML1(I,J)

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HPM 1531
HPM 1532
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HPM 1598
HPM 1599
HPM 1600

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      N1=1                                HPM 1601
      IF(N.EQ.2) N1=IFIX(HGWY(I,J,K)*1000.) HPM 1602
C                                     HPM 1603
C **** PERC. OF PAVEMENT TYPES          HPM 1604
C                                     HPM 1605
      IF(HG5(I,J,K).LT.3.65) IA1(N,I,J)=IA1(N,I,J)+N1 HPM 1606
      IF(HG5(I,J,K).GT.3.65.AND.HG5(I,J,K).LE.4.0) IA2(N,I,J)=IA2(N,I,J)+N1 HPM 1607
      IF(HG5(I,J,K).GT.4.0) IA3(N,I,J)=IA3(N,I,J)+N1 HPM 1608
C                                     HPM 1609
C **** PERC. OF PAVEMENT CONDITIONS      HPM 1610
C                                     HPM 1611
      BOG=2.                              HPM 1612
      IF(I.EQ.1.AND.J.LE.2) BOG=2.5        HPM 1613
      IF(I.GT.1.AND.J.LE.3) BOG=2.5        HPM 1614
      IF(HG6(I,J,K).LT.BOG) IB1(N,I,J)=IB1(N,I,J)+N1 HPM 1615
      IF(HG6(I,J,K).GE.BOG.AND.HG6(I,J,K).LT.3.4) IB2(N,I,J)=IB2(N,I,J)+N1 HPM 1616
      IF(HG6(I,J,K).GE.3.4) IB3(N,I,J)=IB3(N,I,J)+N1 HPM 1617
C                                     HPM 1618
C **** U/C RATIOS                        HPM 1619
C                                     HPM 1620
      BPG=.8                              HPM 1621
      IF(I.NE.1) BPG=.9                    HPM 1622
      IF(HG3(I,J,K).LT.0.31) IC1(N,I,J)=IC1(N,I,J)+N1 HPM 1623
      IF(HG3(I,J,K).GE.0.31.AND.HG3(I,J,K).LT.BPG) IC2(N,I,J)=IC2(N,I,J)+N1 HPM 1624
      IF(HG3(I,J,K).GE.BPG) IC3(N,I,J)=IC3(N,I,J)+N1 HPM 1625
C                                     HPM 1626
C **** LANE WIDTHS                       HPM 1627
C                                     HPM 1628
      IF(HG4(I,J,K).LT.10.) ID1(N,I,J)=ID1(N,I,J)+N1 HPM 1629
      IF(HG4(I,J,K).GE.10.0.AND.HG4(I,J,K).LE.11.) ID2(N,I,J)=ID2(N,I,J)+N1 HPM 1630
      IF(HG4(I,J,K).GT.11.) ID3(N,I,J)=ID3(N,I,J)+N1 HPM 1631
      1984 CONTINUE                        HPM 1632
C                                     HPM 1633
C **** APPLICATION OF WEIGHTING FACTORS   HPM 1634
C                                     HPM 1635
      DO 1986 I=1,3                        HPM 1636
      DO 1986 J=1,5                        HPM 1637
      IF(N.EQ.2) IFAM(I,J)=IFIX(FLOAT(IFAM(I,J))/5.) HPM 1638
      IF(N.EQ.2) KFAM(KFK,I,J)=KFAM(KFK,I,J)/IFAM(I,J) HPM 1639
      ARK=FLOAT(ML1(I,J))                  HPM 1640
      IF(N.EQ.2) ARK=HK(I,J)*1000.         HPM 1641
      IA1(N,I,J)=IFIX((FLOAT(IA1(N,I,J))/ARK*100.+.5) HPM 1642
      IA2(N,I,J)=IFIX((FLOAT(IA2(N,I,J))/ARK*100.+.5) HPM 1643
      IA3(N,I,J)=IFIX((FLOAT(IA3(N,I,J))/ARK*100.+.5) HPM 1644
      IB1(N,I,J)=IFIX((FLOAT(IB1(N,I,J))/ARK*100.+.5) HPM 1645
      IB2(N,I,J)=IFIX((FLOAT(IB2(N,I,J))/ARK*100.+.5) HPM 1646
      IB3(N,I,J)=IFIX((FLOAT(IB3(N,I,J))/ARK*100.+.5) HPM 1647
      IC1(N,I,J)=IFIX((FLOAT(IC1(N,I,J))/ARK*100.+.5) HPM 1648
      IC2(N,I,J)=IFIX((FLOAT(IC2(N,I,J))/ARK*100.+.5) HPM 1649
      IC3(N,I,J)=IFIX((FLOAT(IC3(N,I,J))/ARK*100.+.5) HPM 1650
      ID1(N,I,J)=IFIX((FLOAT(ID1(N,I,J))/ARK*100.+.5) HPM 1651
      ID2(N,I,J)=IFIX((FLOAT(ID2(N,I,J))/ARK*100.+.5) HPM 1652
      ID3(N,I,J)=IFIX((FLOAT(ID3(N,I,J))/ARK*100.+.5) HPM 1653
      1986 CONTINUE                        HPM 1654
      IF(N.EQ.2) GO TO 4056                HPM 1655
      N=2                                  HPM 1656
      GO TO 1985                           HPM 1657
C                                     HPM 1658
C **** AVERAGING VARIABLES               HPM 1659
C                                     HPM 1660
      4056 IK=0                            HPM 1661
      I37=1                                HPM 1662
      4055 DO 4050 N=1,2                    HPM 1663
      DO 4050 I=1,3                        HPM 1664
      DO 4050 J=1,5                        HPM 1665
      IK=IK+1                              HPM 1666
      4055 DO 4050 N=1,2                    HPM 1667
      DO 4050 I=1,3                        HPM 1668
      DO 4050 J=1,5                        HPM 1669
      IK=IK+1                              HPM 1670

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GO TO(20,21,22,23,24,25,26,27,28,29,30,31) I37	HPM 1671
20 KBEL(KFK,IK)=IA1(N,I,J)+KBEL(KFK,IK)	HPM 1672
GO TO 4050	HPM 1673
21 KBEL(KFK,IK)=IA2(N,I,J)+KBEL(KFK,IK)	HPM 1674
GO TO 4050	HPM 1675
22 KBEL(KFK,IK)=IA3(N,I,J)+KBEL(KFK,IK)	HPM 1676
GO TO 4050	HPM 1677
23 KBEL(KFK,IK)=IB1(N,I,J)+KBEL(KFK,IK)	HPM 1678
GO TO 4050	HPM 1679
24 KBEL(KFK,IK)=IB2(N,I,J)+KBEL(KFK,IK)	HPM 1680
GO TO 4050	HPM 1681
25 KBEL(KFK,IK)=IB3(N,I,J)+KBEL(KFK,IK)	HPM 1682
GO TO 4050	HPM 1683
26 KBEL(KFK,IK)=IC1(N,I,J)+KBEL(KFK,IK)	HPM 1684
GO TO 4050	HPM 1685
27 KBEL(KFK,IK)=IC2(N,I,J)+KBEL(KFK,IK)	HPM 1686
GO TO 4050	HPM 1687
28 KBEL(KFK,IK)=IC3(N,I,J)+KBEL(KFK,IK)	HPM 1688
GO TO 4050	HPM 1689
29 KBEL(KFK,IK)=ID1(N,I,J)+KBEL(KFK,IK)	HPM 1690
GO TO 4050	HPM 1691
30 KBEL(KFK,IK)=ID2(N,I,J)+KBEL(KFK,IK)	HPM 1692
GO TO 4050	HPM 1693
31 KBEL(KFK,IK)=ID3(N,I,J)+KBEL(KFK,IK)	HPM 1694
4050 CONTINUE	HPM 1695
I37=I37+1	HPM 1696
IF(I37.NE.13) GO TO 4055	HPM 1697
IF(KSSF.EQ.1) GO TO 1991	HPM 1698
IF(KSSF.EQ.2) GO TO 1987	HPM 1699
GO TO 70	HPM 1700
C	HPM 1701
C **** HEADING AND OUTPUT STATEMENTS	HPM 1702
C	HPM 1703
1987 IK=0	HPM 1704
I37=1	HPM 1705
4065 DO 4060 N=1,2	HPM 1706
DO 4060 I=1,3	HPM 1707
DO 4060 J=1,5	HPM 1708
IK=IK+1	HPM 1709
GO TO(32,33,34,35,36,37,38,39,40,41,42,43) I37	HPM 1710
32 IA1(N,I,J)=KBEL(KFK,IK)/KCOV	HPM 1711
GO TO 4060	HPM 1712
33 IA2(N,I,J)=KBEL(KFK,IK)/KCOV	HPM 1713
GO TO 4060	HPM 1714
34 IA3(N,I,J)=KBEL(KFK,IK)/KCOV	HPM 1715
GO TO 4060	HPM 1716
35 IB1(N,I,J)=KBEL(KFK,IK)/KCOV	HPM 1717
GO TO 4060	HPM 1718
36 IB2(N,I,J)=KBEL(KFK,IK)/KCOV	HPM 1719
GO TO 4060	HPM 1720
37 IB3(N,I,J)=KBEL(KFK,IK)/KCOV	HPM 1721
GO TO 4060	HPM 1722
38 IC1(N,I,J)=KBEL(KFK,IK)/KCOV	HPM 1723
GO TO 4060	HPM 1724
39 IC2(N,I,J)=KBEL(KFK,IK)/KCOV	HPM 1725
GO TO 4060	HPM 1726
40 IC3(N,I,J)=KBEL(KFK,IK)/KCOV	HPM 1727
GO TO 4060	HPM 1728
41 ID1(N,I,J)=KBEL(KFK,IK)/KCOV	HPM 1729
GO TO 4060	HPM 1730
42 ID2(N,I,J)=KBEL(KFK,IK)/KCOV	HPM 1731
GO TO 4060	HPM 1732
43 ID3(N,I,J)=KBEL(KFK,IK)/KCOV	HPM 1733
4060 CONTINUE	HPM 1734
I37=I37+1	HPM 1735
IF(I37.NE.13) GO TO 4065	HPM 1736
DO 1502 I=1,3	HPM 1737
DO 1502 J=1,5	HPM 1738
1502 IFAM(I,J)=KFAM(KFK,I,J)/KCOV	HPM 1739
DO 1988 I=1,3	HPM 1740

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GO TO(7,8,9) I
1989 BPG=.80
IF(I.NE.1) BPG=.90
WRITE(6,101) ((IA3(N,I,K),N=1,2),K=1,5),((IA2(N,I,K),N=1,2),K=1,
A5),((IA1(N,I,K),N=1,2),K=1,5)
101 FORMAT(7X,'PAVEMENT TYPE:',/,9X,'HIGH',16X,5(I3,7X,I3,7X),/,9X,
A,'INTERM',14X,5(I3,7X,I3,7X),/,9X,'LOW',17X,5(I3,7X,I3,7X),///)
WRITE(6,102) ((IB1(N,I,K),N=1,2),K=1,5),((IB2(N,I,K),N=1,2),K=1,
A5),((IB3(N,I,K),N=1,2),K=1,5)
102 FORMAT(7X,'PAVEMENT CONDITION:1/',/,9X,'POOR',16X,5(I3,7X,I3,7X),
A/,9X,'FAIR',16X,5(I3,7X,I3,7X),/,9X,'GOOD',16X,5(I3,7X,I3,7X),///)
WRITE(6,103) ((IC1(N,I,K),N=1,2),K=1,5),BPG,((IC2(N,I,K),N=1,2),
AK=1,5),BPG,((IC3(N,I,K),N=1,2),K=1,5)
103 FORMAT(7X,'VOL/CAP RATIOS:2/',/,9X,'< .31',15X,5(I3,7X,I3,7X),/,
A9X,'.31 - ',F3.2,11X,5(I3,7X,I3,7X),/,9X,'> ',F3.2,15X,5(I3,7X,
BI3,7X),///)
WRITE(6,104) ((ID1(N,I,K),N=1,2),K=1,5),((ID2(N,I,K),N=1,2),K=1,
A5),((ID3(N,I,K),N=1,2),K=1,5)
104 FORMAT(7X,'LANE WIDTH (FT):',/,9X,'< 10',16X,5(I3,7X,I3,7X),/,9X,
A'10 - 11',13X,5(I3,7X,I3,7X),/,9X,'> 11',16X,5(I3,7X,I3,7X),///)
WRITE(6,105) (IFAM(I,K),K=1,5)
105 FORMAT(7X,'5 YEAR AVERAGE',/,7X,'ANNUAL CAPITAL ',/,7X,
A'OUTLAYS: ',/,7X,'(IN THOUSANDS) 3/',8X,4('$',I6,13X),'$',I6,
B////,7X,'1/ POOR - PSR <2.0 (<2.5 PRINCIPAL ARTERIAL): FAIR - PSR
C2.0 TO 3.4: GOOD - PSR>3.4.',/,7X,'2/ TRAVEL IS FOR PEAK HOUR. ONE
D DIRECTION ONLY.',/,7X,'3/ EXCLUDING STRUCTURE COSTS')
1988 CONTINUE
1991 DO 851 I=1,3
DO 851 J=1,5
851 IFAM(I,J)=0
GO TO 70
7 WRITE(6,5000) NOY
5000 FORMAT('1',1X,24('* '),I4,2X,'RURAL SUMMARY IN PERCENTS',24('* '),
A/////,,31X,'INTERSTATE',8X,'OTHER PRIN ART',6X,'MINOR ARTERIAL',
B5X,'MAJOR COLLECTOR',5X,'MINOR COLLECTOR',/,27X,5(1X,'MILES'
C,5X,'TRAVEL',3X),/)
GO TO 1989
8 WRITE(6,5001) NOY
5001 FORMAT('1',1X,24('* '),I4,2X,'URBAN SUMMARY IN PERCENTS',24('* '),
A/////,,31X,'INTERSTATE',8X,'OTH FWY & EXPY',6X,'OTHER PRIN ART',
B,6X,'MINOR ARTERIAL',8X,'COLLECTOR',/,27X,5(1X,'MILES',5X,'TRAVEL'
C,3X),/)
GO TO 1989
9 WRITE(6,5002) NOY
5002 FORMAT('1',1X,23('* '),I4,2X,'SMALL URBAN SUMMARY IN PERCENTS',2
A3('* '),/////,,31X,'INTERSTATE',8X,'OTH FWY & EXPY',6X,'OTHER PRIN
BART',6X,'MINOR ARTERIAL',8X,'COLLECTOR',/,27X,5(1X,'MILES',5X,'TRA
CUEL',3X),/)
GO TO 1989
70 MGFLAG=2
2912 CONTINUE
700 WRITE(6,1234)
1234 FORMAT(10X,'THRESHOLD REQUIRES REVISION')
C1=SMCON9(I,J)/FLOAT(ML1(I,J))
C2=DELCON(I,J)/FLOAT(ML1(I,J))
PRINT,SMCON9
PRINT,DELCON
PRINT,I,J,ML1(I,J)
PRINT,C1,C2
SMCON9(I,J)=0.
DELCON(I,J)=0.
DO 91 K=1-ML1(I,J)
SMCON9(I,J)=SMCON9(I,J)+SMCI(I,J,K)
DELCON(I,J)=DELCON(I,J)+DELCI(I,J,K)
91 PRINT,SMCI(I,J,K),DELCI(I,J,K),K
PRINT,SMCON9(I,J),DELCON(I,J)
GO TO 1235
C
C ***** OUTPUT STATEMENTS
C

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2950 IF(NYEA.EQ.5) GO TO 2989
      IF(NYEA.EQ.10) GO TO 2989
      IF(NYEA.EQ.15) GO TO 2989
      GO TO 710
2989 MKN=0
710 DO 720 I=1,3
      DO 720 J=1,5
      SM1(NYEA,I,J)=SMCON1(I,J)/HK(I,J)
720 TM1(NYEA,I,J)=SM1(NYEA,I,J)+TM1(NYEA,I,J)
      DO 900 J=1,5
      SM1(NYEA,2,J)=(SM1(NYEA,2,J)*HK1(2)+SM1(NYEA,3,J)*HK1(3))/
      A(HK1(2)+HK1(3))
      TM1(NYEA,2,J)=SM1(NYEA,2,J)+TM2(NYEA,J)
900 TM2(NYEA,J)=TM1(NYEA,2,J)
      IF(NYEA.EQ.(NYEAR+1)) GO TO 727
      GO TO 7281
727 IF(KSSF.EQ.2) GO TO 728
      GO TO 1235
728 DO 729 N=2,NYEAR+1
      DO 729 I=1,2
      DO 729 J=1,5
729 SM1(N,I,J)=TM1(N,I,J)/KCOV
      DO 752 I=1,2
      IF(I.EQ.2) GO TO 5
      WRITE(6,1092)
1092 FORMAT('1',1X,26('* '), 'RURAL CONDITION INDICES',26('* '),/////,
      A20X,92('-'),/,53X,'OTHER',12X,'MINOR',12X,'MAJOR',12X,'MINOR',/,
      B20X,'YEAR',9X,'INTERSTATE',8X,'PRIN ART',10X,'ARTERIAL',8X,
      C'COLLECTOR',8X,'COLLECTOR',/,20X,92('-'),/)
      GO TO 9091
5 WRITE(6,1079)
1079 FORMAT('1',1X,24('* '), 'TOTAL URBAN CONDITION INDICES',24('* '),
      A/////,20X,92('-'),/,52X,'OTH FWY',11X,'OTHER',12X,'MINOR',/,
      B20X,'YEAR',9X,'INTERSTATE',9X,'& EXPWY',9X,'PRIN ART',8X,
      C'ARTERIAL',9X,'COLLECTOR',/,20X,92('-'),/)
9091 DO 721 NY=1,NYEAR
      NOY=1974+NY+1
      N=NY+1
      WRITE(6,1007) NOY,SM1(N,I,1),SM1(N,I,2),SM1(N,I,3),SM1(N,I,4),SM1
      1(N,I,5)
1007 FORMAT(20X,14,5(12X,F5.2),/)
721 CONTINUE
      WRITE(6,1080)
1080 FORMAT(20X,92('-'))
752 CONTINUE
      GO TO 508
C
C **** OPTIONAL OUTPUT STATEMENTS
C
      DO 6250 I=1,3
      GO TO(6251,6252,6253) I
6251 WRITE(6,6280)
6280 FORMAT('1',1X,16('* '), 'PERCENT OF RURAL PAVEMENTS WITH PSR BELOW
      AMINIMUM TOLERABLE LEVELS',16('* '),/////,20X,92('-'),/,53X,
      B'OTHER',12X,'MINOR',12X,'MAJOR',12X,'MINOR',/,20X,'YEAR',9X,
      C'INTERSTATE',8X,'PRIN ART',10X,'ARTERIAL',8X,'COLLECTOR',
      D8X,'COLLECTOR',/,20X,92('-'),/)
      GO TO 6255
6252 WRITE(6,6281)
6281 FORMAT('1',1X,16('* '), 'PERCENT OF URBAN PAVEMENTS WITH PSR BELOW
      AMINIMUM TOLERABLE LEVELS',16('* '),/////,20X,92('-'),/,52X,
      B'OTH FWY',11X,'OTHER',12X,'MINOR',/,20X,'YEAR',9X,'INTERSTATE',
      C9X,'& EXPWY',9X,'PRIN ART',8X,'ARTERIAL',9X,'COLLECTOR',/,
      D20X,92('-'),/)
      GO TO 6255
6253 WRITE(6,6282)
6282 FORMAT('1',1X,15('* '), 'PERCENT OF SMALL URBAN PAVEMENTS WITH PSR
      ABELOW MINIMUM TOLERABLE LEVELS',15('* '),/////,20X,92('-'),
      B/,52X,'OTH FWY',11X,'OTHER',12X,'MINOR',/,20X,'YEAR',9X,
      C'INTERSTATE',9X,'& EXPWY',9X,'PRIN ART',8X,'ARTERIAL',9X,

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D'COLLECTOR',/,20X,92(' - '),/)	HPM 1881
6255 DO 6260 N=1,NYEAR	HPM 1882
DO 6260 K=1,5	HPM 1883
6260 RPAD(N,I,K)=RPAD(N,I,K)/KCOV*100.	HPM 1884
DO 6261 NY=1,NYEAR	HPM 1885
NOY=1975+NY	HPM 1886
WRITE(6,6262) NOY,(RPAD(NY,I,J),J=1,5)	HPM 1887
6262 FORMAT(20X,I4,5(12X,F5.2),/)	HPM 1888
6261 CONTINUE	HPM 1889
WRITE(6,6270)	HPM 1890
6270 FORMAT(20X,92(' - '))	HPM 1891
6250 CONTINUE	HPM 1892
508 WRITE(6,507)	HPM 1893
507 FORMAT('1',1X,26('* '), 'SUMMARY OF DISBURSEMENTS',1X,26('* '),////	HPM 1894
A/,19X,92(' - '),/,37X,'ADMIN,MAIN',16X,'LOCAL',14X,'NON-LOCAL',11X,	HPM 1895
B'PRICE',/,19X,'YEAR',15X,'& OTHER',14X,'CAPITAL OUTLAYS',5X,	HPM 1896
C'CAPITAL OUTLAYS',7X,'DEFLATOR',/,19X,92(' - '),/)	HPM 1897
AKER=1.	HPM 1898
DO 16 I=1,NYEAR	HPM 1899
AKER=AKER*(1.+WSIN(I)/100.)	HPM 1900
NOY=1975+I	HPM 1901
NZ1=IFIX(FUND(I))	HPM 1902
NZ2=IFIX(TFUND1(I))	HPM 1903
NZ3=IFIX(ADMIN(I))	HPM 1904
WRITE(6,15) NOY,NZ1,NZ2,NZ3,AKER	HPM 1905
15 FORMAT(19X,I4,16X,I6,18X,I6,15X,I6,14X,F4.2,/)	HPM 1906
16 CONTINUE	HPM 1907
WRITE(6,17)	HPM 1908
17 FORMAT(19X,92(' - '))	HPM 1909
1235 RETURN	HPM 1910
END	HPM 1911

APPENDIX B

Sample HIPERFORM Output

(Scenario T-4)

***** INDIANA POPULATION ESTIMATES *****

YEAR	FEMALE	MALE	TOTAL
1976	2721213	2583408	5304622
1977	2724349	2585777	5310128
1978	2734861	2595147	5330011
1979	2753609	2612330	5365943
1980	2776940	2633871	5410811
1981	2794016	2650734	5444751
1982	2811092	2667597	5478691
1983	2828163	2684460	5512631
1984	2845244	2701323	5546571
1985	2862323	2718189	5580512
1986	2880076	2736110	5616187
1987	2897829	2754031	5651862
1988	2915582	2771952	5687537
1989	2933335	2789873	5723212
1990	2951091	2807798	5758889

***** U.S. AUTO EFFICIENCY PROJECTIONS *****

YEAR	NEW CAR SALES 1/	TOTAL NUMBER OF AUTOS 1/	FLEET MPG	PERSONS PER AUTO
1976	10100	98504	13.71	2.18
1977	11199	101289	14.08	2.14
1978	11300	103118	14.62	2.12
1979	10899	105360	15.23	2.09
1980	11399	108351	15.92	2.05
1981	11100	111043	16.70	2.02
1982	11000	113036	17.60	2.00
1983	11500	115311	18.61	1.98
1984	12000	118152	19.73	1.95
1985	12300	120979	20.92	1.92
1986	12300	123550	22.07	1.90
1987	12399	125942	23.06	1.88
1988	12500	128279	23.90	1.87
1989	12500	130483	24.62	1.85
1990	12500	132340	25.21	1.84

1/ IN THOUSANDS

***** UMT PROJECTIONS *****

YEAR	AUTO UMT 1/	COMBINATION UMT 1/	TOTAL UMT 1/	FLEET MPG
1976	29373	2126	38473	12.15
1977	30180	2168	39555	12.42
1978	31050	2275	40781	12.77
1979	31851	2319	41861	13.18
1980	32280	2434	42553	13.58
1981	33012	2503	43578	14.05
1982	33806	2513	44623	14.59
1983	34527	2642	45597	15.14
1984	35229	2752	46733	15.72
1985	35940	2821	47740	16.34
1986	36650	2877	48736	16.92
1987	37346	2932	49717	17.42
1988	38012	2996	50669	17.85
1989	38648	3057	51585	18.22
1990	39261	3115	52471	18.53

1/ IN MILLIONS OF VEHICLE MILES TRAVELED

***** REGISTRATION PROJECTIONS *****

YEAR	TRUCKS			TOTAL REGISTRATIONS	PERSONS PER VEHICLE
	AUTO REGISTRATIONS	SINGLE UNIT REGISTRATIONS	COMBINATION REGISTRATIONS		
1976	2652311	719704	39958	3426833	1.55
1977	2713495	739988	41074	3509769	1.51
1978	2759177	756208	42126	3573046	1.49
1979	2803721	772253	43146	3634859	1.48
1980	2847795	788320	44475	3696578	1.46
1981	2882846	802013	45683	3746735	1.45
1982	2915602	815181	46704	3793873	1.44
1983	2946675	827938	48232	3839464	1.44
1984	2976460	840540	49781	3883525	1.43
1985	3005231	852508	51161	3926235	1.42
1986	3034119	865412	52572	3953189	1.41
1987	3062337	877826	54010	4011427	1.41
1988	3089993	890184	55562	4053157	1.40
1989	3117173	902504	57157	4094414	1.40
1990	3143945	914807	58779	4135271	1.39

***** FUEL CONSUMPTION AND TON-MILE ESTIMATES *****

YEAR	RETAIL GAS PRICE	MOTOR FUEL CONSUMPTION 1/	INTERCITY TON-MILES 2/
1976	.61	3165000	19270
1977	.64	3183000	19651
1978	.65	3193000	20621
1979	.68	3177000	21022
1980	.78	3133000	22061
1991	.83	3101000	22686
1982	.88	3057000	22777
1983	.92	3019000	23946
1984	.98	2972000	24949
1985	1.04	2321000	25567
1986	1.10	2879000	26074
1987	1.17	2853000	26581
1988	1.24	2838000	27153
1989	1.32	2831000	27710
1990	1.40	2831000	23234

1/ IN THOUSANDS OF GALLONS

2/ IN MILLIONS

***** REVENUE PROJECTIONS 1/ *****

YEAR	REGISTRATION REVENUES	FUEL TAX REVENUES	OTHER REVENUES	TOTAL REVENUES
1976	75447	245448	266821	587716
1977	77401	246768	269551	593720
1978	79024	247388	271437	597849
1979	80558	245914	271537	598009
1980	82253	401810	400271	884334
1981	83701	420413	416970	921084
1982	85018	438906	433218	957142
1983	86530	456433	448834	991797
1984	88027	479892	469291	1037210
1985	89438	503260	489409	1082107
1986	90852	527274	510433	1128559
1987	92276	554908	534232	1181416
1988	93740	586766	561519	1242025
1989	95220	622194	591741	1309155
1990	96705	660149	623913	1380767

1/ IN THOUSANDS OF DOLLARS

***** 1980 URBAN SUMMARY IN PERCENTS*****

	INTERSTATE MILES	TRAVEL	OTH FWY & EXPY MILES	TRAVEL	OTHER PRIN ART MILES	TRAVEL	MINOR ARTERIAL MILES	TRAVEL	COLLECTOR MILES	TRAVEL
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PAVEMENT TYPE:

HIGH	100	100	100	100	100	100	100	100	87	94
INTERM	0	0	0	0	0	0	0	0	13	6
LOW	0	0	0	0	0	0	0	0	0	0

PAVEMENT CONDITION: 1/

POOR	0	0	0	0	6	5	0	0	13	13
FAIR	10	12	10	36	34	34	52	51	46	43
GOOD	90	88	90	58	60	60	46	48	40	43

VOL/CAP RATIOS: 2/

< .31	7	3	29	16	13	7	4	2	24	16
.31 - .90	61	51	67	78	28	21	41	31	69	75
> .90	32	45	5	6	58	71	54	67	6	8

LANE WIDTH (FT):

< 10	0	0	0	0	9	6	4	4	27	25
10 - 11	0	0	5	4	24	27	56	55	49	45
> 11	100	100	95	96	67	67	39	40	24	25

5 YEAR AVERAGE

ANNUAL CAPITAL

OUTLAYS:

(IN THOUSANDS) 3/

\$ 46399	\$ 18044	\$ 30933	\$ 14177	\$ 7732
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1/ POOR - PSR < 2.0 (< 2.5 PRINCIPAL ARTERIAL): FAIR - PSR 2.0 TO 3.4: GOOD - PSR > 3.4.

2/ TRAVEL IS FOR PEAK HOUR. ONE DIRECTION ONLY.

3/ EXCLUDING STRUCTURE COSTS

***** 1980 SMALL URBAN SUMMARY IN PERCENTS*****

	INTERSTATE MILES	OTH FWY & EXPY MILES	OTHER PRIN ART MILES	MINOR ARTERIAL MILES	COLLECTOR MILES
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PAVEMENT TYPE:

HIGH	100	100	100	100	58	81
INTERM	0	0	0	0	28	17
LOW	0	0	0	0	4	1

PAVEMENT CONDITION: 1/

POOR	0	2	8	13	13	13
FAIR	0	13	42	48	46	45
GOOD	100	84	49	39	40	41

VDL/CAP RATIOS: 2/

< .31	0	42	10	23	52	50
.31 - .90	70	53	62	56	42	42
> .90	30	5	27	20	5	7

LANE WIDTH (FT):

< 10	0	0	11	14	25	30
10 - 11	0	0	15	33	38	36
> 11	100	100	73	52	36	34

5 YEAR AVERAGE

ANNUAL CAPITAL

OUTLAYS:

(IN THOUSANDS) 3/

\$ 1288	\$ 2577	\$ 7732	\$ 5155	\$ 5155
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1/ POOR - PSR < 2.0 (< 2.5 PRINCIPAL ARTERIAL): FAIR - PSR 2.0 TO 3.4: GOOD - PSR > 3.4.

2/ TRAVEL IS FOR PEAK HOUR. ONE DIRECTION ONLY.

3/ EXCLUDING STRUCTURE COSTS

***** 1985 RURAL SUMMARY IN PERCENTS*****

INTERSTATE TRAVEL MILES OTHER PRIN ART TRAVEL MILES MINOR ARTERIAL TRAVEL MILES MAJOR COLLECTOR TRAVEL MILES MINOR COLLECTOR TRAVEL MILES

PAVEMENT TYPE:

HIGH	100	100	100	100	100	37	60	6	14
INTERM	0	0	0	0	0	47	33	41	45
LOW	0	0	0	0	0	16	6	53	39

PAVEMENT CONDITION: 1/

POOR	4	2	3	4	2	25	24	30	31
FAIR	9	8	16	21	18	51	40	46	46
GOOD	87	89	80	74	80	24	36	23	23

VDL/CAP RATIOS: 2/

< .31	12	7	28	17	12	38	30	33	29
.31 - .80	66	67	63	66	66	57	55	65	66
> .80	22	25	8	17	21	5	14	1	4

LANE WIDTH (FT):

< 10	0	0	0	0	0	37	30	48	43
10 - 11	0	0	2	17	12	58	62	49	43
> 11	100	100	98	82	87	5	7	3	3

5 YEAR AVERAGE

ANNUAL CAPITAL

OUTLAYS:

(IN THOUSANDS) 3/

\$ 37266	\$ 44253	\$ 76862	\$ 27949	\$ 27949
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1/ POOR - PSR < 2.0 (< 2.5 PRINCIPAL ARTERIAL); FAIR - PSR 2.0 TO 3.4: GOOD - PSR > 3.4.

2/ TRAVEL IS FOR PEAK HOUR. ONE DIRECTION ONLY.

3/ EXCLUDING STRUCTURE COSTS

***** 1985 URBAN SUMMARY IN PERCENTS*****

	INTERSTATE MILES	OTH FWY & EXPY TRAVEL MILES	OTHER PRIN ART TRAVEL MILES	MINOR ARTERIAL TRAVEL MILES	COLLECTOR TRAVEL MILES
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PAVEMENT TYPE:

HIGH	100	100	100	100	87	94
INTERM	0	0	0	0	13	6
LOW	0	0	0	0	0	0

PAVEMENT CONDITION: 1/

POOR	0	0	9	6	12	12
FAIR	3	12	37	72	59	56
GOOD	97	88	54	22	29	32

VOL/CAP RATIOS: 2/

< .31	0	10	9	1	7	5
.31 - .90	66	71	31	39	76	73
> .90	34	19	59	59	16	21

LANE WIDTH (FT):

< 10	0	0	9	3	26	24
10 - 11	0	5	21	54	47	47
> 11	100	95	70	42	26	29

5 YEAR AVERAGE
ANNUAL CAPITAL
OUTLAYS:

(IN THOUSANDS) 3/	\$ 83849	\$ 32608	\$ 55899	\$ 25620	\$ 13974
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1/ POOR - PSR < 2.0 (< 2.5 PRINCIPAL ARTERIAL): FAIR - PSR 2.0 TO 3.4: GOOD - PSR > 3.4.

2/ TRAVEL IS FOR PEAK HOUR. ONE DIRECTION ONLY.

3/ EXCLUDING STRUCTURE COSTS

***** 1985 SMALL URBAN SUMMARY IN PERCENTS*****

	INTERSTATE MILES	OTH FWY & EXPY MILES	OTHER PRIN ART MILES	MINOR ARTERIAL MILES	COLLECTOR MILES
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PAVEMENT TYPE:

HIGH	100	100	100	100	72	84
INTERM	0	0	0	0	24	15
LOW	0	0	0	0	3	1

PAVEMENT CONDITION: 1/

POOR	0	0	12	13	10	10
FAIR	0	26	33	52	40	41
GOOD	100	73	55	34	50	47

VDL/CAP RATIOS: 2/

< .31	0	11	5	15	28	26
.31 - .90	65	84	57	58	66	67
> .90	35	5	38	26	5	7

LANE WIDTH (FT):

< 10	0	0	11	14	23	26
10 - 11	0	0	14	32	37	35
> 11	100	100	74	55	39	39

5 YEAR AVERAGE

ANNUAL CAPITAL

OUTLAYS:

(IN THOUSANDS) 3/

\$ 2328	\$ 4657	\$ 13974	\$ 9316	\$ 9315
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1/ POOR - PSR <2.0 (<2.5 PRINCIPAL ARTERIAL): FAIR - PSR 2.0 TO 3.4: GOOD - PSR >3.4.

2/ TRAVEL IS FOR PEAK HOUR. ONE DIRECTION ONLY.

3/ EXCLUDING STRUCTURE COSTS

***** 1990 RURAL SUMMARY IN PERCENTS*****

	INTERSTATE MILES	OTHER PRIN ART TRAVEL MILES	MINOR ARTERIAL TRAVEL MILES	MAJOR COLLECTOR TRAVEL MILES	MINOR COLLECTOR TRAVEL MILES
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PAVEMENT TYPE:

HIGH	100	100	100	43	65	15
INTERM	0	0	0	42	28	45
LOW	0	0	0	15	6	39

PAVEMENT CONDITION: 1/

POOR	2	1	3	32	26	35
FAIR	5	27	18	38	39	38
GOOD	92	71	78	29	35	26

UOL/CAP RATIOS: 2/

< .31	0	6	4	16	12	9
.31 - .80	73	81	69	77	71	84
> .80	25	12	25	6	17	7

LANE WIDTH (FT):

< 10	0	0	0	37	30	49
10 - 11	0	1	12	58	62	46
> 11	100	99	87	5	7	4

5 YEAR AVERAGE

ANNUAL CAPITAL

OUTLAYS:

(IN THOUSANDS) 3/

\$ 49080	\$ 58283	\$ 101229	\$ 36810	\$ 36810
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1/ POOR - PSR < 2.0 (< 2.5 PRINCIPAL ARTERIAL): FAIR - PSR 2.0 TO 3.4: GOOD - PSR > 3.4.

2/ TRAVEL IS FOR PEAK HOUR, ONE DIRECTION ONLY.

3/ EXCLUDING STRUCTURE COSTS

***** 1990 URBAN SUMMARY IN PERCENTS *****

PAVEMENT TYPE:	INTERSTATE MILES	TRAVEL	OTH FWY & EXPY MILES	TRAVEL	OTHER PRIN ART MILES	TRAVEL	MINOR ARTERIAL MILES	TRAVEL	COLLECTOR MILES	TRAVEL
HIGH	100	100	100	100	100	100	100	100	89	95
INTERM	0	0	0	0	0	0	0	0	10	4
LOW	0	0	0	0	0	0	0	0	0	0

PAVEMENT CONDITION: 1/

POOR	0	0	0	0	11	9	10	8	20	15
FAIR	1	1	12	6	41	37	80	80	45	47
GOOD	98	99	88	94	47	53	10	12	34	37

VOL/CAP RATIOS: 2/

< .31	0	0	0	0	2	1	0	0	3	2
.31 - .90	60	44	81	73	34	24	35	25	77	72
> .90	40	56	19	26	63	74	64	74	19	25

LANE WIDTH (FT):

< 10	0	0	0	0	9	6	3	3	25	23
10 - 11	0	0	2	2	18	20	52	49	47	47
> 11	100	100	97	98	72	74	44	47	27	29

5 YEAR AVERAGE

ANNUAL CAPITAL

OUTLAYS:

(IN THOUSANDS) 3/

\$110431	\$ 42945	\$ 73621	\$ 33742	\$ 18405
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1/ POOR - PSR < 2.0 (< 2.5 PRINCIPAL ARTERIAL); FAIR - PSR 2.0 TO 3.4: GOOD - PSR > 3.4.

2/ TRAVEL IS FOR PEAK HOUR, ONE DIRECTION ONLY.

3/ EXCLUDING STRUCTURE COSTS

***** 1990 SMALL URBAN SUMMARY IN PERCENTS*****

INTERSTATE TRAVEL MILES OTH FWY & EXPY TRAVEL MILES OTHER PRIN ART TRAVEL MILES MINOR ARTERIAL TRAVEL MILES COLLECTOR TRAVEL MILES

PAVEMENT TYPE:

HIGH	100	100	100	100	100	100	100	75	86
INTERM	0	0	0	0	0	0	0	21	12
LOW	0	0	0	0	0	0	0	2	0

PAVEMENT CONDITION:1/

POOR	0	0	11	5	18	14	15	11	12
FAIR	0	0	10	10	37	39	54	38	39
GOOD	100	100	78	84	44	46	31	51	49

UOL/CAP RATIOS:2/

< .31	0	0	5	3	1	1	5	9	10
.31 - .90	50	55	84	90	56	50	63	81	78
> .90	50	45	11	7	42	49	31	9	12

LANE WIDTH (FT):

< 10	0	0	0	0	11	10	13	21	24
10 - 11	0	0	0	0	14	13	32	34	32
> 11	100	100	100	100	74	77	55	44	44

5 YEAR AVERAGE

ANNUAL CAPITAL

OUTLAYS:

(IN THOUSANDS) 3/

\$ 3057	\$ 6134	\$ 18405	\$ 12270	\$ 12270
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1/ POOR - PSR <2.0 (<2.5 PRINCIPAL ARTERIAL): FAIR - PSR 2.0 TO 3.4: GOOD - PSR>3.4.

2/ TRAVEL IS FOR PEAK HOUR, ONE DIRECTION ONLY.

3/ EXCLUDING STRUCTURE COSTS

***** RURAL CONDITION INDICES*****

YEAR	INTERSTATE	OTHER PRIN ART	MINOR ARTERIAL	MAJOR COLLECTOR	MINOR COLLECTOR
1976	80.38	80.53	75.24	56.13	54.41
1977	80.44	81.18	75.53	56.28	53.49
1978	80.24	81.60	75.56	55.19	52.81
1979	79.69	81.57	74.99	57.90	51.18
1980	80.19	82.18	75.83	56.91	50.35
1981	80.40	82.79	76.07	56.99	49.56
1982	79.98	82.98	76.41	55.48	49.03
1983	79.40	82.69	76.12	55.33	48.13
1984	79.05	82.96	76.09	55.10	47.86
1985	78.36	82.80	75.45	54.24	47.62
1986	78.29	82.75	75.09	54.80	46.57
1987	78.15	82.03	74.72	53.63	46.06
1988	77.66	81.64	74.15	52.79	45.82
1989	76.94	81.83	74.64	51.98	45.46
1990	76.95	82.12	74.38	51.39	44.78

***** TOTAL URBAN CONDITION INDICES*****

YEAR	INTERSTATE	OTH HWY & EXPRV	OTHER PRIN ART	MINOR ARTERIAL	COLLECTOR
1976	70.08	81.25	55.32	58.83	63.04
1977	70.16	80.02	54.96	57.78	62.41
1978	69.65	79.21	54.28	57.15	62.07
1979	69.69	78.61	54.30	56.53	61.74
1980	69.53	78.23	54.31	55.82	60.90
1981	69.74	78.32	54.33	55.43	60.42
1982	69.20	77.53	54.25	54.63	59.66
1983	69.19	76.16	53.92	53.77	58.97
1984	68.95	75.89	53.47	53.62	58.97
1985	68.52	76.13	53.00	52.66	58.74
1986	68.31	75.20	52.53	51.70	59.03
1987	67.94	74.36	52.25	51.26	58.39
1988	67.44	74.28	51.94	50.53	58.73
1989	66.78	73.51	51.54	49.79	57.74
1990	66.97	73.51	51.47	49.67	56.52

***** SUMMARY OF DISBURSEMENTS *****

YEAR	ADMIN, MAIN & OTHER	LOCAL CAPITAL OUTLAYS	NON-LOCAL CAPITAL OUTLAYS	PRICE DEFLATOR
1976	246785	115638	234780	1.07
1977	251413	117230	238014	1.15
1978	256252	106751	216738	1.23
1979	261057	110232	223804	1.33
1980	266082	204022	414228	1.43
1981	271737	214284	435062	1.55
1982	276900	224479	455762	1.67
1983	281884	234271	475641	1.79
1984	286746	247652	502810	1.91
1985	291406	260931	529769	2.04
1986	295996	274745	557817	2.16
1987	300584	290674	590157	2.30
1988	305168	309162	627694	2.44
1989	309821	329779	669553	2.59
1990	314546	351852	714367	2.75