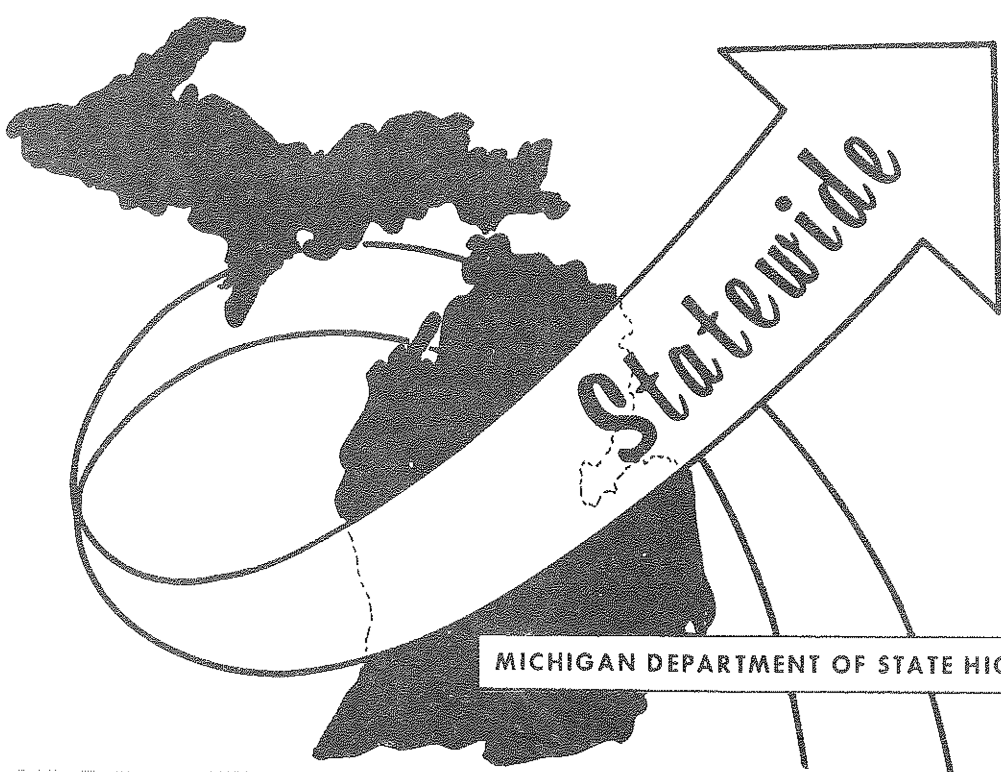
# Statewide Transportation Analysis & Research

A STATEWIDE TRANSPORTATION
MODELING SYSTEM EFFECTIVELY
MEETS THE TRANSPORTATION
CHALLENGE OF THE 70'S




MICHIGAN DEPARTMENT OF STATE HIGHWAYS AND TRANSPORTATION

# A STATEWIDE TRANSPORTATION MODELING SYSTEM EFFECTIVELY MEETS THE TRANSPORTATION CHALLENGE OF THE 70'S

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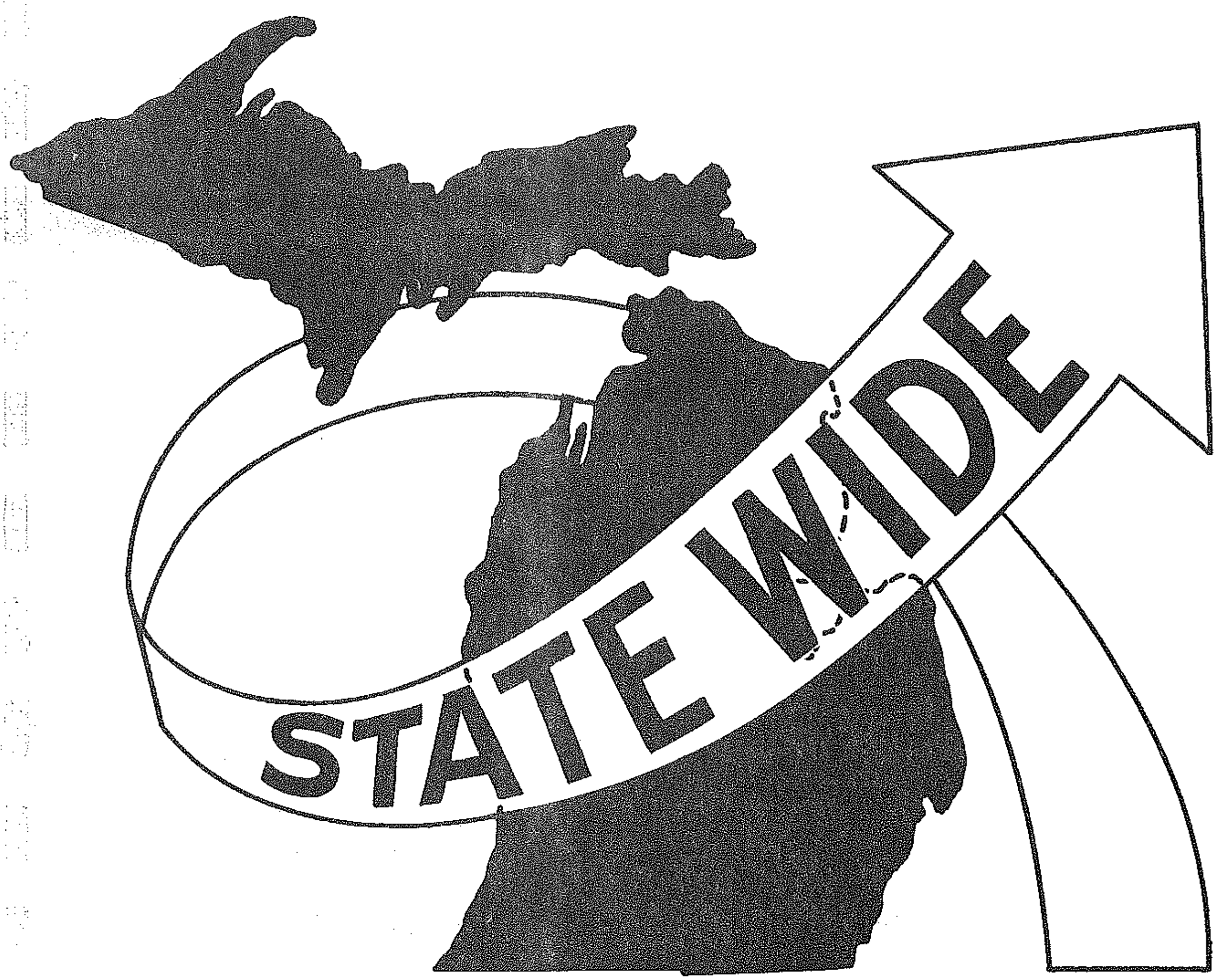
# INTRODUCTION

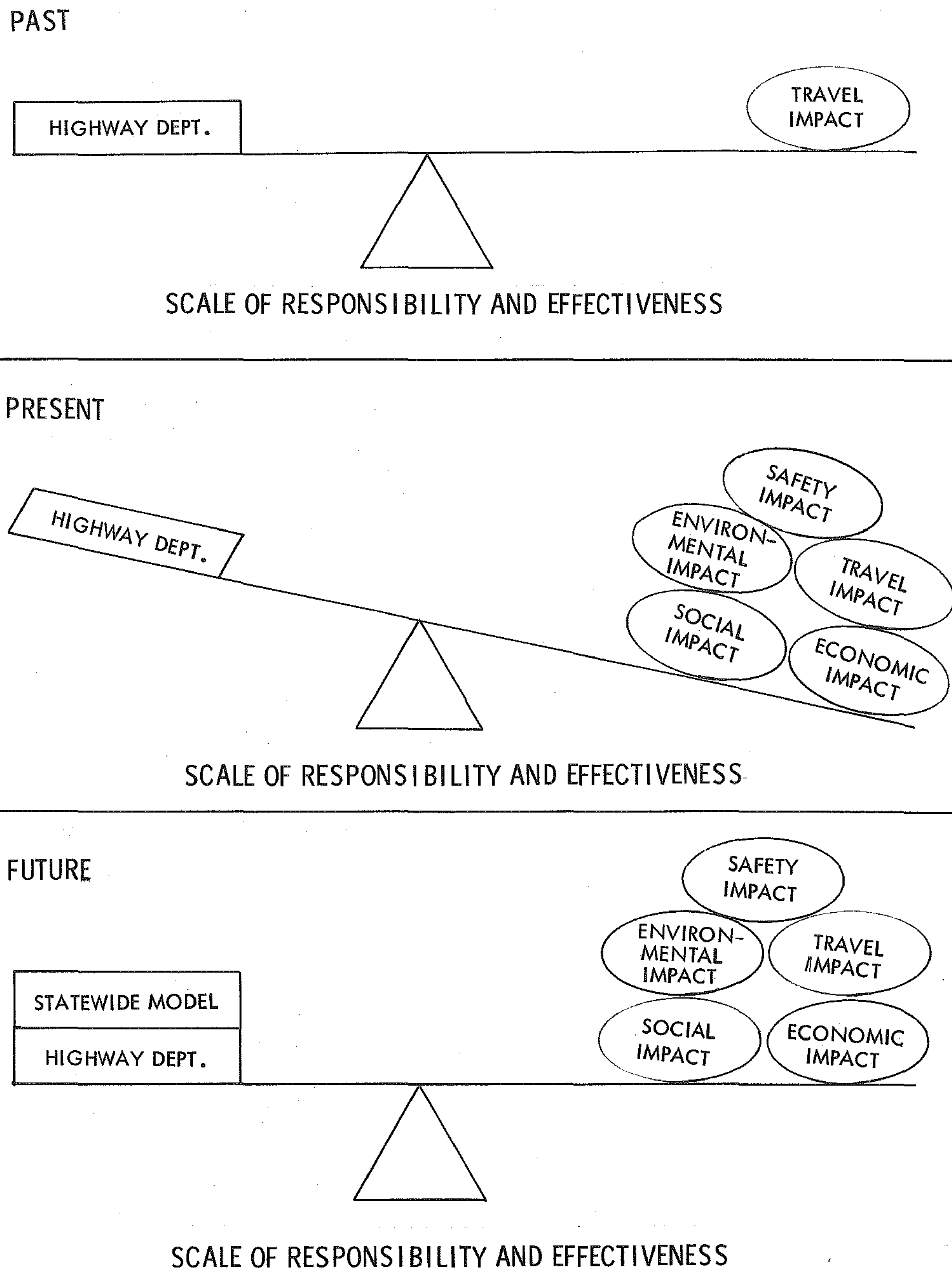


# INTRODUCTION

The responsibilities of the modern highway department are increasing dramatically as the result of recent Federal legislation. Additionally, most highway departments have become increasingly aware of the extremely sensitive and complicated nature of transportation. It is influenced by, and interrelated with, a great many human, monetary, and natural factors. A change in the nature of transportation services has far-reaching effects on the economy of regions, the social, psychological, and political characteristics of individuals, and the quality of the environment. The changing nature of the transportation planning process has increased the tasks confronting each highway agency as identified in Figure 1. Research and analysis efforts completed within the Statewide Studies Unit of the Transportation Planning Division indicate that the development of a statewide transportation modeling system may be the most effective means of efficiently fulfilling these additional responsibilities.

In order to more efficiently allocate the public resources available, some highway agencies have turned to analysis of transportation at the (statewide) system level. States which have developed a statewide traffic forecasting model have recognized that effective planning must take into account the comprehensive review of many interrelated factors. To this end, selected highway planning agencies have modeled the entire transportation system, complete with social, economic and environmental aspects of travel:

FIGURE 1 CHANGING RESPONSIBILITIES



"Using a model, an analyst is much more apt to be able to perceive where inefficiencies occur, . . . where links are weak, and where reorganization or elimination or organizational elements can occur. Study of the system model can be a most fruitful source of alternative solutions to problems". (NCHRP Report 96, p. 13.)

Section 109(h) of Title 23, United States Code, defines system planning as "regional analysis of transportation needs and the identification of transportation corridors." Regional analysis may be sufficient if the study region is identified such that no major Interstate or U.S. route passes through the region. On the other hand, if a principal route does pass through the regional study area, major changes in that route within the region could have significant impact on statewide travel patterns. Problems of this nature will be reduced if each state has the opportunity to employ a statewide transportation modeling system evaluation model in the planning process.

The technique of selecting the best of a set of alternative transportation plans most often consists of four major elements. This technique defined in Figure 2 would continue until significant "trade-offs" are identified and an optimal alternative is evident, with information about the assets of one plan influencing the design of the next. Therefore, each transportation agency should be able to identify and evaluate the consequences of each plan quickly and systematically in order for the process to arrive at an optimal plan within a reasonable time frame.

"A great deal of work needs to be done to bring statewide transportation planning to the level where it can in fact provide the kinds of output that are desired, and to do so with the speed that officials and public demand." (HRB Report 401, p. 25.)

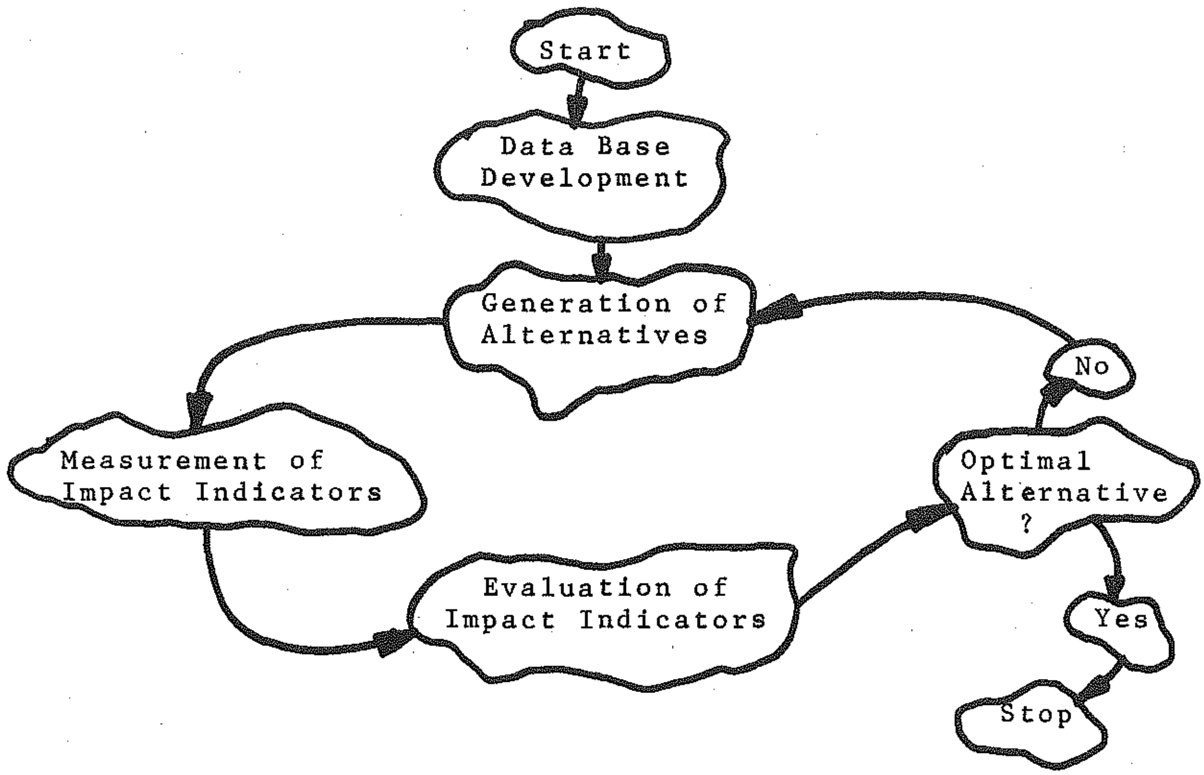



FIGURE 2 - ALTERNATE SELECTION PROCESS

Many transportation planning agencies can forecast isolated impact of a plan, but few offer a system level evaluation of consequences; many can identify the effects of a new freeway on the region in which it lies, but few are able to evaluate these effects on the entire transportation system or on other state agencies. Still fewer have formulated a systematic method for this evaluation process.

Those states which presently have the potential to offer a fully automated means of carrying out this system-level evaluation number no more than five. (HRB Report 401, pp. 39-40.) More efficient means of meeting additional transportation department responsibility must be found if transportation planning is to realize its full potential.

However, agencies assigned the responsibility for highway planning must also be aware of the fact that modeling applications, although exceptionally useful, are limited by various computer system capabilities. A report entitled "The GCARS System: A Computer Assigned Method of Regional Route Location", in Highway Research Record 348 states that:

> "The capabilities of currently available computers and our knowledge of the highway planning functions make automated planning systems in which the computer does all of the work impractical. In contrast, computer-aided planning systems are feasible." (HRB Report #348, pp. 1-15)

As technology does improve and the knowledge of the highway planning function increases, additional computer applications will almost certainly be developed. The development and efficient use of these new tools may well be the major challenge facing many highway planning agencies in the present decade.

Finally the added responsibilities in transportation planning efforts have been defined. The tools to be used in the process have not. The purpose of this presentation is to suggest an effective system of techniques which we feel may open new avenues of analysis to the states currently facing these responsibilities.

# THE CHALLENGE

STATE WIDE

# THE CHALLENGE

In compliance with Section 109(h) of Title 23, United States Code, each state is required to formulate an Action Plan detailing how the social, economic, and environmental impacts of any alternative transportation plan will be identified, measured and evaluated. Much of the literature dealing with the action plan and its implementation poses the challenge facing highway departments today. The following three excerpts may serve to illustrate this point.

The part of Section 109(h) of Title 23 which deals with the interrelation of systems and project decisions states that:

> "Many significant economic, social, and environmental effects of a proposed project are difficult to anticipate at the systems planning stage and become clear only during location and design studies. Conversely, many significant environmental effects of a proposed project are set at the systems planning stage. Decisions at the system and project stages shall be made with consideration of their social, economic, environmental, and transportation effects to the extent possible at each stage."

Section 4, the implementation document for Section 109(h) of PPM 90-4, Paragraph B, states that:

> The process by which decisions are reached should be such as to merit public confidence in the highway agency. To achieve this objective, it is the FHWA's policy that:
>
> (1) Economic, social, and environmental effects be identified and studied early enough to permit analysis and consideration while alternatives are being formulated and evaluated.
>
> (2) Other agencies and the public be involved in the project development early enough to influence technical studies and final decisions.

(3) Appropriate consideration be given to reasonable alternatives, including the alternative of not building the project and alternative modes.

Additionally, section 9 challenges each highway agency to establish:

Procedures to be followed to insure that timely information on social, economic, and environmental effects:

(a) Is developed in parallel with alternatives and related engineering data, so that the development and selection of alternatives can be influenced appropriately.

(b) Indicates the manner and extent to which specific groups and interests are beneficially and/or adversely affected by alternative proposed highway improvements.

(c) Is developed sufficiently to allow for the estimation of costs, financial or otherwise, of eliminating of minimizing identified adverse effects.

From these and other examples it appears that the major elements of the challenge confronting each transportation agency in the 70's are: (See Figure 3 ).

1. Measurement of highway impacts at the system level rather than isolated project.
2. Evaluation of "no-build" along with other alternatives.
3. Consideration of Social Impacts which highway plans might have on society and the individual.
4. Consideration of the effect of highway plans upon the economics of the entire society.
5. Consideration of impacts which highway plans will have upon the environment.
6. Involvement of both public and private agencies throughout the development of the plan.

## CHALLENGE OF THE 70's

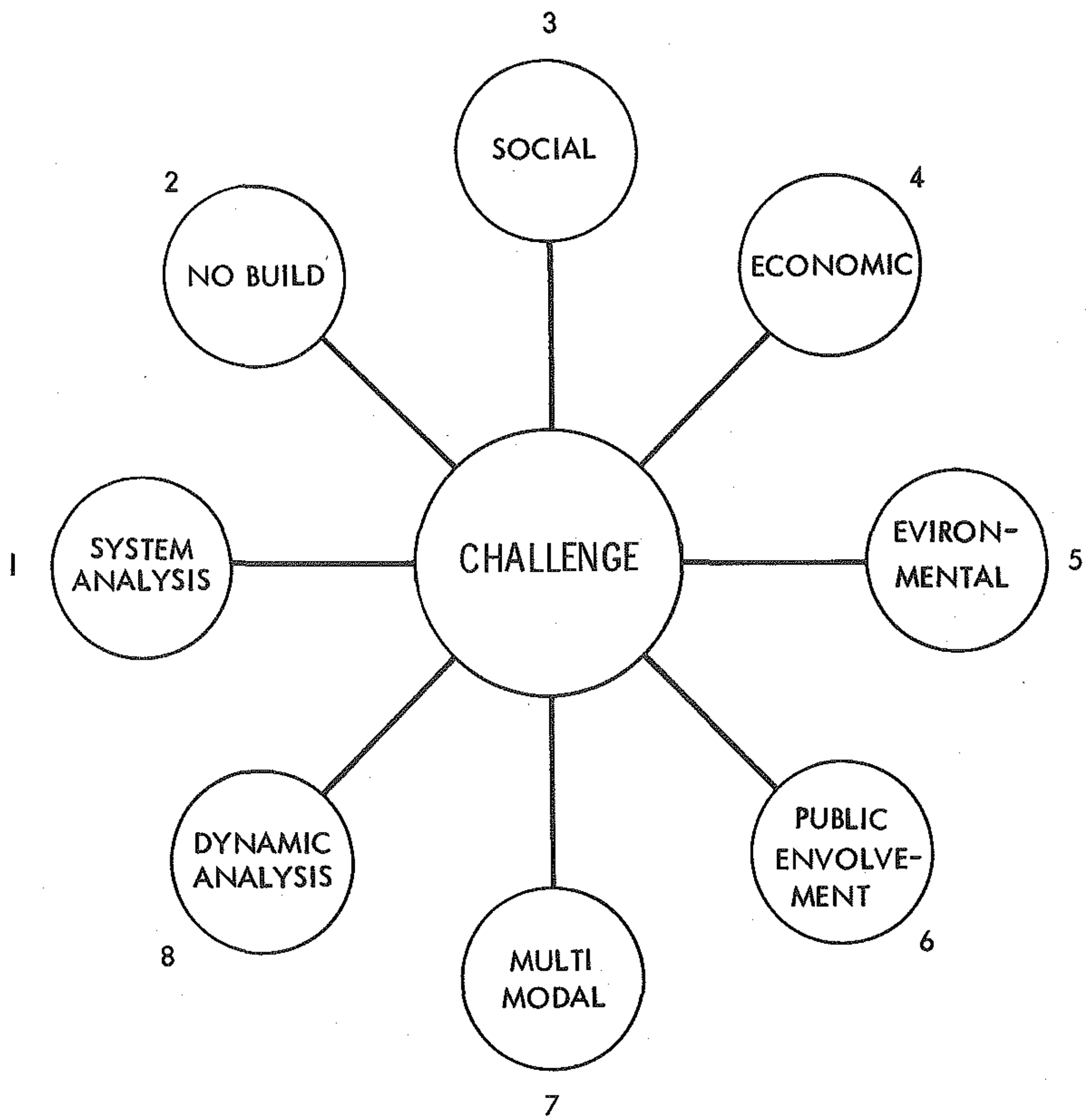


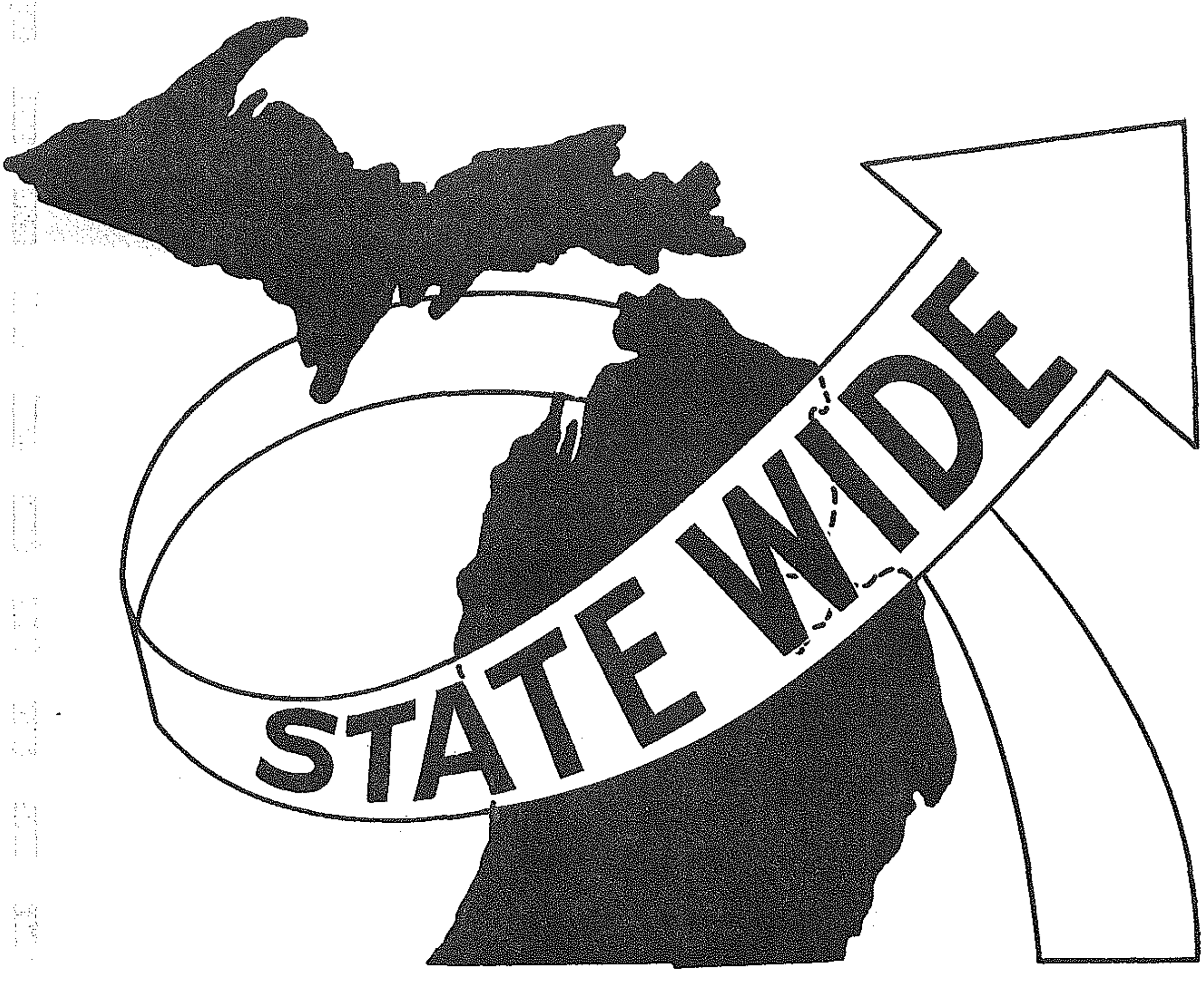

FIGURE 3

7. Consideration of other modes of transportation.

8. Dynamic Analysis - ability to rapidly reanalyze and evaluate the impacts and changes in travel patterns on the entire system due to actual or proposed changes in the transportation system.

Although there may be additional challenges that might be added to figure 3 it appears that these should be the basic consideration. It is toward answering these challenges that more comprehensive and powerful tools of analysis must be developed by today's transportation agencies.

# A STATEWIDE MODELING SYSTEM

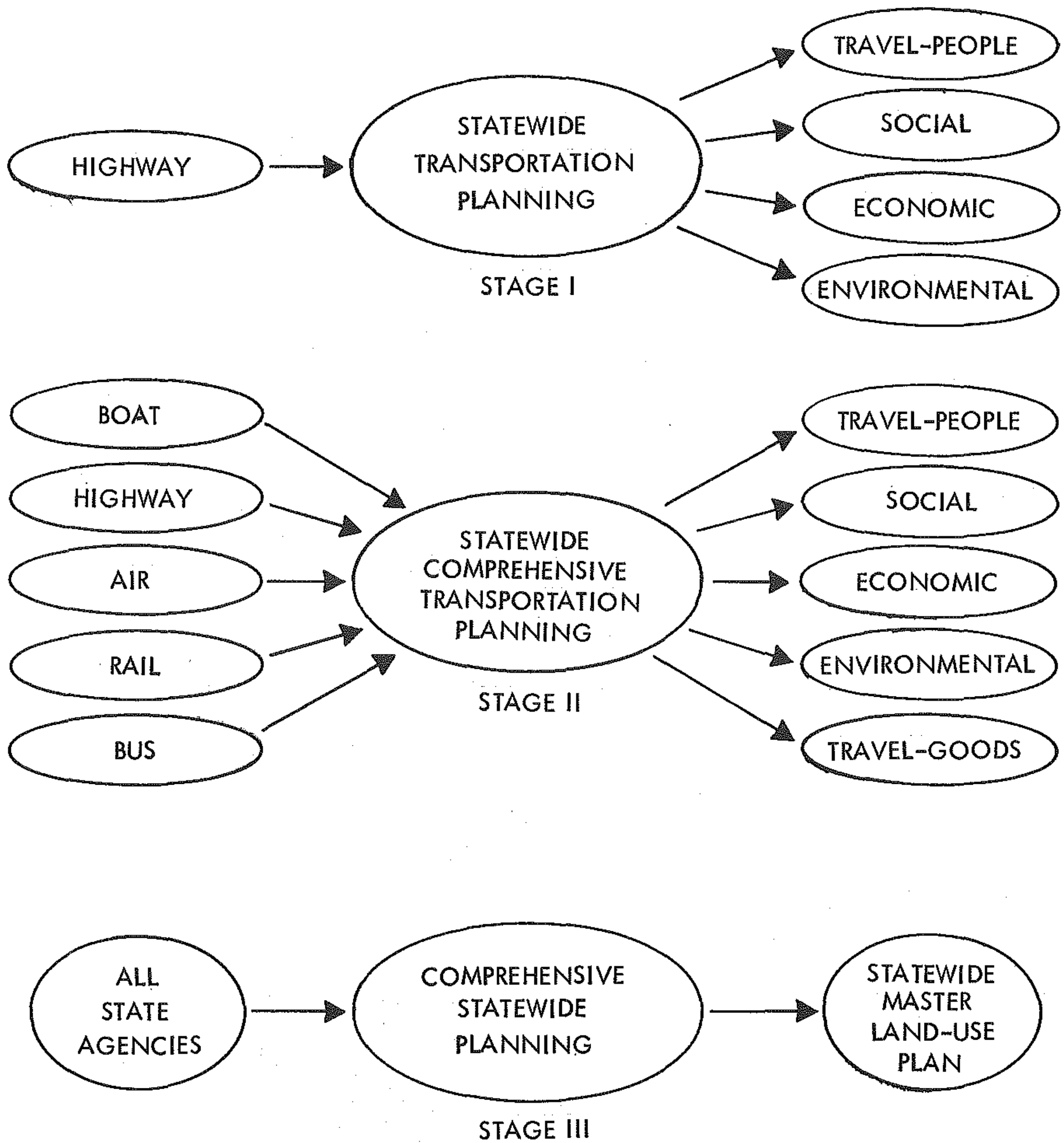


# A STATEWIDE MODELING SYSTEM

The Statewide Studies Unit of the Transportation Planning Division, Michigan Department of State Highways has approached the challenge of system-wide impact analysis through the development and application of a statewide transportation modeling system. This report deals with a modeling solution which will hopefully complement the typical transportation planning process and effectively meet the challenge of the 70's. It is, in fact, a sincere attempt to document the possible framework and system components through which any transportation agency may develop a dynamic statewide transportation planning process. The impact evaluation system discussed in the following paragraphs is a systematic approach to the analysis of travel and its effect on selected social, economic and environmental effects of alternative transportation plans. Using the statewide travel forecasting model as the nucleus special social, economic and environmental impact analysis models have been developed to complete the statewide modeling system. The entire system is responsive to proposed changes in the transportation system, thus providing an evaluation process that attempts to simulate the "real world".

Because of the complexity of the real world being simulated, the statewide modeling system presently being developed in Michigan envisions three levels or stages in the total development of its modeling system similar to those in Figure 4.

FIGURE 4
SYSTEM DEVELOPMENT PROCESS



This report deals primarily with research efforts at the development stage I; test results for both stages II and III are also included in lesser detail. If each state is to be successful in meeting the previously discussed challenges, then initially, it must develop the three basic information files described in Figure 5 before a statewide modeling system can function effectively.

These three files are defined in the modeling process to represent society. When developing each of the components in the statewide modeling system the persons involved in the system analysis phase defined these files to be:

1. The Natural Environment and information about the environment.
2. The communication system which acts as the interchange element between the physical and natural environment.
3. The Physical Environment or things that man has placed in the natural environment.

The complexity of each of these statewide files could vary as the proposed goals of the statewide modeling system in each state dictates.

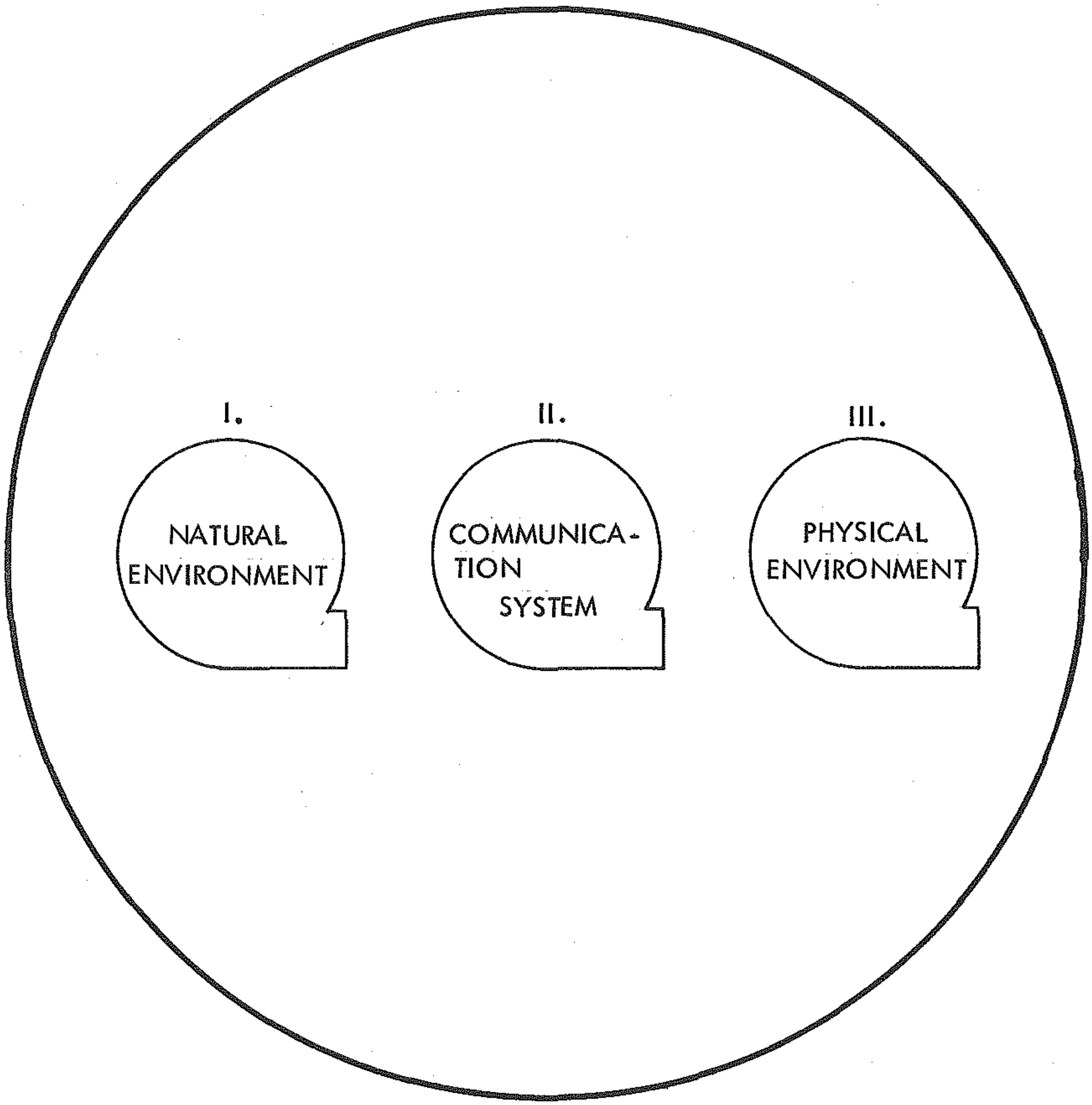
The Natural Environment file used in stage I in the Michigan process includes such things as:

1. Population data
2. Socio-economic attributes of the population (1970 Census)
3. Assessed valuation
4. Land Use data by ten classes
5. Water area information

A more detailed list of data in the first file appears in Figure 6.

FIGURE 5

SOCIETY




I. STATEWIDE SOCIO-ECONOMIC DATA FILE

II. STATEWIDE TRANSPORTATION NETWORK

III. STATEWIDE PUBLIC & PRIVATE FACILITY FILE

# STATEWIDE SOCIO-ECONOMIC DATA FILE *

## GENERAL CHARACTERISTICS OF POPULATION

SCHOOL ENROLLMENT BY TYPE OF SCHOOL
YEARS OF SCHOOL COMPLETED
CITIZENSHIP BY AGE

## INCOME CHARACTERISTICS OF POPULATION

FAMILY INCOME
INCOME BY OCCUPATION AND SEX
RATIO OF FAMILY INCOME TO POVERTY LEVEL

## LABOR FORCE CHARACTERISTICS OF POPULATION

EMPLOYMENT BY AGE
EMPLOYMENT BY OCCUPATION AND SEX
EMPLOYMENT BY INDUSTRY AND SEX

## SOCIAL CHARACTERISTICS OF POPULATION

AGE BY SEX
TYPE OF FAMILY
MARITAL STATUS

## AREA CHARACTERISTICS

LAKE FRONTAGE
ASSESSED VALUATION
WATER AREA

FIGURE 6

*THOSE ITEMS LISTED HERE ARE SAMPLES TAKEN FROM THE COMPLETE FILE WHICH CONTAINS OVER 700 ITEMS.

This initial file describes man and his natural environment, whereas the third file which is referred to as the "Statewide Public and Private Facilities File" contains data on the physical environment or the results of man's achievement. Elements of this file presently include such things as those listed in Figure 7. Selected elements in this file such as the bus, rail, truck and port facilities actually deal with the second stage (Figure 4) in the development of a statewide transportation modeling system where multi-modal considerations become necessary.

The second element which must be included as one of the three basic elements of a statewide transportation analysis model is the communication system file. This file, as previously stated deals with a specific system which connects the natural environment with the physical environment. It could be a multi-modal file and contain data on pipe lines, railroads, waterways or airways. The present communication system file in Michigan's modeling system contains data on the highway mode only as indicated in Figure 8.

This second file was created by developing a program referred to as "automated data-bank interface" which allows the travel modeling process to access and summarize information residing in any of the following department files:

A. TRUNKLINE VEHICLE-MILES MASTER FILE

B. MICHIGAN HIGHWAYS YEARLY SUFFICIENCY RATING FILE

C. ACCIDENT MASTER FILE

D. STATE TRUNKLINE CONTROL SECTION LOG RECORD FILE

E. STATE TRUNKLINE NEEDS FILE

# STATEWIDE FACILITY FILE

HISTORIC SITES
HOSPITALS
AIRPORTS
WHOLESALE TRADE CENTERS
MAJOR PARKS
NON-PUBLIC COLLEGES
PUBLIC COMMUNITY COLLEGES
CITIES OVER 30,000 POPULATION
UNEMPLOYMENT OFFICES
MENTAL HEALTH CENTERS
CERTIFIED INDUSTRIAL PARKS
MICHIGAN'S UNIVERSITIES
SKI AREAS
SNOWMOBILE TRAILS
CBD w/5,000 POPULATION
TRUCK TERMINALS
STATE POLICE POSTS
DAILY NEWSPAPERS
WEEKLY NEWSPAPERS
SEWAGE TREATMENT FACILITIES
TOURIST ATTRACTIONS
BUS TERMINALS
MANUFACTURERS
CAMPSITES

FIGURE 7

# STATEWIDE HIGHWAY NETWORK

# LINK FILE

## CONTENTS OF EACH HIGHWAY SEGMENT OR LINK

- AVERAGE SPEED
- DISTANCE
- URBAN-RURAL DESIGNATION
- TYPE OF ROUTE
- TRAFFIC VOLUME CAPACITY
- AVERAGE ANNUAL DAILY TRAFFIC VOLUME
- COMMERCIAL TRAFFIC VOLUME
- DESIGN HOUR VOLUME
- ACCIDENT FATAL RATE
- ACCIDENT INJURY RATE
- ACCIDENT RATE
- NUMBER OF LANES
- LANE WIDTH
- SURFACE CONDITION
- RIGHT OF WAY
- SIGHT RESTRICTION

FIGURE 8

This data-file interaction is absolutely necessary to permit rapid monitoring of the total system-level impacts of alternative highway plans. As an additional benefit of the development of the "interface" program, information residing in other department files may also be graphically displayed using the statewide model network plotting techniques discussed later in this document.

Creation of these three basic files now provide a solid foundation for the development of a statewide modeling system solution to the challenge of the 70's as identified in Figure 3. The Statewide Studies Unit of the Michigan Department of State Highways has developed a modeling system which will effectively allow each transportation agency to meet that challenge. The components of that system appear in Figure 9.

The major components of the statewide modeling system have been grouped into four basic elements as indicated in Figure 10. During the operation of this system the network generation program referred to as "segmental model" is an optional routine which may or may not be used depending on whether regional or statewide planning analysis is being conducted. The design hour volume (DHV) model and proposed modal split model are also optional system components depending on each project's goals and objectives.

This modeling system and the components within the system were developed specifically with the idea of symatically meeting the challenge of the 70's discussed in the previous

# STATEWIDE MODELING SYSTEM COMPONENTS

FIGURE 9

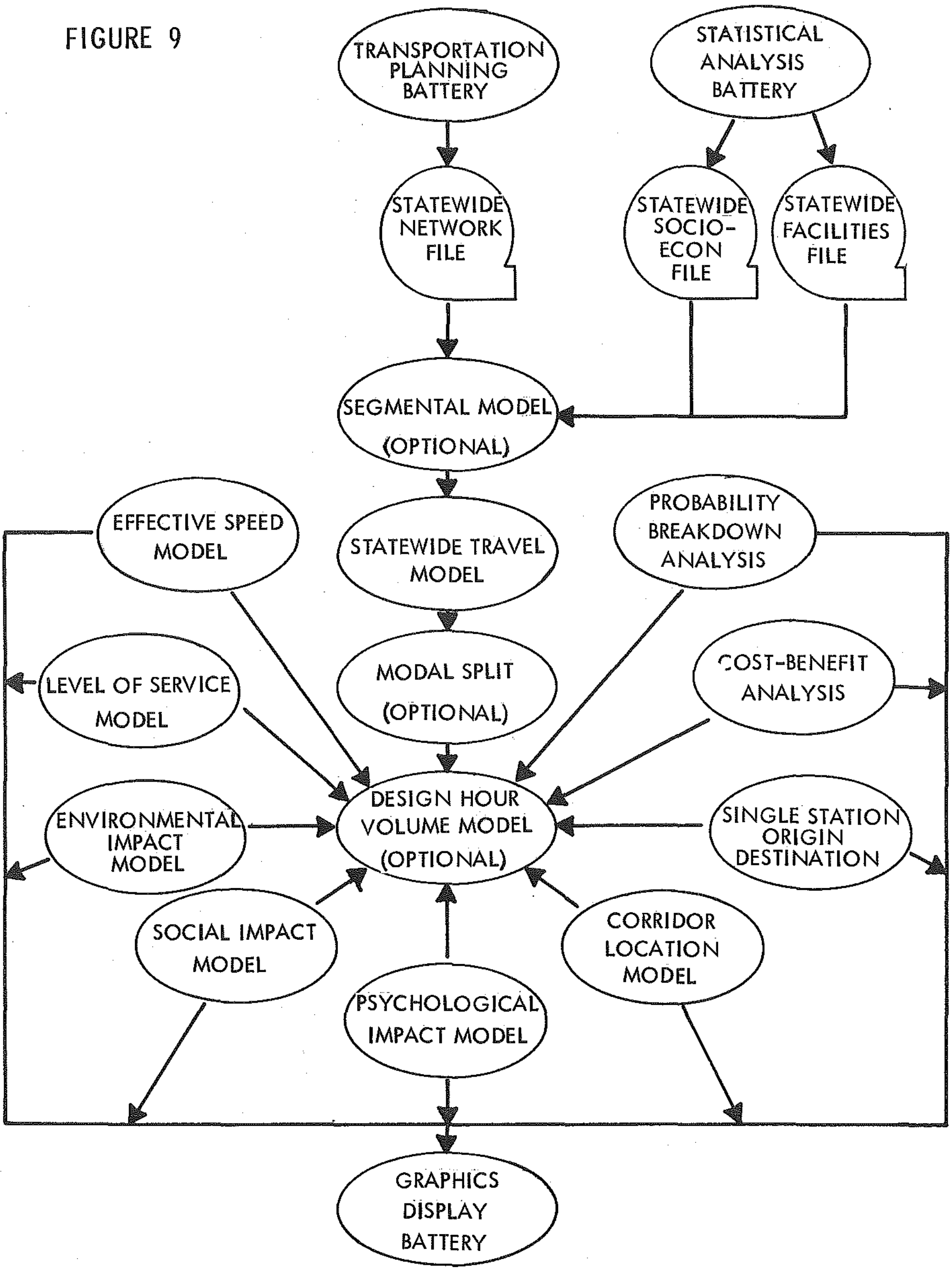


FIGURE 10

# COMPONENT DETAIL

## 1. GENERAL UTILITY

A. TP PACKAGE

B. STATISTICAL BATTERY

C. GRAPHIC DATA PRESENTATION BATTERY

## 2. BASIC TRAFFIC FORECASTING AND EVALUATION TOOLS

A. TRIP GENERATION-DISTRIBUTION MODEL

B. SEGMENTAL MODEL

C. DHV MODEL

D. MASS TRANSIT MODEL

## 3. SPECIFIC-IMPACT MODELING PROCESSES

A. COST-BENEFIT ANALYSIS

B. SOCIAL IMPACT ANALYSIS

C. PSYCHOLOGICAL IMPACT ANALYSIS

D. LEVEL OF SERVICE ANALYSIS

E. EFFECTIVE SPEED ANALYSIS

F. ENVIRONMENTAL IMPACT ANALYSIS

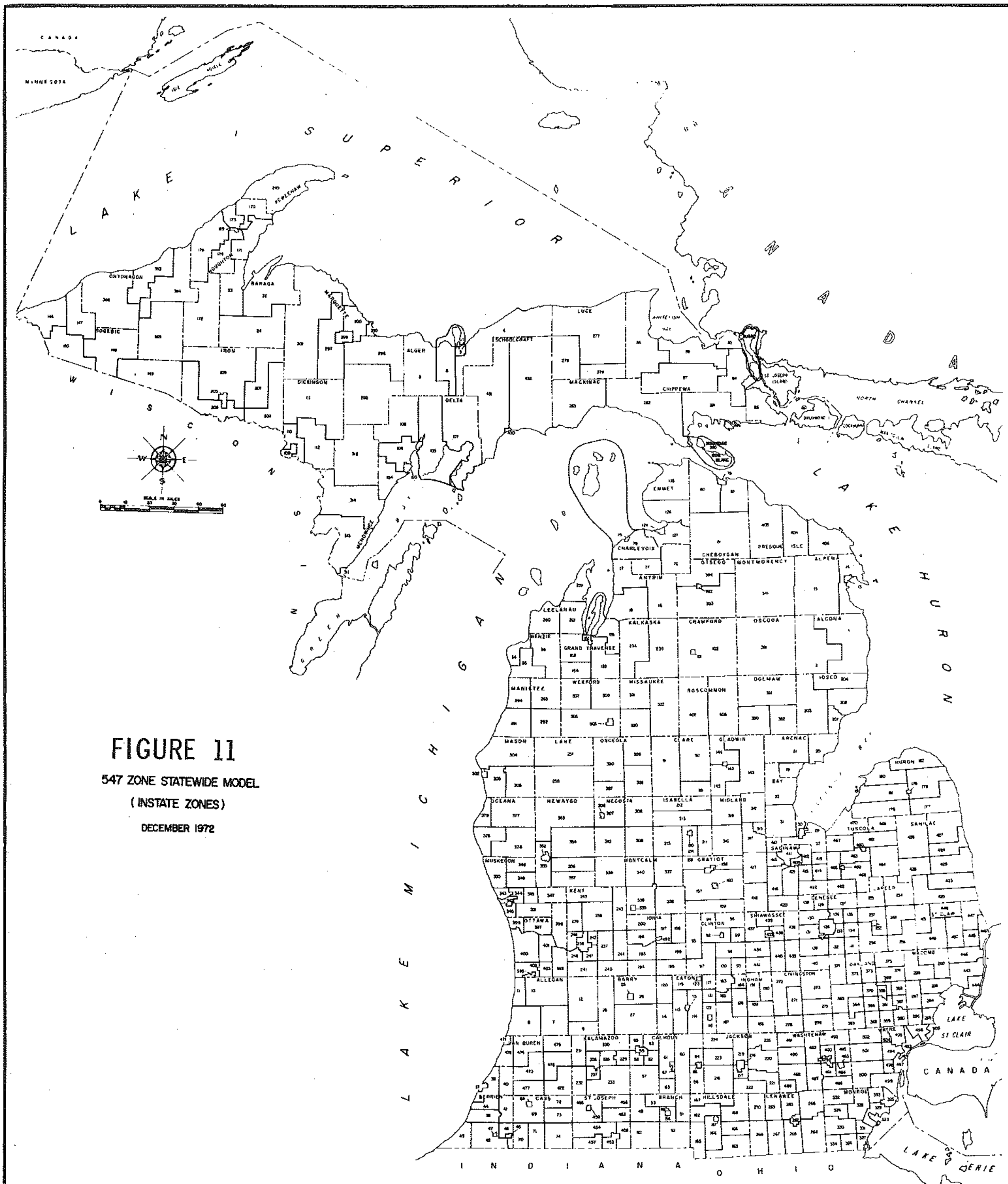
G. HIGHWAY BREAKDOWN PROBABILITY MODEL

## 4. CONTINUING PROCESSES

A. SINGLE-STATION O & D ANALYSIS

B. CORRIDOR LOCATION MODEL

section. All of the model development was based on the 547 zone system appearing in Figure 11. This zone system is based on a combination of townships and city boundaries. The highway network used with this system follows in Figure 12.




# FIGURE 11

547 ZONE STATEWIDE MODEL

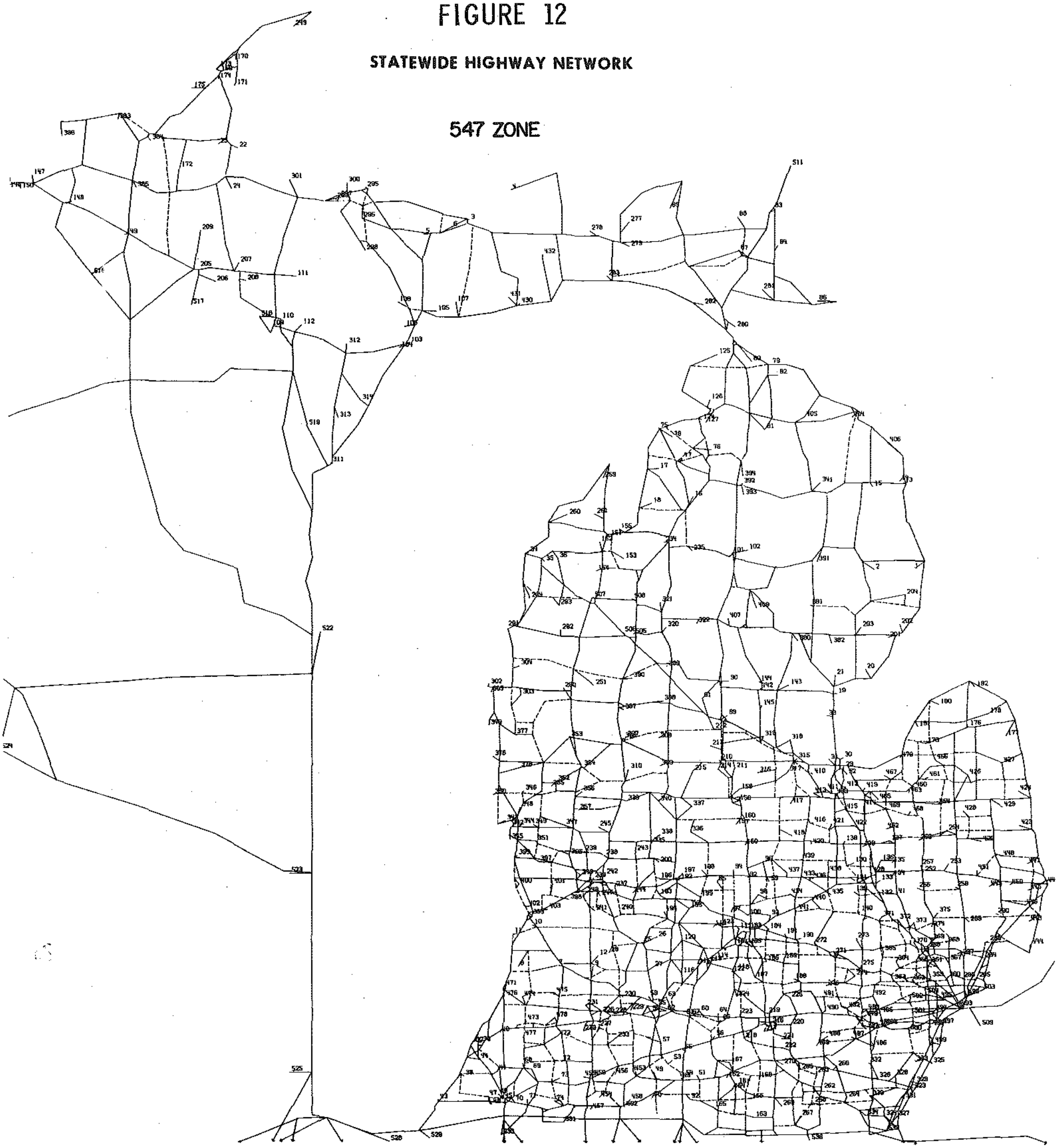
(INSTATE ZONES)

DECEMBER 1972

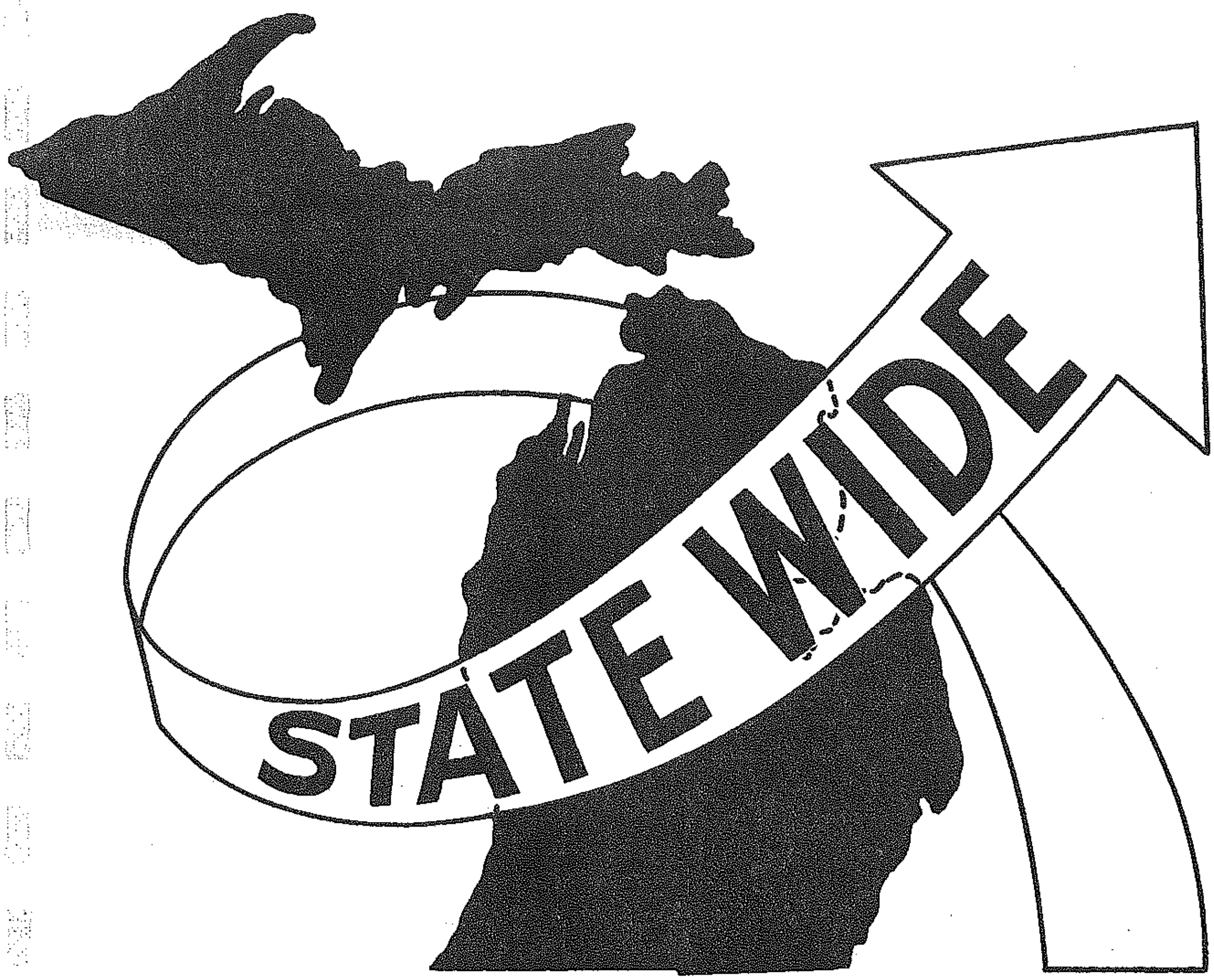
# FIGURE 12

**STATEWIDE HIGHWAY NETWORK**

**547 ZONE**



# A MODELING SYSTEM MEETS THE CHALLENGE



# A MODELING SYSTEM MEETS THE CHALLENGE

Each of the challenges identified in the initial section of this document may be met through differing techniques. This portion defines how each component or group of components (Figure 9) in the statewide transportation modeling system might symatically meet each challenge. The previously identified challenges were:

1. System Analysis
2. "No-Build" Consideration
3. Social Impact
4. Economic Impact
5. Environmental Impact
6. Public Involvement
7. Multi Modal
8. Dynamic Operation

(FIGURE 3)

System analysis requirements of the 70's will be met in two basic ways. In the 50's and 60's most transportation agencies evaluated construction proposals on a project by project basis as appears in Figure 13. Each project was essentially separated from the impact it might have on the total system. Development of a statewide modeling system will eliminate this situation because:

1. The communication system file (Figure 5) includes all state trunklines so that each project's effect is measured on all routes in the system as indicated in Figure 14.

FIGURE 13

# PROJECT ANALYSIS

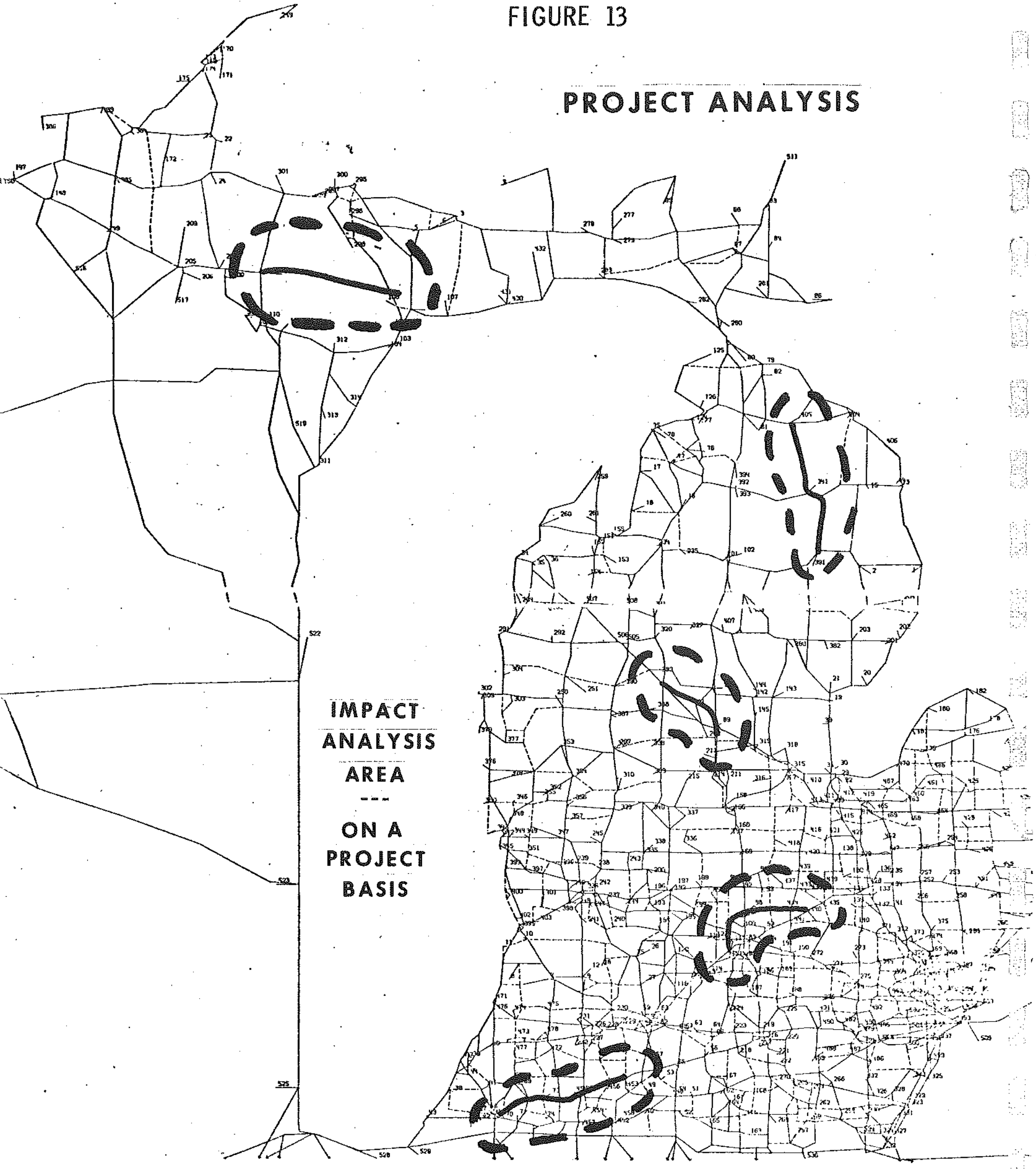
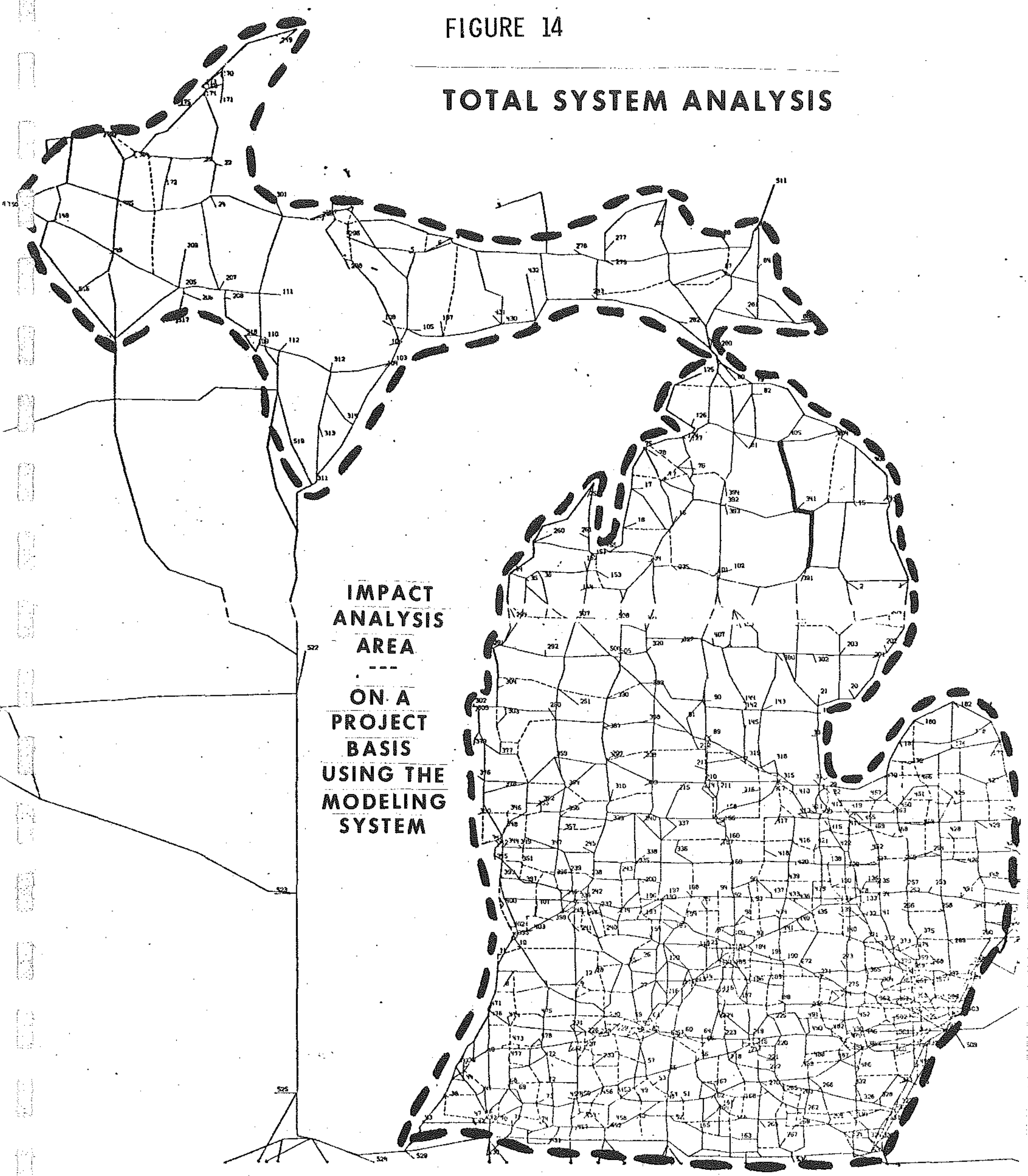


FIGURE 14

# TOTAL SYSTEM ANALYSIS



2. The system is computer oriented so that analysis at the system level for each project can be completed in most cases more efficiently than with the manual project oriented techniques.
3. Computer technology has been developed so that the urban travel forecasting model process can become an integrated subset of the total statewide system, if desired, as indicated in Figure 15 and 16.

Michigan's Statewide modeling process has developed around the 547 zone system as shown in Figure 11, but the 2300 zone (Figure 15) system is a sincere attempt at coordination of both urban and statewide models, since the zones in the 2300 zone statewide model match with each of the existing urban model zones as indicated in Figure 16.

The second challenge of the "no-build" consideration which recent Federal legislation now requires and which many citizen groups have now championed is symatically resolved within the framework of the modeling system diagram (Figure 9). The solution is direct in that the communication system file which contains the highway network information would remain the same for the future year as in the base year. The reason being that the "no-build" situation implies that basically the highway network should remain unchanged except for minor maintenance improvements. Figure 17 is a schematic of the "no-build" alternative. Additionally, Michigan's modeling process also handles this effectively because the statewide travel forecasting model takes into consideration the highway network

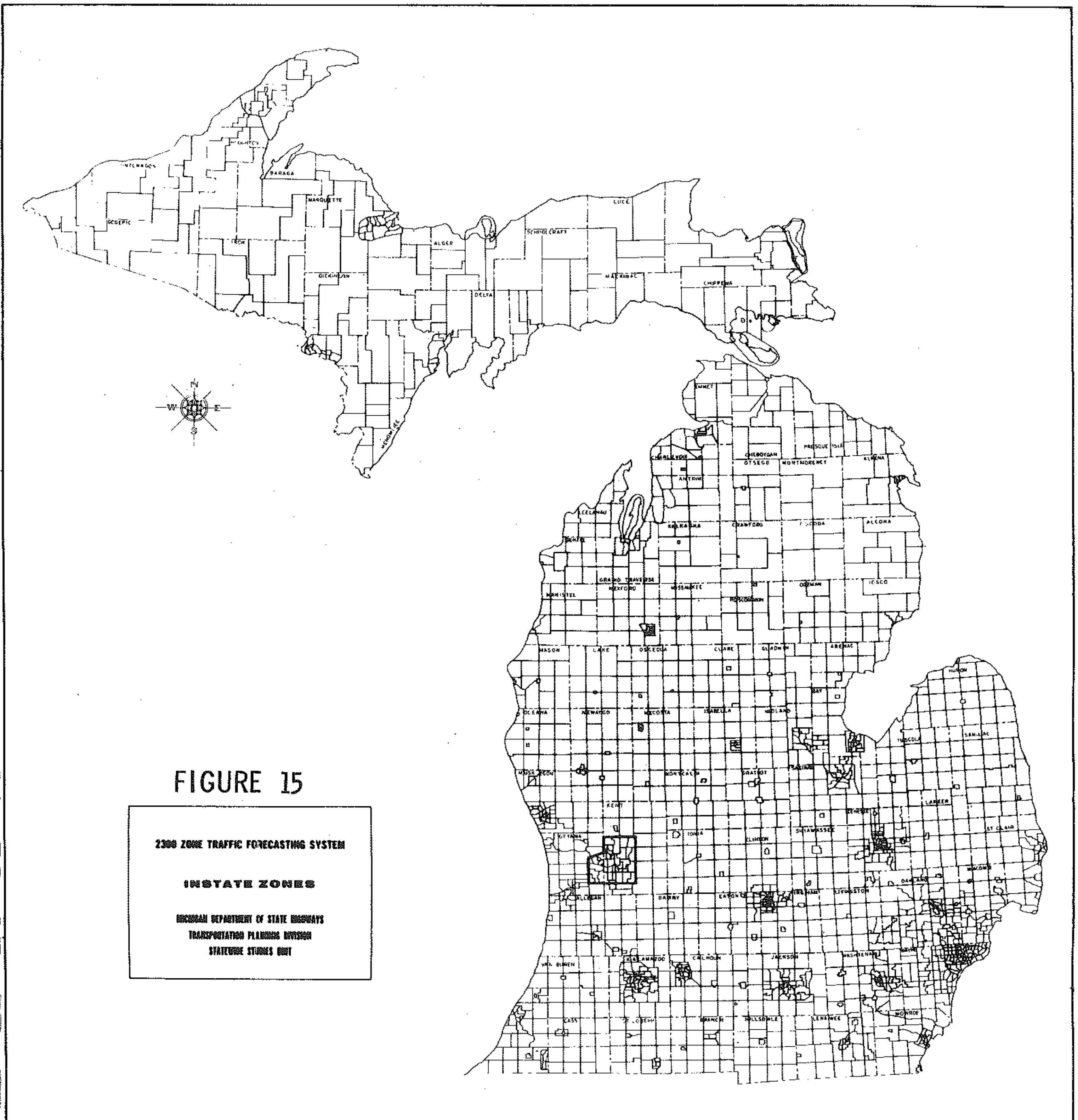



FIGURE 15

2300 ZONE TRAFFIC FORECASTING SYSTEM

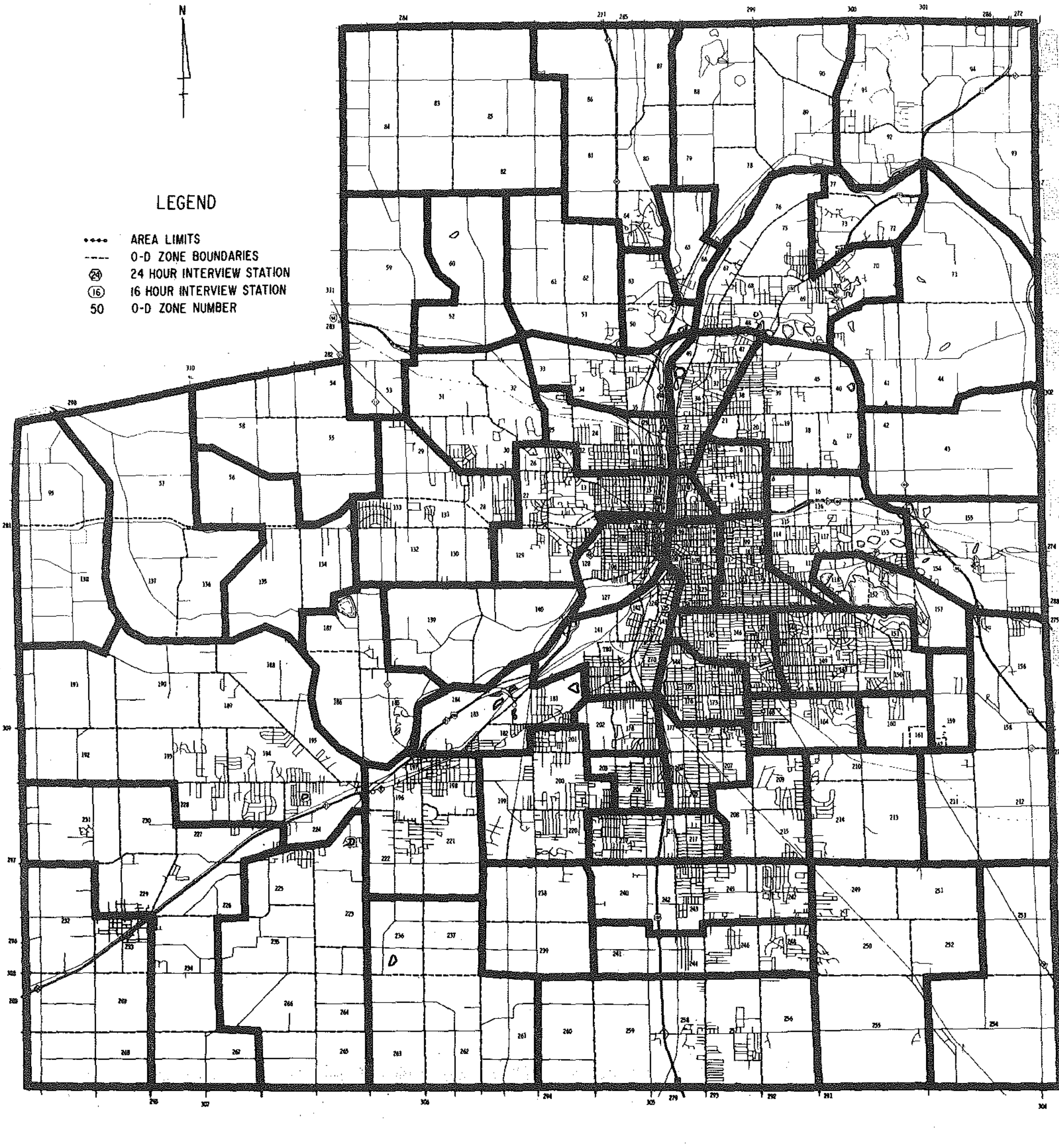
INSTATE ZONES

MICHIGAN DEPARTMENT OF STATE HIGHWAYS
TRANSPORTATION PLANNING DIVISION
STATEWIDE STUDIES UNIT

# FIGURE 16

## GRAND RAPIDS AND ENVIRONS TRANSPORTATION STUDY

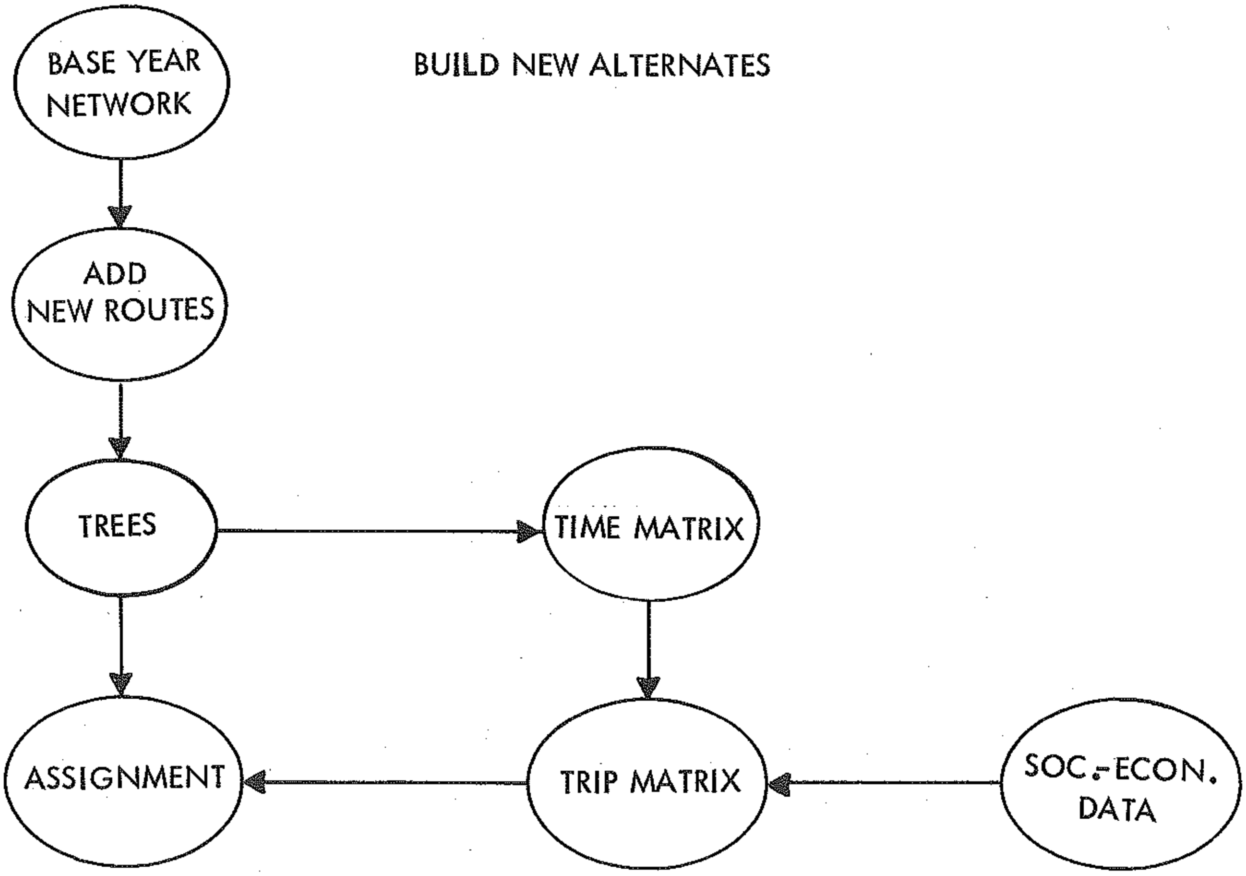
### AREA BASE MAP



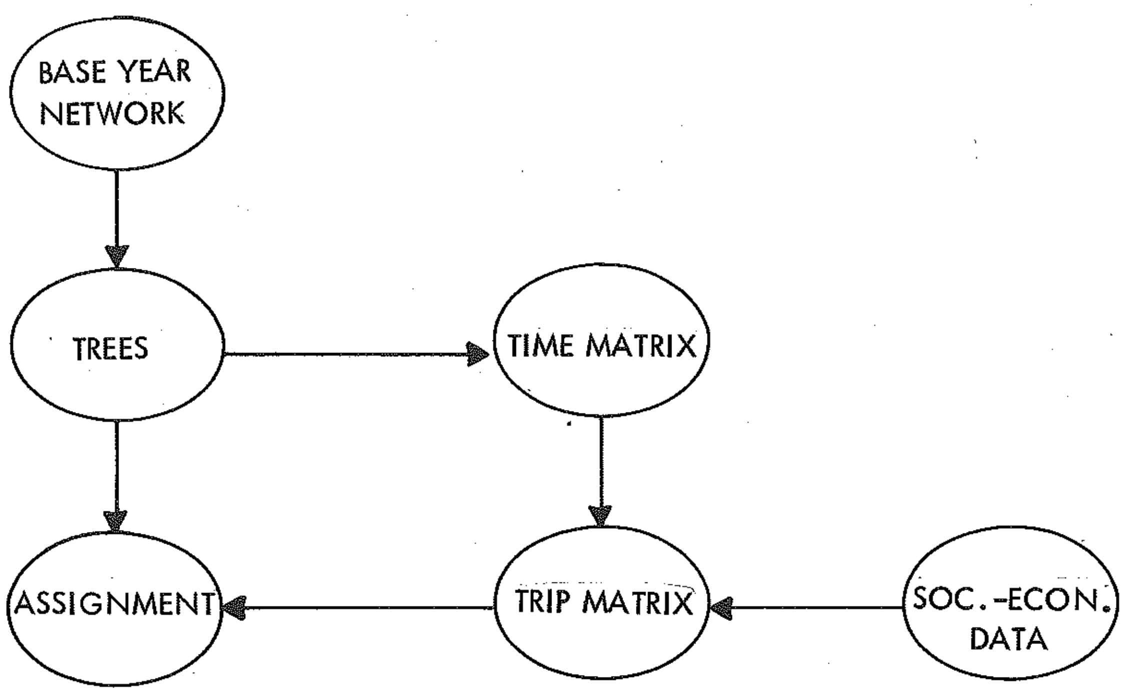
# STATEWIDE MODELING SYSTEM

FIGURE 17

BUILD NEW ALTERNATES




NO BUILD



configuration in addition to socio-economic data before generation of future travel forecasts.

The social impact analysis area is the third challenge confronting each and every highway agency. Many complex research projects have been completed or are under way which hopefully will clear up many of the issues in this area. The modeling system documented in this report deals with this element by using several modeling system components. One of these components was the result of the development of a Psychological Impact Model which monitors the psychological impact of each highway proposal on the mental state of the driver as related to existing highway situations. Factors which are considered during the psychological impact analysis process appear in Figure 18. In the safety area, several analysis routines within the TP Battery or the cost-benefit analysis routine are available to measure the probable impact of each highway proposal on the safety of the highway user. Figure 19 is a bandwidth plot of some of the accident rate data used in actual model analysis.

Finally, the program referred to as the "proximity analysis model" allows each highway agency to study the impact of each highway proposal on the relationship of man and his social institutions such as hospitals, schools, fire stations, and cultural facilities. Figure 20 is an abstraction of a typical social mix and the location of the transportation system element can dramatically affect the interaction of this mix. Proximity analysis will allow each transportation agency to measure this change. It might even be used to monitor how

FIGURE 18

# PSYCHOLOGICAL IMPACT MODEL

## INPUT FACTORS

PERCENT COMMERCIAL

LANE WIDTH

SURFACE CONDITION

VOLUME/CAPACITY RATIO

SIGHT DISTANCE (% RESTRICTION)

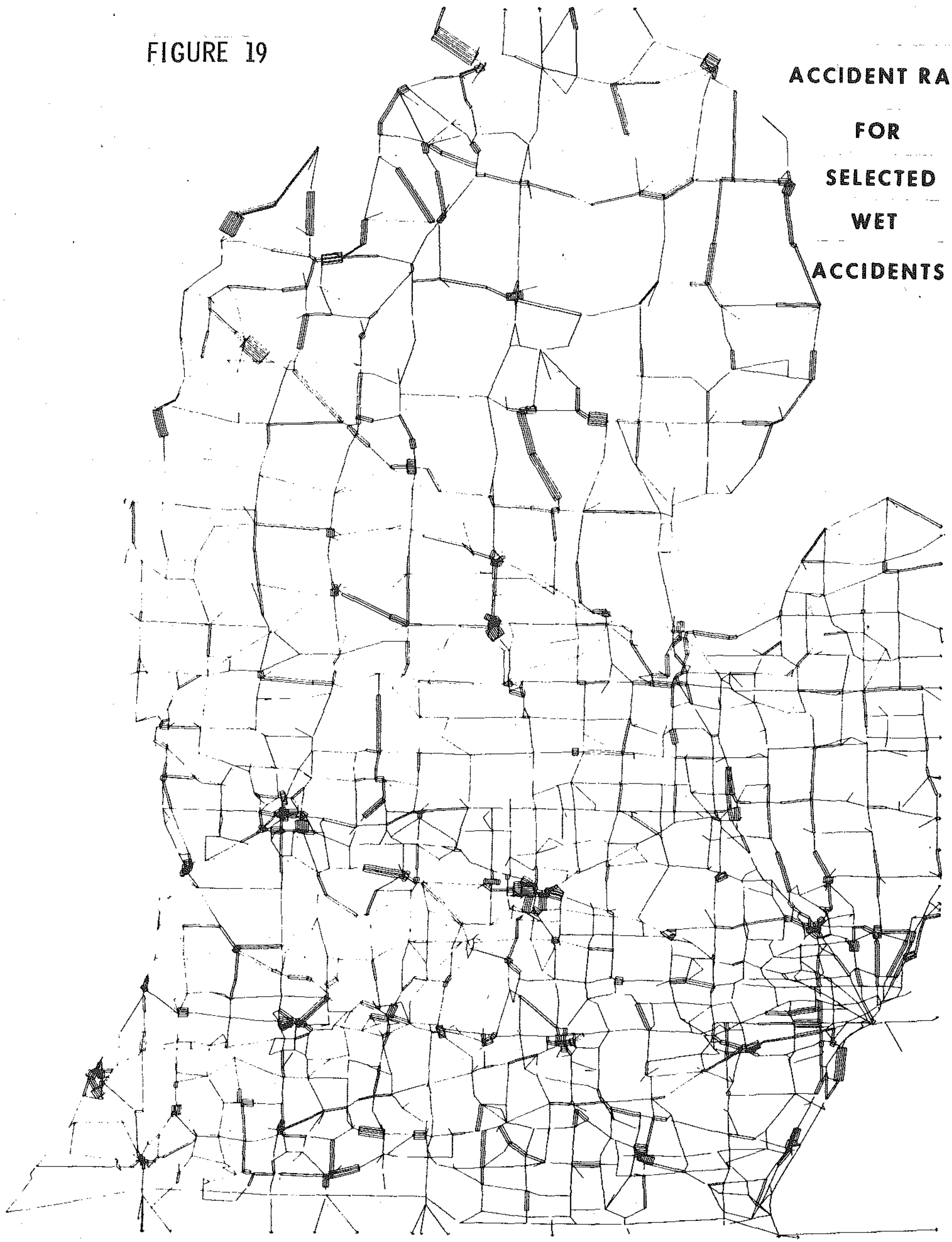
## OPTIONAL INPUT

SHOULDER WIDTH

POPULATION DENSITY

URBAN-RURAL ENVIRONMENT
(NO. DRIVEWAYS, ETC.)

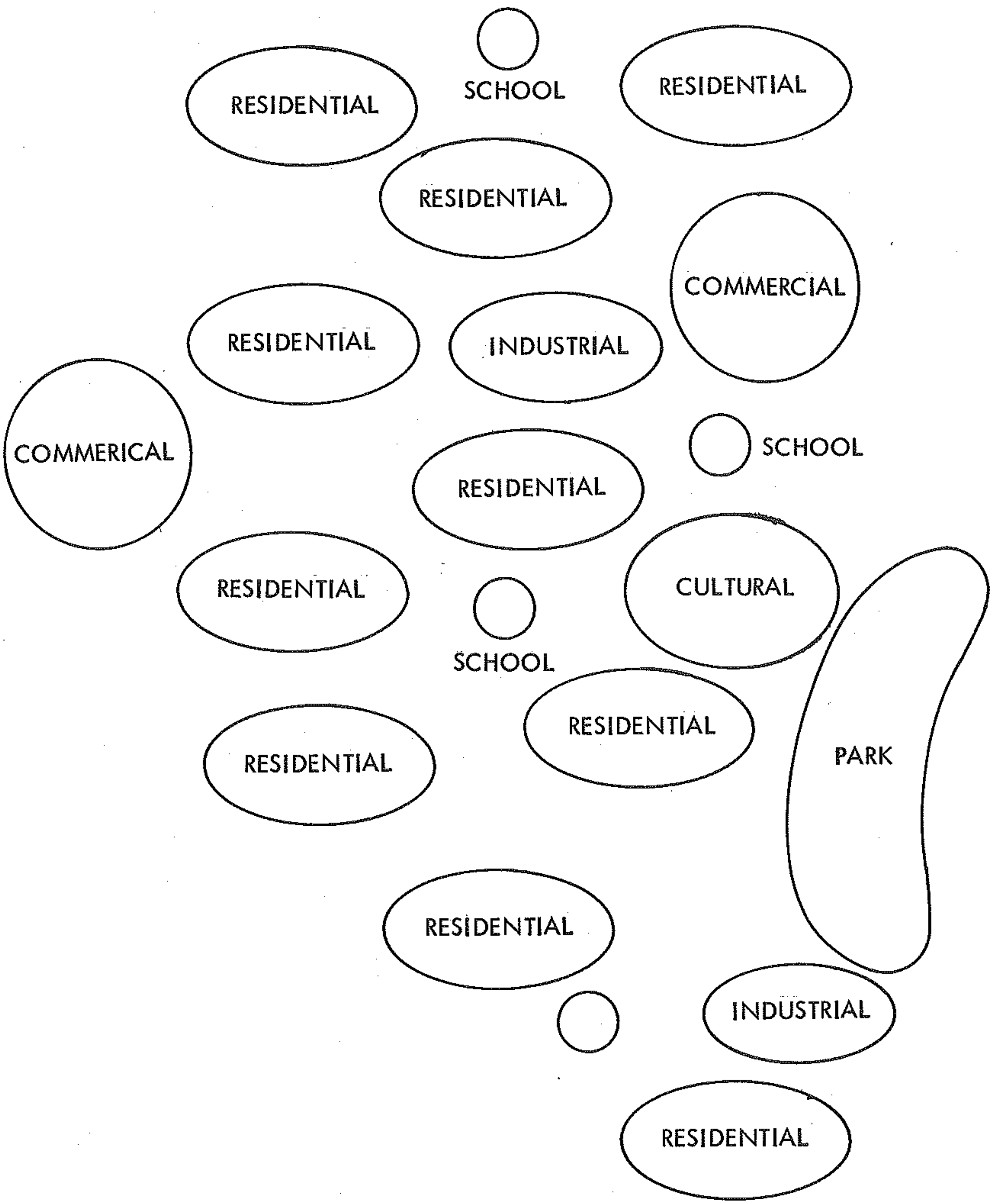
FIGURE 19



ACCIDENT RATE FOR SELECTED WET ACCIDENTS

# FIGURE 20

## SOCIAL INTERACTION ANALYSIS



accessible each neighborhood is in relation to others. Many of these types of impacts have no predetermined dollar value but each does have a positive or negative impact and the modeling system developed can identify this aspect. Figure 21 is the results of a test of the measure of accessibility of each zone in Michigan to hospital facilities.

The fourth challenge has been identified and studied for at least a decade but truly has come to the forefront as the result of 1970 Federal legislation. Quite naturally, the economic impact challenge must be subdivided into highway user and non-highway user economics. The first portion of this challenge is effectively met with the development of statewide cost-benefit analysis model. The cost-benefit analysis model used in Michigan's statewide modeling system monitors the following elements:

1. Capital Cost
2. Maintenance Cost
3. Administration Cost
4. Operation Cost
5. Safety Cost

This model will also operate by vehicle type depending on the capability of the original travel model.

The second element of the economic analysis process is the non-user impacts on elements in society such as:

1. Retail Sales
2. Employment
3. Assessed Valuation

Although some states such as Kentucky have completed the evaluation of relationships between area accessibility and

# HOSPITALS WITHIN 60 MIN.

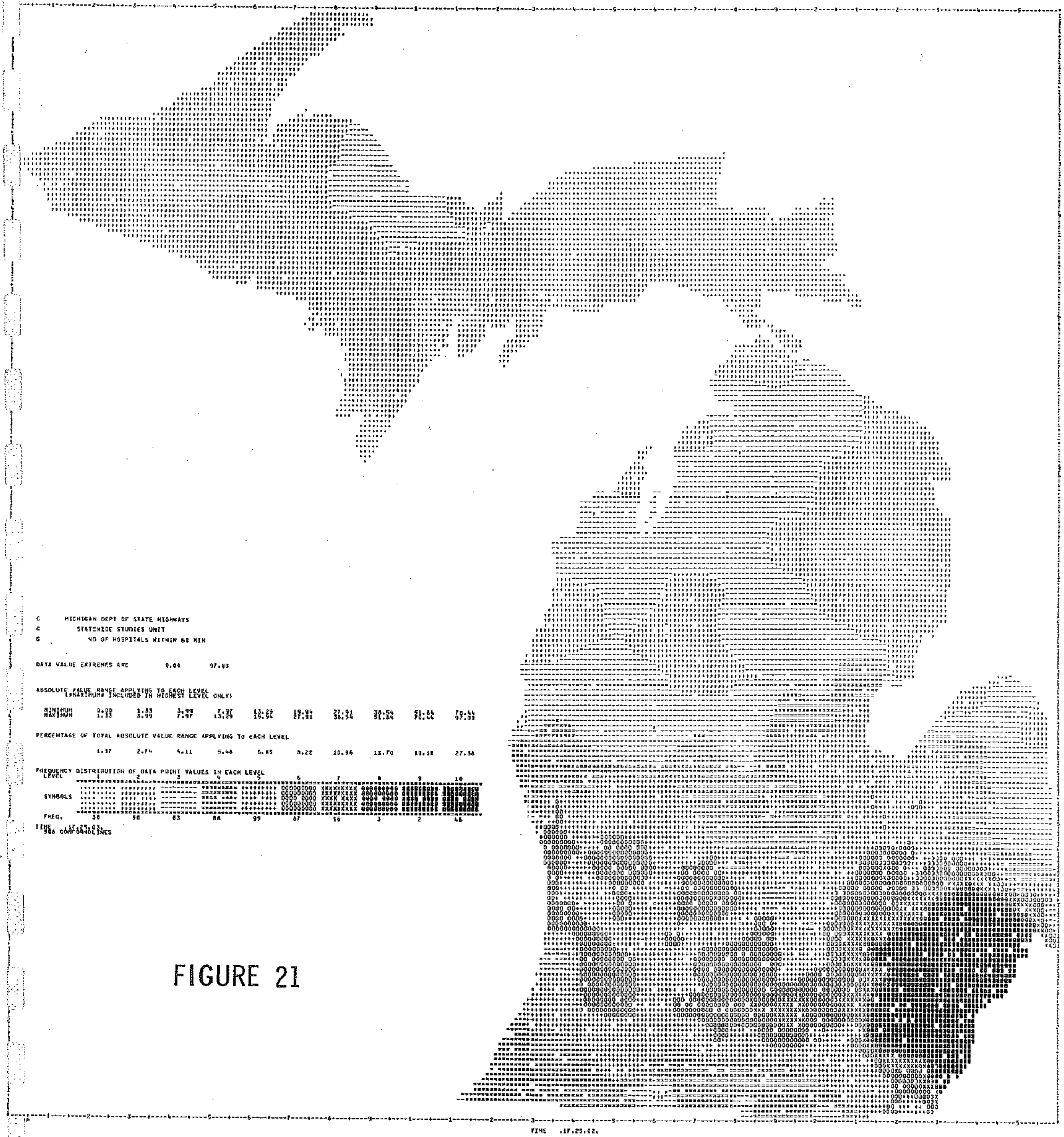



FIGURE 21

the above variables; Michigan has just initiated the process. The modeling system defined in this report will allow Michigan to complete this type of research by development of a 1950, 60 and 70 highway network and statistically evaluating the impact of highway changes on pertinent economic measurements. Figure 22 is the results of an accessibility analysis test for all zones in Michigan for 1970. Data similar to this for 1950 and 1960 will also be evaluated and related to economic information to complete the project.

The challenge confronting each transportation agency with regard to environmental impact is as complex as the non-user economic impacts. Furthermore, research in this area is in its infancy. This is the fifth challenge confronting transportation agencies and the modeling system defined in Figure 9 meets a portion of this challenge through the application of a statewide air pollution model. Figure 23 is a sample output of the air pollution model. The statewide noise pollution model is a second element in the environment analysis system. This model may be used to identify the noise level in decibals or the probable number of people affected by a predetermined noise level as indicated in Figure 24.

The sixth challenge may be the most difficult for highway agencies to fulfill. This challenge of public involvement in the transportation planning process could be difficult for several reasons:

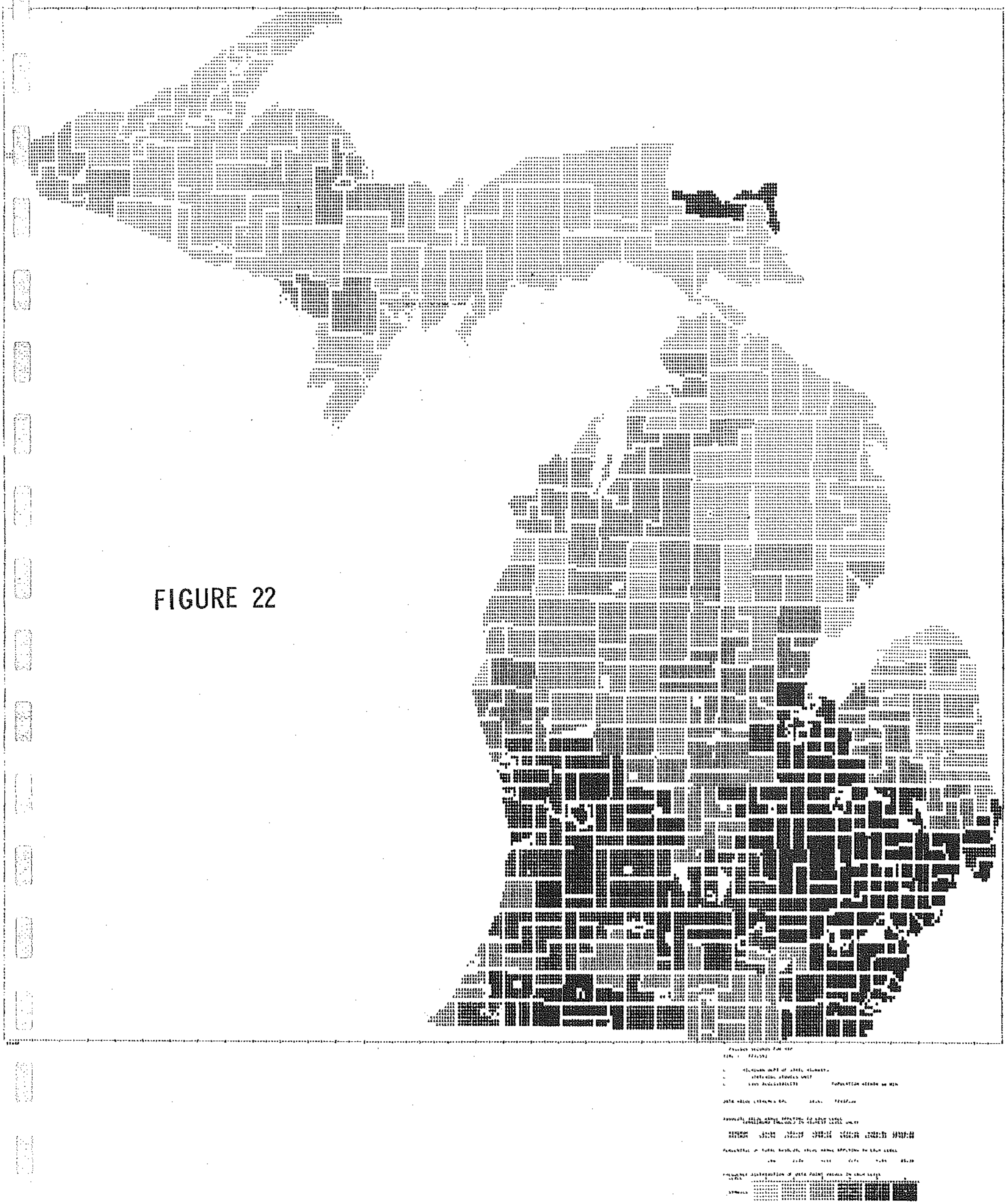


FIGURE 22

# AIR POLLUTION MODEL OUTPUT

THE SPECIAL STUDY COUNTIES ARE

5
10
15
18
28
40
43
45
51
53
57
67
83

CO = 29.26956 LBS PER SQ MILE
HC = 1.50728 LBS PER SQ MILE
NOX= 2.70449 LBSPER SQ MILE

FIGURE 23

EMISSIONS (POUNDS) PER SQ. MILE

| COUNTY | CO | HC | NOX |
|---|---|---|---|
| 1 | 0.89005 | 0.04598 | 0.08655 |
| 2 | 0.83965 | 0.04318 | 0.07600 |
| 3 | 5.59199 | 0.28896 | 0.54683 |
| 4 | 2.25800 | 0.11661 | 0.21815 |
| 5 | 1.52615 | 0.07859 | 0.14102 |
| 6 | 4.25184 | 0.21980 | 0.41788 |
| 7 | 0.82010 | 0.04219 | 0.07459 |
| 8 | 2.74083 | 0.14108 | 0.25106 |
| 9 | 14.75462 | 0.76067 | 1.39433 |
| 10 | 1.95369 | 0.10062 | 0.18048 |
| 11 | 17.00697 | 0.87729 | 1.61993 |
| 12 | 4.41070 | 0.22743 | 0.41730 |
| 13 | 11.46951 | 0.59242 | 1.11421 |
| 14 | 5.19398 | 0.26779 | 0.48870 |
| 15 | 1.71699 | 0.08838 | 0.15724 |
| 16 | 2.54168 | 0.13149 | 0.25239 |
| 17 | 0.92746 | 0.04779 | 0.08673 |
| 18 | 4.71808 | 0.24353 | 0.45368 |
| 19 | 7.15959 | 0.36968 | 0.68976 |
| 20 | 2.62223 | 0.13562 | 0.25975 |
| 21 | 1.57631 | 0.08125 | 0.14744 |
| 22 | 1.65734 | 0.08481 | 0.13911 |
| 23 | 10.69491 | 0.55016 | 0.97514 |
| 24 | 3.47846 | 0.17893 | 0.31566 |
| 25 | 25.59498 | 1.31592 | 2.31887 |
| 26 | 1.72492 | 0.08880 | 0.1584[illegible] |
| 27 | 0.92124 | 0.04728 | 0.08076 |
| 28 | 3.65776 | 0.18825 | 0.33427 |
| 29 | 5.41568 | 0.27890 | 0.50322 |
| 30 | 3.03378 | 0.15621 | 0.2793[illegible] |
| 31 | 1.67725 | 0.08605 | 0.1461[illegible] |
| 32 | 2.11480 | 0.10891 | 0.1951[illegible] |
| 33 | 21.17254 | 1.08708 | 1.87734 |
| 34 | 5.38058 | 0.27792 | 0.52219 |
| 35 | 2.38090 | 0.12283 | 0.22639 |
| 36 | 0.67088 | 0.03452 | 0.0611[illegible] |
| 37 | 4.29044 | 0.22116 | 0.40467 |
| 38 | 11.29883 | 0.58283 | 1.0781[illegible] |
| 39 | 13.89121 | 0.71615 | 1.31462 |
| 40 | 1.20488 | 0.06210 | 0.11276 |
| 41 | 19.46514 | 1.00383 | 1.84471 |
| 42 | 0.18281 | 0.00942 | 0.01689 |
| 43 | 1.30828 | 0.06738 | 0.12086 |
| 44 | 4.80367 | 0.24730 | 0.44089 |
| 45 | 1.66853 | 0.08592 | 0.15383 |
| 46 | 5.65013 | 0.29094 | 0.52059 |
| 47 | 11.10655 | 0.57538 | 1.12811 |
| 48 | 0.58909 | 0.03034 | 0.05443 |
| 49 | 2.09327 | 0.10784 | 0.19449 |
| 50 | 40.14061 | 2.06803 | 3.73801 |
| 51 | 1.75535 | 0.09042 | 0.16267 |
| 52 | 1.43771 | 0.07372 | 0.12453 |
| 53 | 2.75182 | 0.14133 | 0.24427 |
| 54 | 2.89292 | 0.14901 | 0.26804 |
| 55 | 1.73347 | 0.08879 | 0.14790 |
| 56 | 5.73948 | 0.29544 | 0.53118 |
| 57 | 0.91826 | 0.04723 | 0.08308 |
| 58 | 16.26689 | 0.84123 | 1.6087[illegible] |
| 59 | 3.96817 | 0.20400 | 0.35636 |
| 60 | 0.90099 | 0.04640 | 0.08323 |
| 61 | 11.55503 | 0.59420 | 1.05086 |
| 62 | 1.90073 | 0.09778 | 0.17274 |
| 63 | 37.33054 | 1.92613 | 3.5665[illegible] |
| 64 | 2.60654 | 0.13417 | 0.23901 |
| 65 | 1.92521 | 0.09913 | 0.17733 |
| 66 | 0.73447 | 0.03783 | 0.06794 |
| 67 | 2.87678 | 0.14823 | 0.26764 |
| 68 | 0.98183 | 0.05060 | 0.09157 |
| 69 | 2.20686 | 0.11416 | 0.2192[illegible] |
| 70 | 9.42452 | 0.48646 | 0.90487 |
| 71 | 1.09699 | 0.05650 | 0.1018[illegible] |
| 72 | 3.59761 | 0.18598 | 0.35357 |
| 73 | 13.71742 | 0.70424 | 1.21423 |
| 74 | 2.28844 | 0.11790 | 0.21255 |
| 75 | 0.85576 | 0.04413 | 0.0806[illegible] |
| 76 | 6.28091 | 0.32372 | 0.58877 |
| 77 | 8.05085 | 0.41364 | 0.72054 |
| 78 | 5.61603 | 0.28917 | 0.51810 |
| 79 | 3.21273 | 0.16499 | 0.28395 |
| 80 | 6.79077 | 0.35096 | 0.6653[illegible] |
| 81 | 19.73188 | 1.01863 | 1.90447 |
| 82 | 141.06542 | 7.26013 | 12.94511 |
| 83 | 3.21301 | 0.16531 | 0.29270 |
| TOTALS | 627.66465 | 32.33712 | 58.5796[illegible] |

KEY: CO = CARBON MONOXIDE
HC = HYDROCARBONS
NOX = OXIDES OF NITROGEN

# FIGURE 24

# NOISE POLLUTION

# MODEL OUTPUT

THE SPECIAL STUDY COUNTIES ARE

5
10
15
18
28
40
43
45
51
53
57
67
83

PEOPLE AFFECTED BY NOISE 1958

| COUNTY | NO. PEOPLE EXPOSED TO NOISE LEVELS > 70DBA |
|---|---|
| 1 | 52 |
| 2 | 22 |
| 3 | 765 |
| 4 | 242 |
| 5 | 117 |
| 6 | 208 |
| 7 | 26 |
| 8 | 318 |
| 9 | 1182 |
| 10 | 145 |
| 11 | 3424 |
| 12 | 263 |
| 13 | 1613 |
| 14 | 663 |
| 15 | 94 |
| 16 | 106 |
| 17 | 140 |
| 18 | 190 |
| 19 | 1084 |
| 20 | 41 |
| 21 | 174 |
| 22 | 92 |
| 23 | 1545 |
| 24 | 109 |
| 25 | 16479 |
| 26 | 99 |
| 27 | 23 |
| 28 | 414 |
| 29 | 203 |
| 30 | 346 |
| 31 | 202 |
| 32 | 333 |
| 33 | 1544 |
| 34 | 500 |
| 35 | 524 |
| 65 | 85 |
| 66 | 59 |
| 67 | 159 |
| 68 | 23 |
| 69 | 51 |
| 70 | 1805 |
| 71 | 108 |
| 72 | 120 |
| 73 | 2358 |
| 74 | 359 |
| 75 | 22 |
| 76 | 563 |
| 77 | 1767 |
| 78 | 900 |
| 79 | 421 |
| 80 | 1067 |
| 81 | 5157 |
| 82 | 8307 |
| 83 | 224 |
| TOTALS | 95030 |

1. Complacency on the part of some citizen.

2. Difficulty of communication of technical modeling process.

3. Many public and private agencies involved.

The components identified in the statewide modeling system diagram in Figure 9 have been developed with the idea of overcoming some of the above problems.

The complacency of many organizations or individual citizens is becoming a special problem for most state highway departments since the public was not often directly involved in past transportation planning projects. Feeling they have little voice in transportation planning, they fail to attend many hearings.

One component of the evaluation process -- the Corridor Location Model -- might allow a highway department to involve the public effectively and stimulate interaction in the selection of alternative plans. Planning data is collected and placed in a grid similar to Figure 25. This could also be a grid based on political boundaries. Information such as the elements identified in Figure 26 could be part of this data base. This information may vary from plan to plan depending on the purpose. If the members of a community have outlined their goals and objectives, this model will allow any transportation agency to generate all route corridors which are optimal from the community's point of view. For those communities which have no specific goal or objectives, the tool might be useful in stimulating the community interest by demonstrating the results of various sets of values placed

# CORRIDOR LOCATION GRID SYSTEM

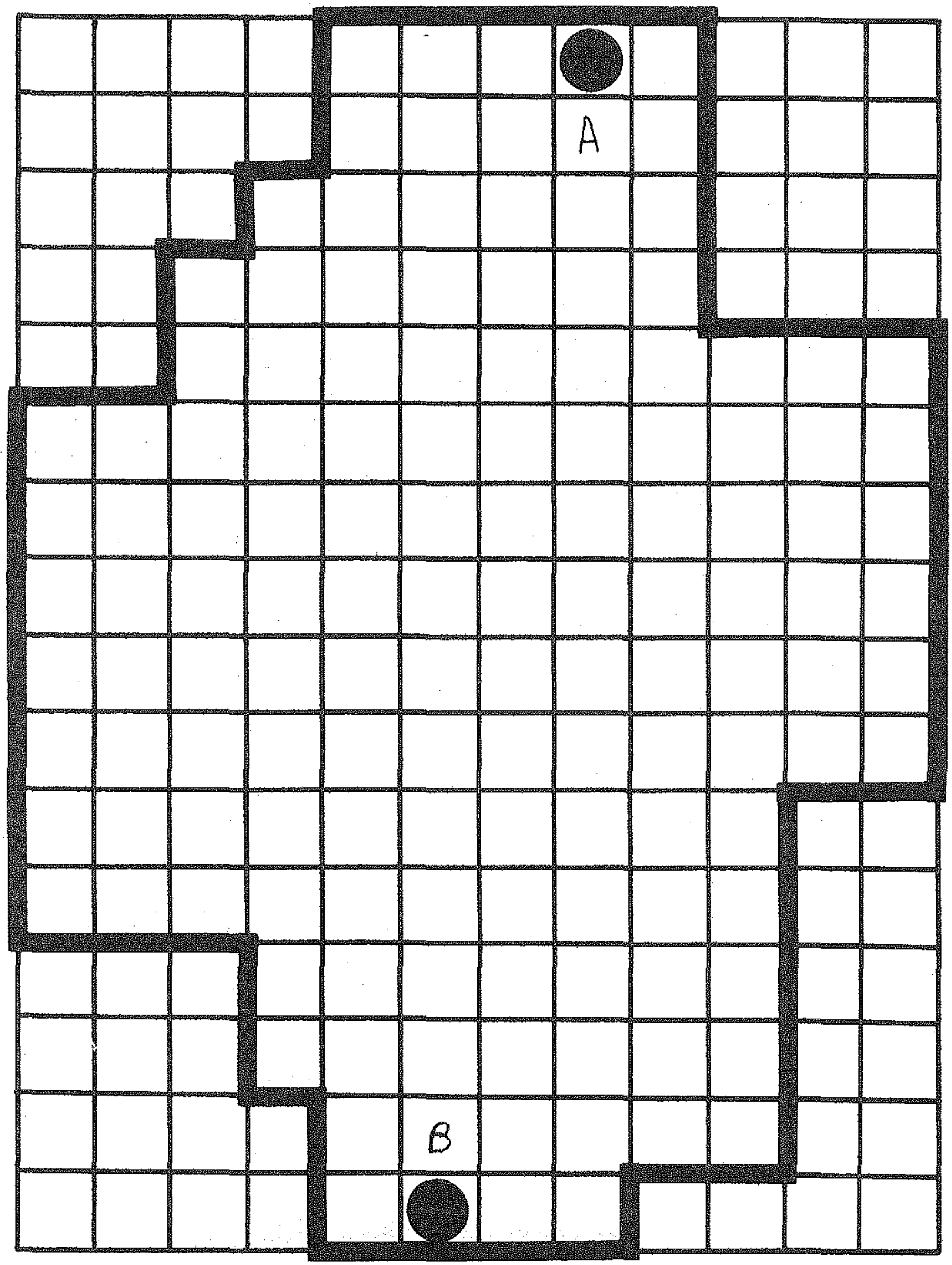



FIGURE 25

# CORRIDOR LOCATION VARIABLES

## (1) NATURAL CHARACTERISTICS

WATERS - STREAMS, RIVERS, LAKES, ETC.

VEGETATION - BARREN LAND, FORESTS, NATURAL AREAS

TOPOGRAPHY - ORIENTATION, DIRECTION, SLOPE, ELEVATION CHANGE

SOIL CONDITION - SURFACE AND SUBSURFACE SOIL TYPES

## (2) CULTURAL CHARACTERISTICS

LAND USE - EXISTING AND PLANNED RESIDENTIAL, COMMERCIAL, INDUSTRIAL, AGRICULTURAL, RECREATIONAL AREAS

POPULATION DISTRIBUTION - URBAN CENTERS OF VARIOUS SIZES

COMMUNICATION SYSTEM - LOCAL ROADS, ARTERIALS, FREEWAYS, UTILITY LINES

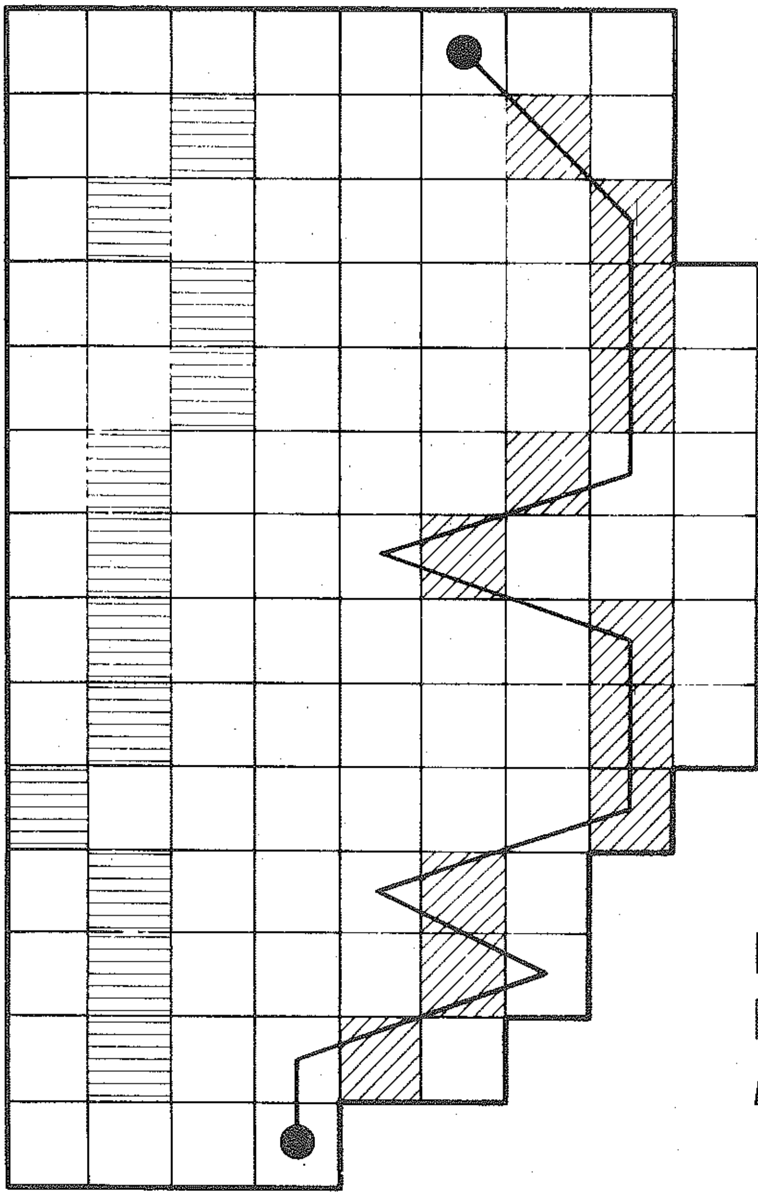
FIGURE 26

on data. This may cause them to become aware of possible trade-offs early in the actual planning process. Note that Figure 27 and 28 are corridors generated as the results of differing community values.

Difficulty of communication with the typical citizen in many cases is the result of a basic unfamiliarity with the technical models used and the planning jargon required for model explanation. Because of this problem, the modeling system defined in Figure 9 includes the following components:

1. Level of Service Model
2. Effective Operating Speed Model
3. Psychological Impact Analysis Model
4. Vehicle Operating Cost Analysis Model
5. Accident Analysis Model
6. Highway Capacity Deficiency Frequency Model

Each of these models has one element in common - they individually generate output that is familiar to the citizen using the state trunkline system. This includes elements or measures of the (1) visual condition existing, (Figure 29) based on the volume capacity ratios (Figure 30), (2) probable operating speed (Figure 31), (3) mental strain relative to an existing condition (Figure 32), (4) cost of using a highway system (Figure 33) and (5) the safety of the system proposed (Figure 34). The sixth model may also be able to supply information on the probable number of times a year the motoring public might experience a particular situation. These measures allow for a technical analysis to be monitored or evaluated on a more "human" level.

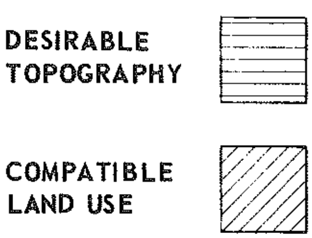


# ROUTE LOCATION MODEL TEST

## CASE 1

FIGURE 27

| | WEIGHT |
|---|---|
| ENVIRON GOALS | |
| TOPOGRAPHY | 0 |
| LAND USE | 1 |
| COMPOSITE ENVIR. GOAL | 1 |
| DISTANCE | 0 |



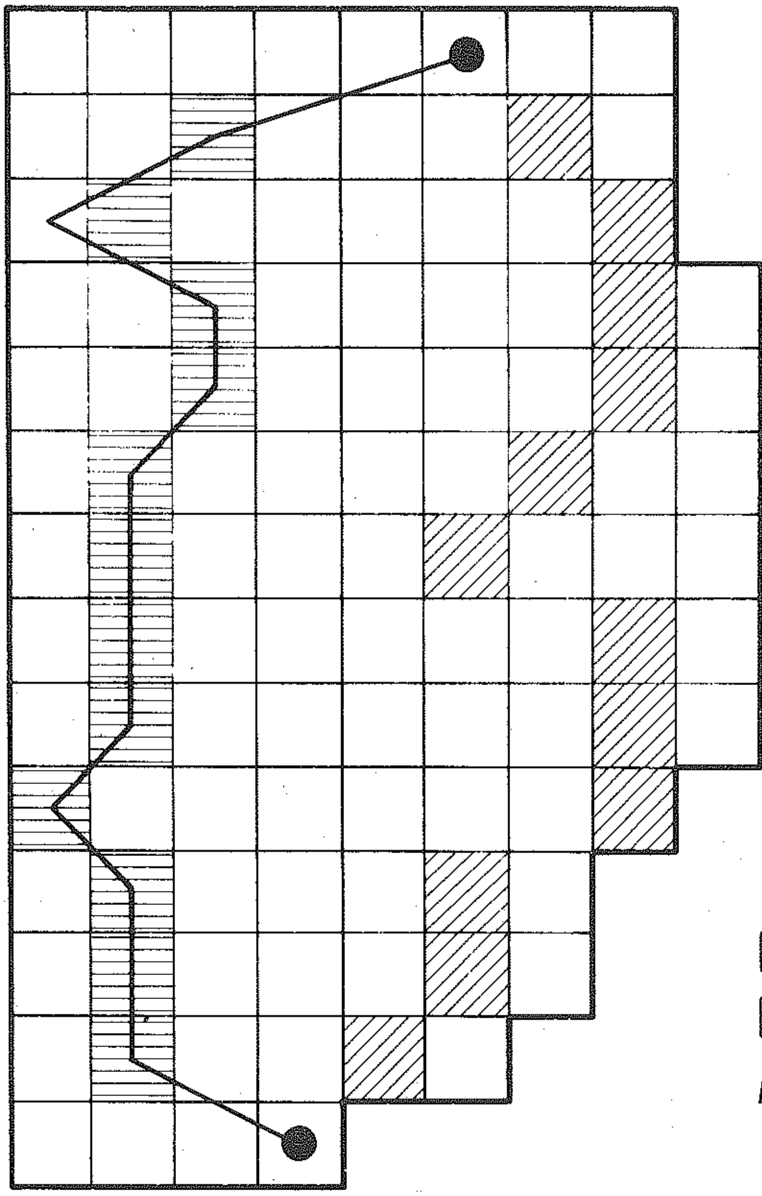


FIGURE 28

DESIRABLE TOPOGRAPHY

COMPATIBLE LAND USE

# ROUTE LOCATION MODEL TEST

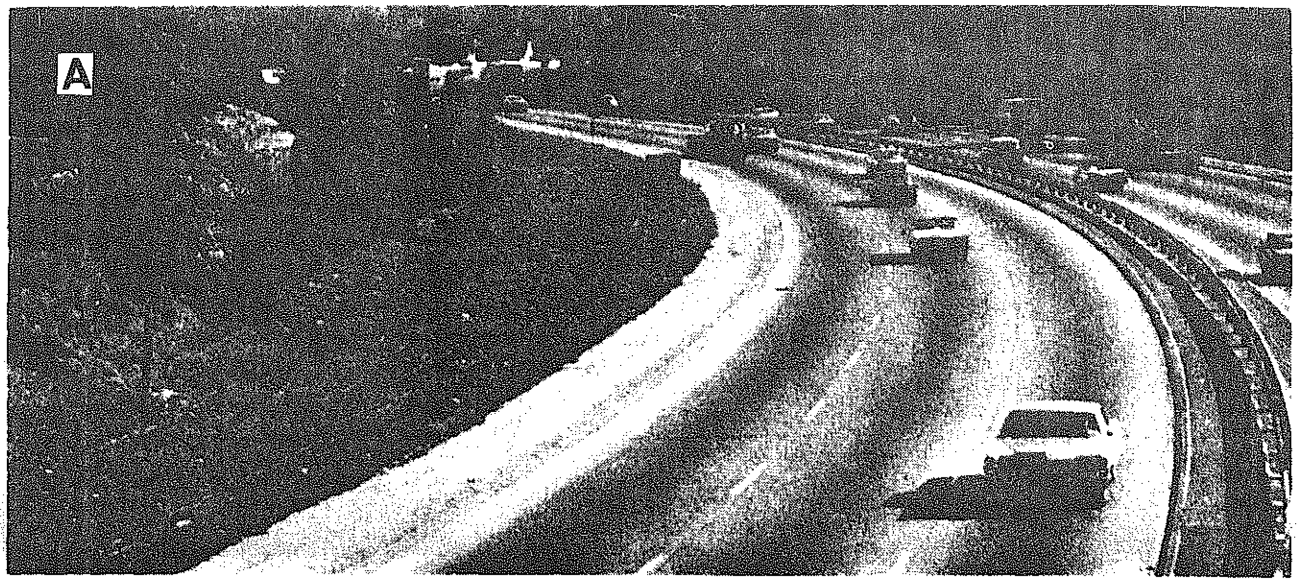
**CASE 2**

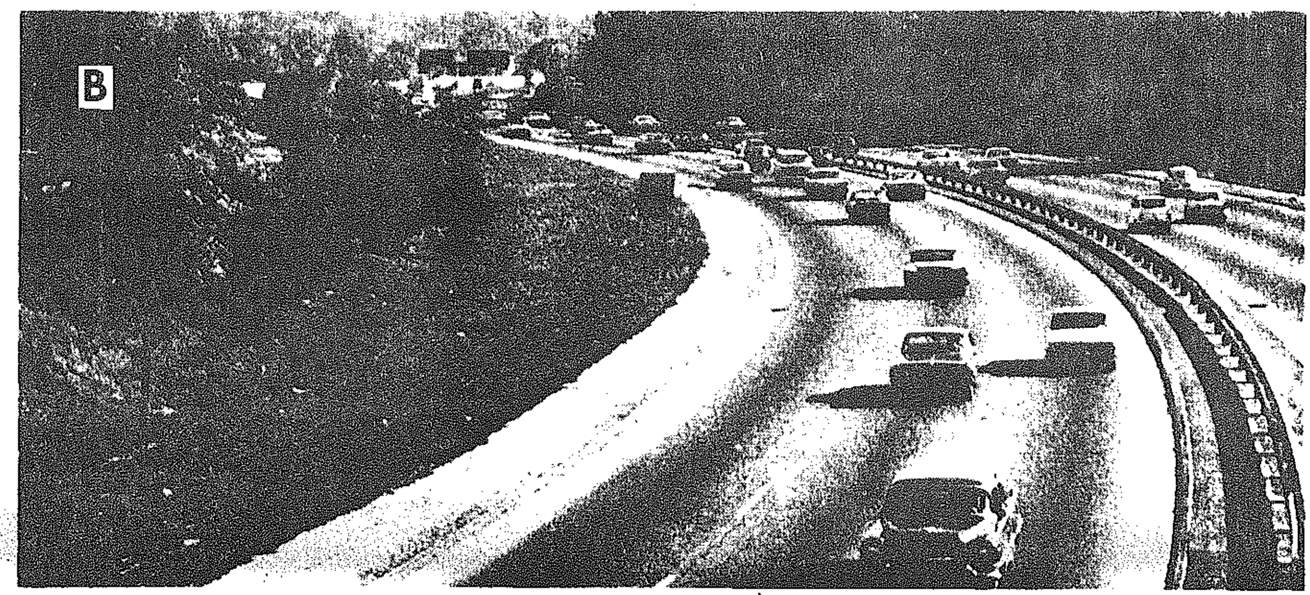
| | WEIGHT |
|---|---|
| ENVIRON GOALS | |
| TOPOGRAPHY | 1 |
| LAND USE | 0 |
| COMPOSITE ENVIR. GOAL | 1 |
| DISTANCE | 1 |

FIGURE 29

# LEVEL OF SERVICE AS VIEWED LOOKING UPSTREAM

SOURCE: 1965 HIGHWAY CAPACITY MANUAL



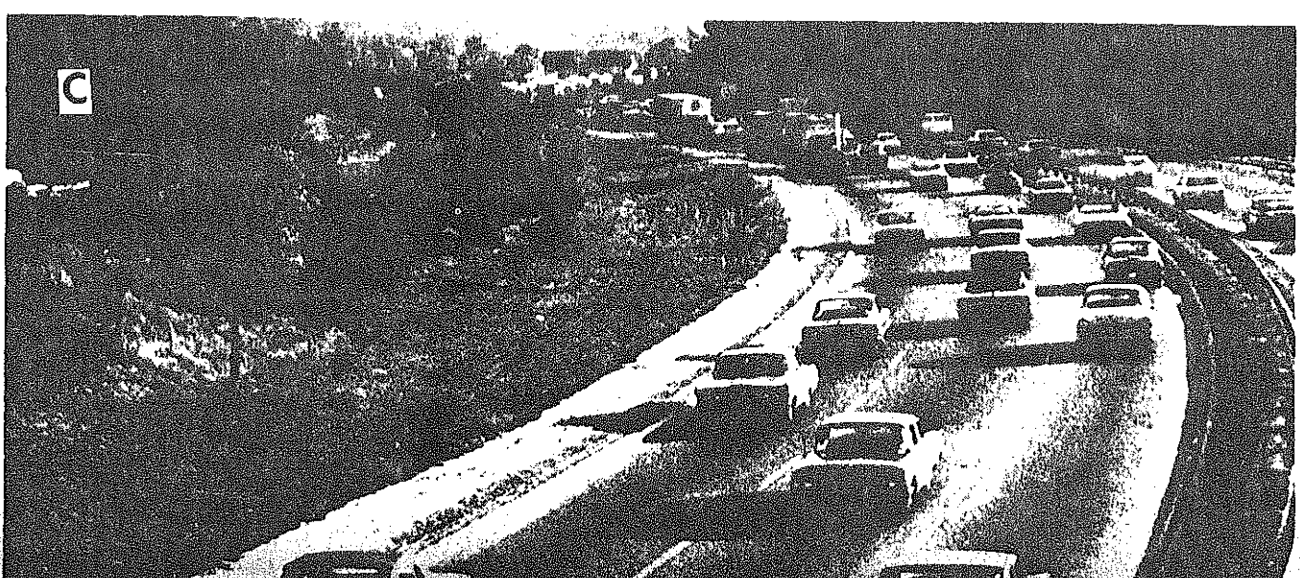



FIGURE 30

# V/C RATIOS FOR RURAL ROADWAYS

## UNDIVIDED AND/OR UNCONTROLLED ACCESS MULTI-LANE HIGHWAY

| LEVEL OF SERVICE | 2 LANES | 3 LANES | 4 LANES | 6 LANES |
|---|---|---|---|---|
| | | | | |
| A | 0.286 | 0.360 | 0.400 | 0.400 |
| B | 0.643 | 0.659 | 0.667 | 0.667 |
| C | 1.000 | 1.000 | 1.000 | 1.000 |
| D | 1.214 | 1.205 | 1.200 | 1.200 |
| E | 1.428 | 1.366 | 1.333 | 1.333 |

## DIVIDED WITH CONTROLLED ACCESS MULTI-LANE FREEWAY

| LEVEL OF SERVICE | 4 LANES | 6 LANES | 8 LANES | 10 LANES | 12 LANES |
|---|---|---|---|---|---|
| | | | | | |
| A | 0.509 | 0.552 | 0.567 | 0.575 | 0.581 |
| B | 0.727 | 0.805 | 0.833 | 0.850 | 0.860 |
| C | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| D | 1.200 | 1.126 | 1.100 | 1.078 | 1.065 |
| E | 1.455 | 1.379 | 1.333 | 1.307 | 1.290 |

FIGURE 31

# EFFECTIVE SPEEDS

(IN TENTHS OF A MINUTE)

## FUTURE EFFECTIVE SPEEDS RESULTING FROM PROJECTED TRAVEL PATTERNS:

FUTURE EFFECTIVE SPEED

PRESENT EFFECTIVE SPEED

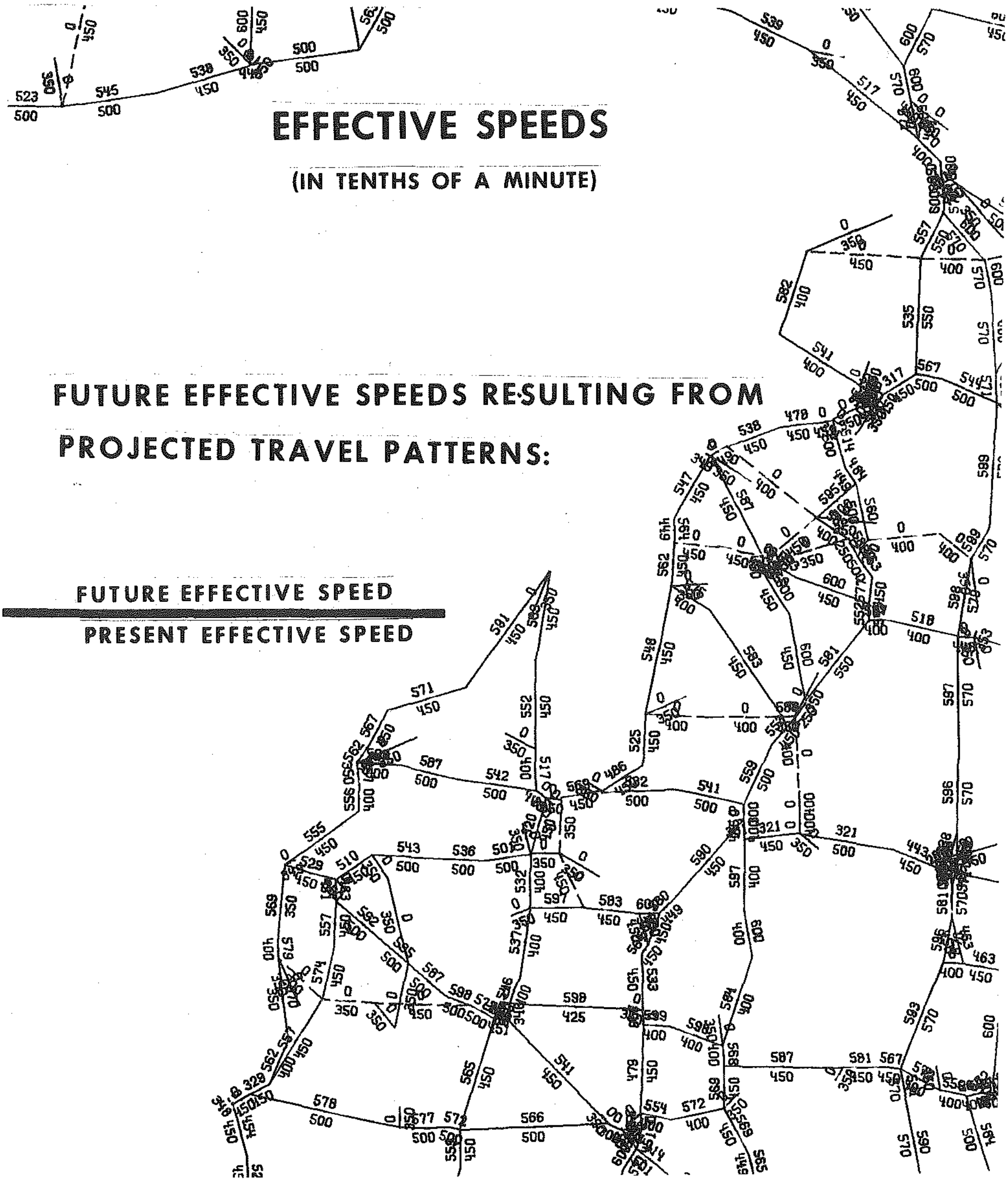


FIGURE 32

# MENTAL STRESS INDICES (HASSLE FACTORS) REGIONAL BLOW-UP

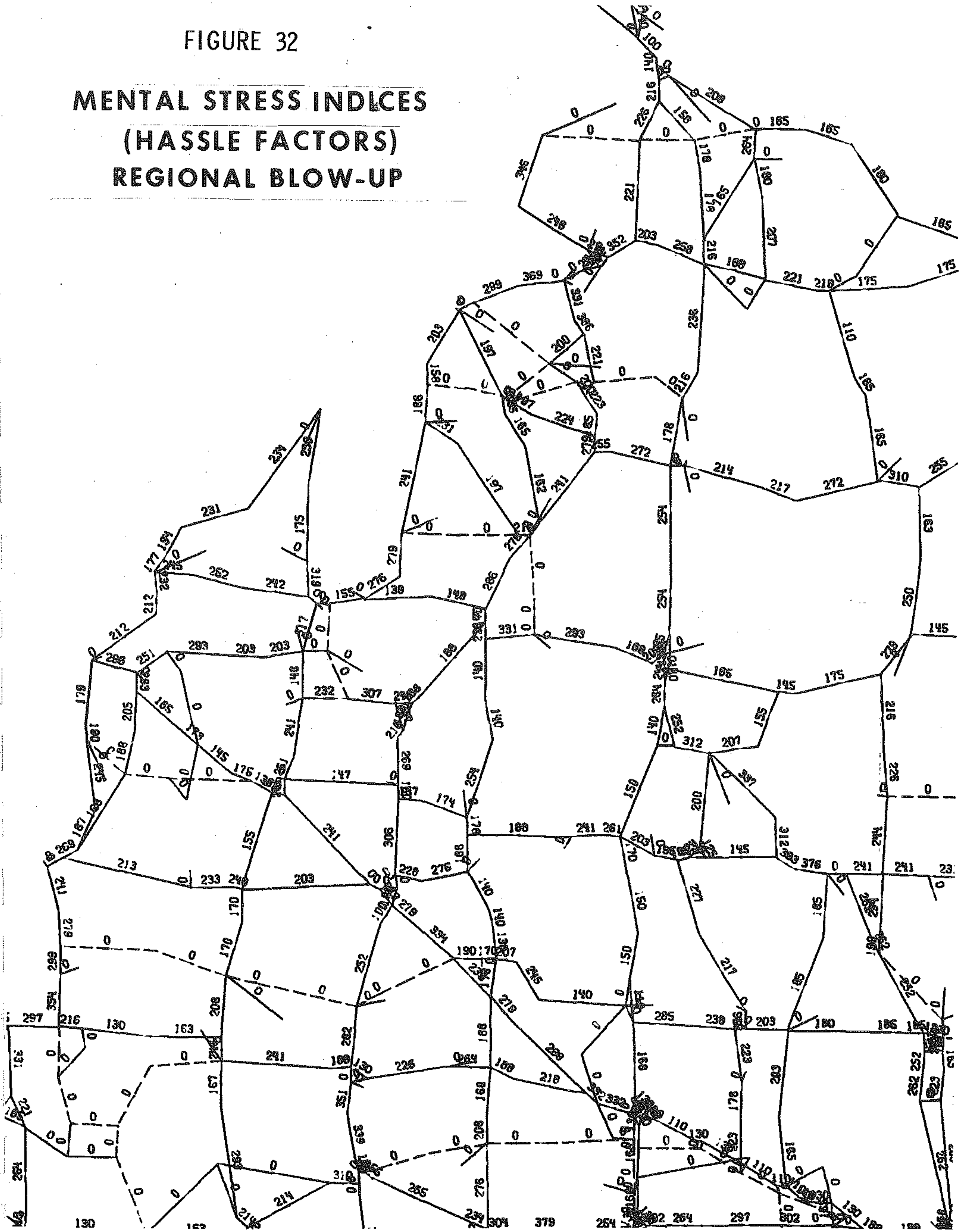


FIGURE 33

# COST-BENEFIT ANALYSIS OUTPUT

PROJECT NO. 2322110001 — 28OCT72
SEGMENT GROUP ALL
ALTERNATIVE 1 VS. 0

(THOUSANDS OF DOLLARS)

| PRESENT WORTHS AT 6 PERCENT | ALT. 0 ORIGINAL COST | ALT. 1 TOTAL COST | ALT. 1 NEW BENEFITS |
|---|---|---|---|
| Present Worths at 6 Percent | | | |
| Auto Running Costs | 13889614.631 | 22852292.154 | 9757909.541 |
| Auto Time Costs | 6062357.833 | 10010135.802 | 4283194.175 |
| Truck Running Costs | 9159155.496 | 15366387.836 | 6864461.622 |
| Truck Time Costs | 2111147.106 | 3569909.923 | 1591898.070 |
| Accident Costs | 1968927.292 | 3112763.383 | 1408069.096 |
| Total User Costs | 33191202.358 | 54911489.097 | 23905532.505 |
| Maintenance Costs | 47930.519 | 54629.862 | |
| Total Present Worth of Costs | 33239132.877 | 54966118.959 | 23905532.505 |
| Capital Costs | 0.000 | 4072.000 | |

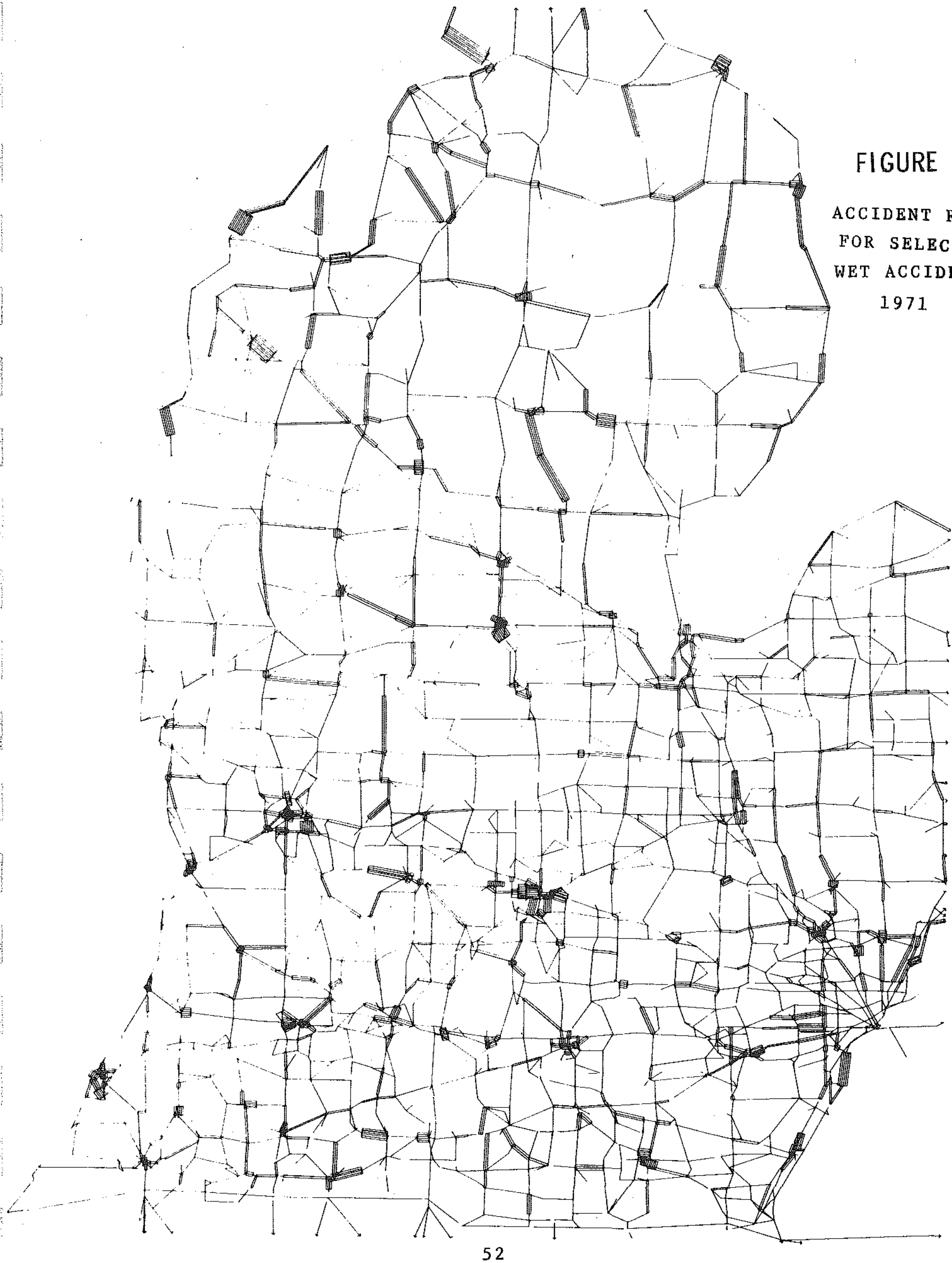


FIGURE 34

ACCIDENT RATE FOR SELECTED WET ACCIDENTS 1971

Finally, the proximity analysis model used in conjunction with the Statewide Facility File will allow any private group or public agency to efficiently place their facilities in the analysis process so the impact of transportation proposals on their own interests may also be monitored. Figure 35 indicates that many public and private facilities are already in the present file. Because this evaluation process is extremely simple and very inexpensive, this should open up a new world of cooperation between transportation agencies and many public and private interest groups.

Many evaluation techniques summarize impact-analyses mainly from the system operator's (highway department's) viewpoint. Using the statewide modeling approach, any highway department with an operational statewide system evaluation process would be capable of summarizing results to provide information form the perspective of:

(1) ROAD USERS
(2) COUNTIES AND COMMUNITIES
(3) THE SYSTEM OPERATOR
(4) THE EXECUTIVE OFFICE
(5) THE LEGISLATURE
(6) OTHER AGENCIES OF STATE GOVERNMENT
(7) COMMERCIAL INTERESTS
(8) INDUSTRIAL INTERESTS
(9) PEOPLE OR CITIZENS

This multiplicity of possible perspectives is a unique feature of this particular system-evaluation process.

FIGURE 35

# STATEWIDE FACILITY FILE

| JURISDICTION | FACILITIES |
|---|---|
| DEPT. OF STATE | HISTORIC SITES |
| DEPT. OF HEALTH | HOSPITALS |
| AREONAUTIC | AIRPORTS |
| GENERAL | WHOLESALE TRADE CENTERS |
| DEPT. OF NAT.RES. | MAJOR PARKS |
| PRIVATE | NON-PUBLIC COLLEGES |
| DEPT. OF EDUCATION | PUBLIC COMMUNITY COLLEGES |
| GENERAL | CITIES OVER 30,000 POPULATION |
| DEPT. OF LABOR | UNEMPLOYMENT OFFICES |
| DEPT. OF HEALTH | MENTAL HEALTH CENTERS |
| DEPT. OF COMMERCE | CERTIFIED INDUSTRIAL PARKS |
| DEPT. OF EDUCATION | MICHIGAN'S UNIVERSITIES |
| PRIVATE | SKI AREAS |
| PRIVATE | SNOWMOBILE TRAILS |
| GENERAL | CBD w/5,000 POPULATION |
| PRIVATE | TRUCK TERMINALS |
| DEPT. OF JUSTICE | STATE POLICE POSTS |
| PRIVATE | DAILY NEWSPAPERS |
| PRIVATE | WEEKLY NEWSPAPERS |
| CITY GOV'T. | SEWAGE TREATMENT FACILITIES |
| PRIVATE | TOURIST ATTRACTIONS |
| PRIVATE | BUS TERMINALS |
| PRIVATE | MANUFACTURERS |
| DEPT. OF NAT.RES. | CAMPSITES |

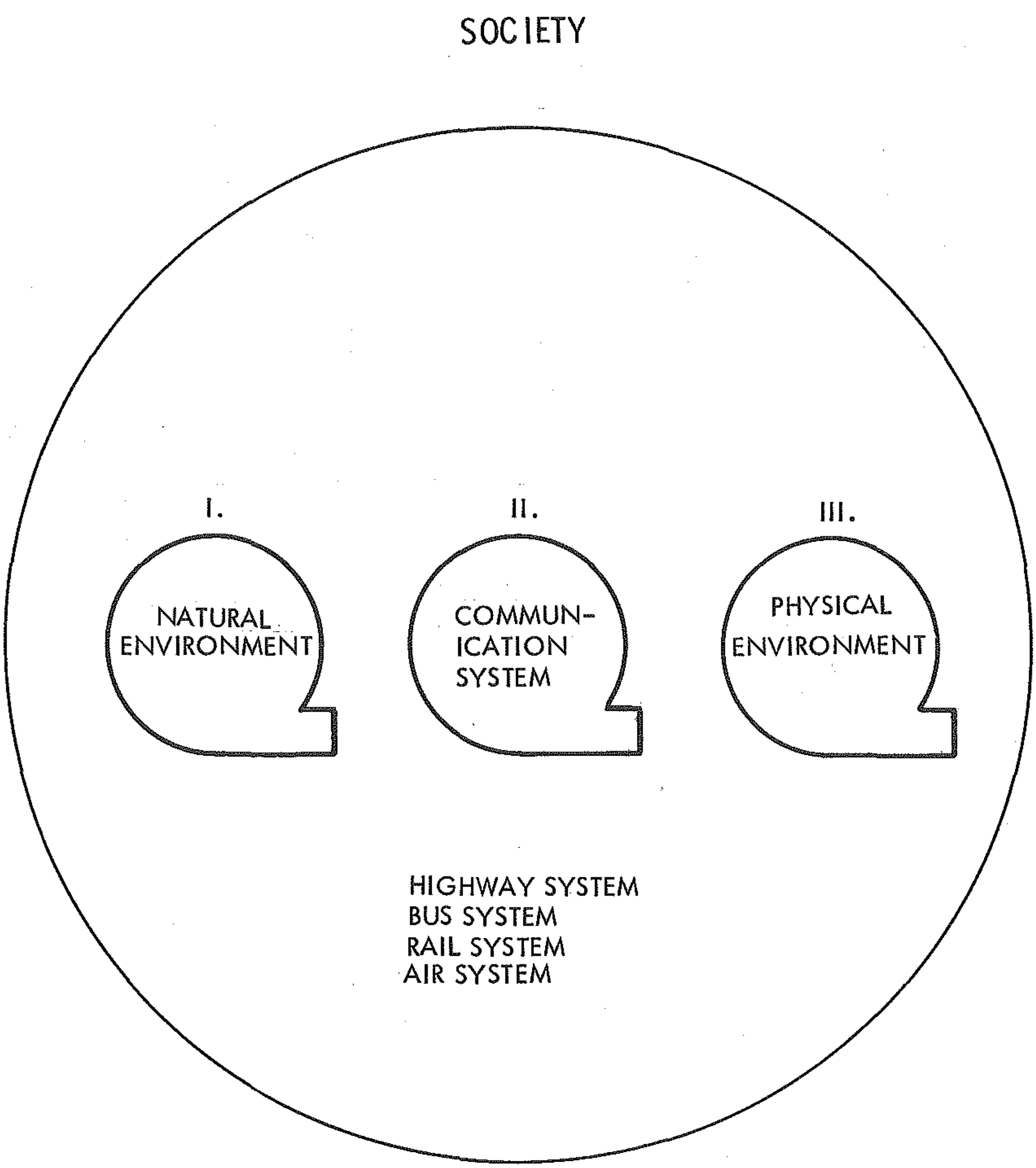
With the "multi-viewpoint" approach, each highway department thus obtains greater value from a single evaluation process; the multi-perspective aspect of the model permits greater efficiency within inter-agency projects and aids in avoiding possible duplication of effort. This system might enable both public and private agencies to participate in the early stages of the planning process, thus eliminating many areas of controversy from the final plan.

The seventh challenge confronting the proposed statewide modeling system is that of multi-modal transportation analysis. This can be handled by developing a communication system file (Figure 36) that includes statewide air, rail, bus and water networks.

Additionally, a preliminary modal split model has been calibrated and compared with actual multi-modal data for Michigan but actual testing of this model in conjunction with the multi-modal network has not been completed. The proper location of these two elements appear in the diagram in Figure 9. Proximity analysis also contributes to the future success of any statewide multi-modal analysis as this serves as the connecting link between each model.

The eighth challenge can symatically be met because of recent developments in computer technology which now will allow each state to develop statewide transportation modeling systems that operate efficiently. Michigan's modeling system operates on a Burrough's 5500 with plans

# FIGURE 36




I. STATEWIDE SOCIO-ECONOMIC DATA FILE

II. STATEWIDE TRANSPORTATION NETWORK

III. STATEWIDE PUBLIC & PRIVATE FACILITY FILE to convert to a B-7700 in the future. Application of computer technology will allow each transportation agency to operate in an effective time frame as specified by recent legislation. Changes in planning data input may also be rapidly evaluated for the same reasons.

The system is also dynamic for another reason. All output information for both zonal analysis (Figure 37) and link analysis (Figure 38) may be graphically displayed on a single sheet or document for effective management application or public presentation. This will allow for rapid evaluation of analysis operations.

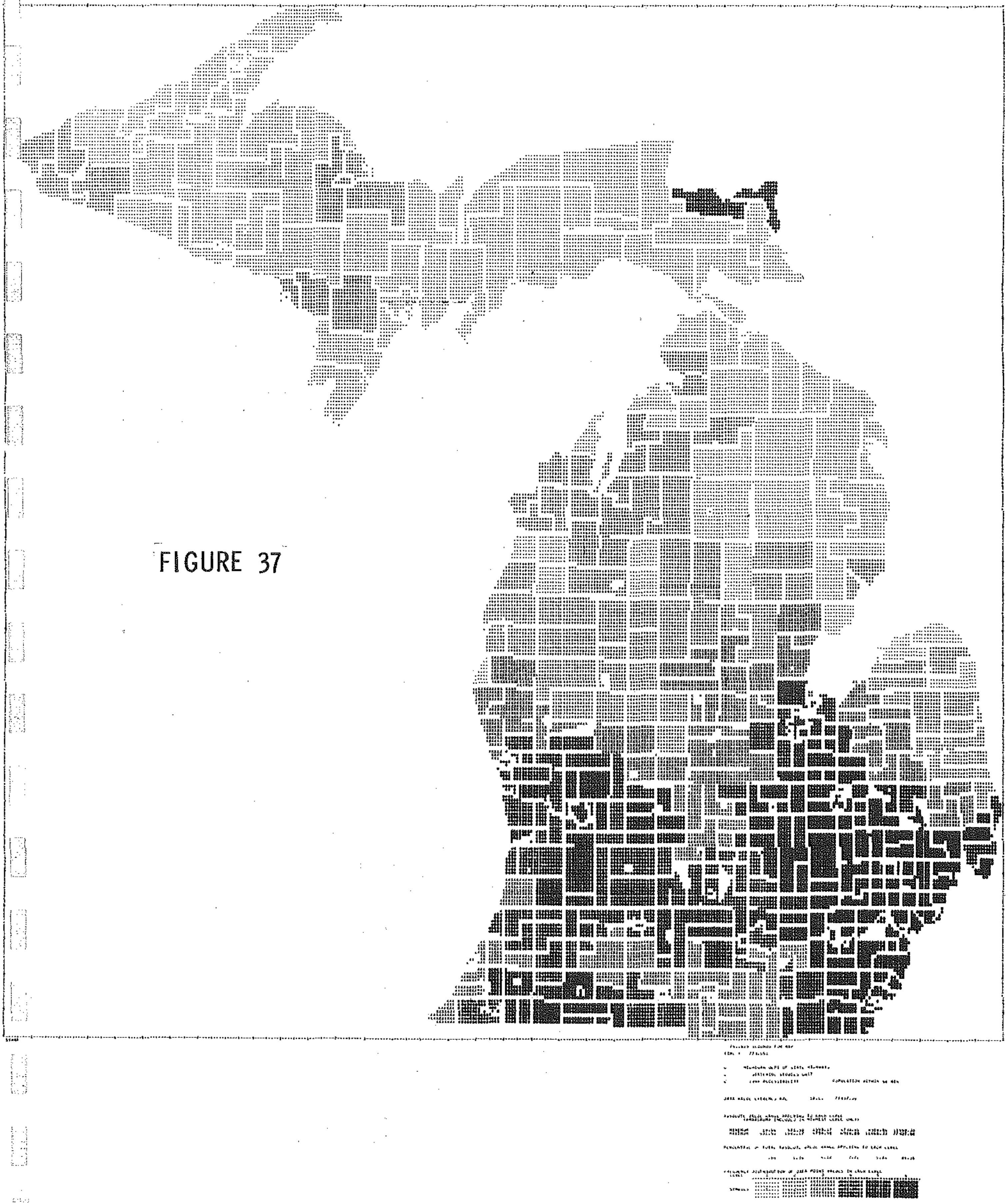
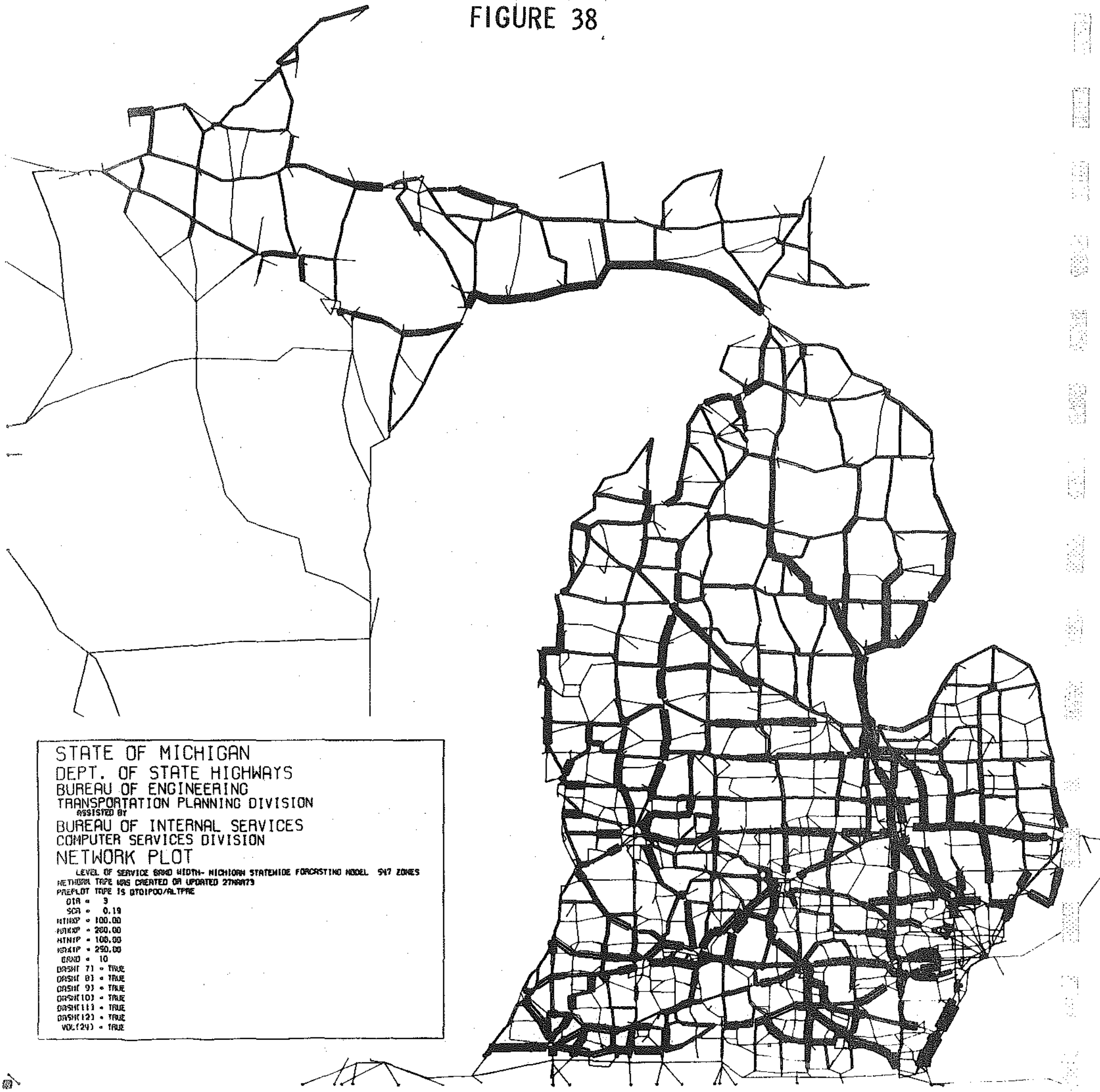


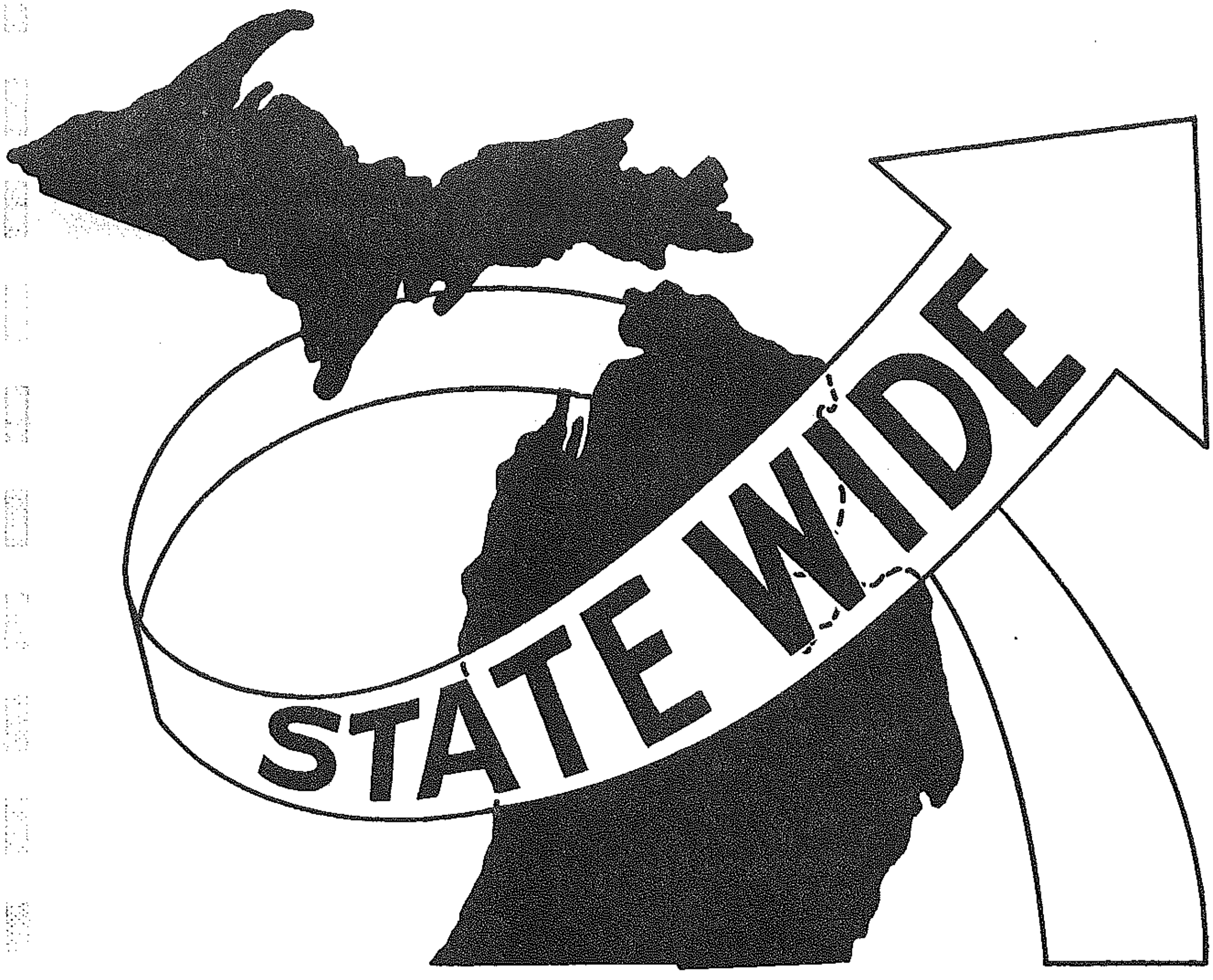
FIGURE 37

FIGURE 38



STATE OF MICHIGAN
DEPT. OF STATE HIGHWAYS
BUREAU OF ENGINEERING
TRANSPORTATION PLANNING DIVISION
ASSISTED BY
BUREAU OF INTERNAL SERVICES
COMPUTER SERVICES DIVISION
NETWORK PLOT
LEVEL OF SERVICE BAND WIDTH- MICHIGAN STATEWIDE FORCASTING MODEL 947 ZONES
NETWORK TAPE WAS CREATED OR UPDATED 27MAR73
PREPLOT TAPE IS DT01P00/ALTPRE
DIR = 3
SCA = 0.19
MINXP = 100.00
MAXXP = 260.00
MINYP = 100.00
MAXYP = 250.00
BAND = 10
DASH( 7) = TRUE
DASH( 8) = TRUE
DASH( 9) = TRUE
DASH(10) = TRUE
DASH(11) = TRUE
DASH(12) = TRUE
VOL(24) = TRUE

# CONCLUSION



# CONCLUSION

Each state transportation agency has been assigned additional responsibilities as the result of recent Federal legislation. Because of the complexity of many of these additional responsibilities, few agencies will be able to effectively meet these responsibilities using existing staff if the same analysis methods are retained. If in fact the same methods are retained then in most situations additional staffing will be required. Requests for additional staff are coming under heavy fire as the results of increased tax burdens on all governmental agencies. Therefore, as the results of the research and development on the statewide modeling system completed by the Statewide Studies Unit this document defines what the unit feels is possibly the only effective solution to this problem. Development of a modeling system such as the one defined in Figure 9 will allow each agency to symatically meet the challenge of the 70's.

Secondly, this system has received acceptance in inter-department operation as a result of those projects identified in Figure 39 . Each test was conducted so that other state agencies would have an opportunity to apply selected system components in their particular operation. The success of these tests indicate the true multi-department benefits to be gained by the development of a statewide transportation modeling system.

FIGURE 39

# INTER-DEPARTMENTAL TEST PROJECTS

## DEPARTMENT OF NATURAL RESOURCES

- -STATE PARK PLANNING
- -RIFLE RANGE

## AERONAUTICS

- -AIRPORT PLANNING

## DEPARTMENT OF COMMERCE

- -INDUSTRIAL SITE ANALYSIS
- -RECREATION INDUSTRY ANALYSIS

## DEPARTMENT OF STATE

- -REGIONAL OFFICE PLANNING

## DEPARTMENT OF PUBLIC HEALTH

- -HOSPITAL PLANNING
- -ACCIDENT LOCATION ANALYSIS

## DEPARTMENT OF TREASURY

- -DATA COLLECTION CENTER ANALYSIS

## EXECUTIVE OFFICE

- -LEGISLATIVE PLANNING - AMBULANCE SERVICE

Additionally, the system has been developed in a manner such that users of the system are not confronted with massive data reformation efforts in order to apply the system. For example all data on 248 hospital in the state was prepared and entered in the system in approximately three man-hours. The assessed valuation for all political jurisdictions from the Department of Treasury was converted and placed in the socio-economic data file in approximately two man-days.

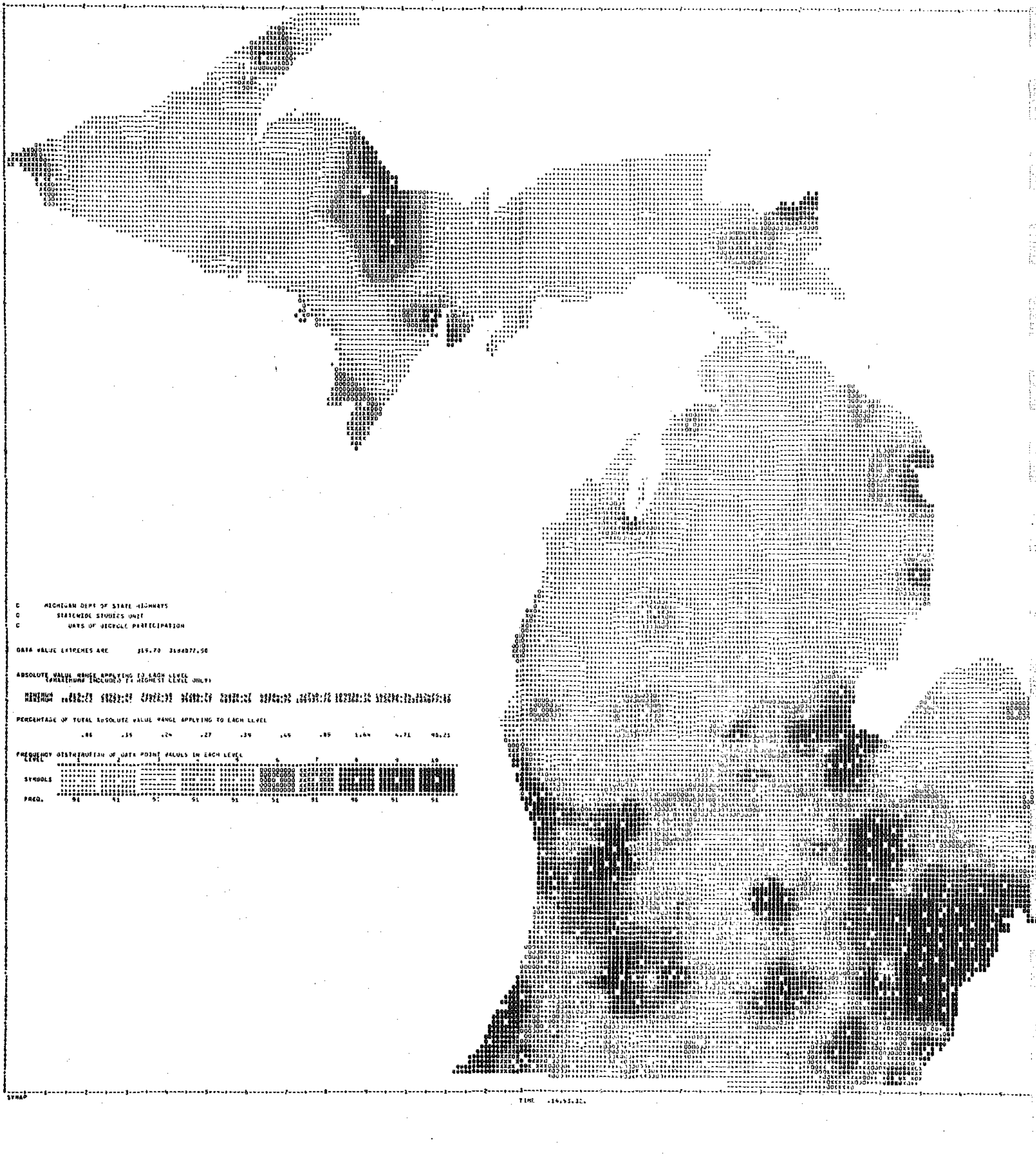
Finally, the process was developed with the idea that the system could effectively assist agency management in the daily decision making process. System analysis output is not measured in thousands of pages of computer listings or tons of output, but is presented on precise single page graphic display.

All statewide area information and analysis may be presented using graphics such as the area plot in Figure 40. This happens to be the bicycle demand each area has in relation to all other zones. The components of the modeling system automatically complete all data collection reformation and analysis required to generate this display. If a policy decision or transportation system change is suggested that may effect accessibility of an area this change can be evaluated and the resulting impact displayed for comparison.

Transportation analysis on a "link" basis for the total system may also be displayed in a manner similar to Figure 41, which is a bandwidth plot of psychological impact factors.

FIGURE 40

# BICYCLE DEMAND



If desired, the actual factor could have been plotted beside the link instead of using bandwidths. Techniques such as this will effectively allow management to accumulate vast amounts of transportation information in a very short time frame for later use in agency decisions.

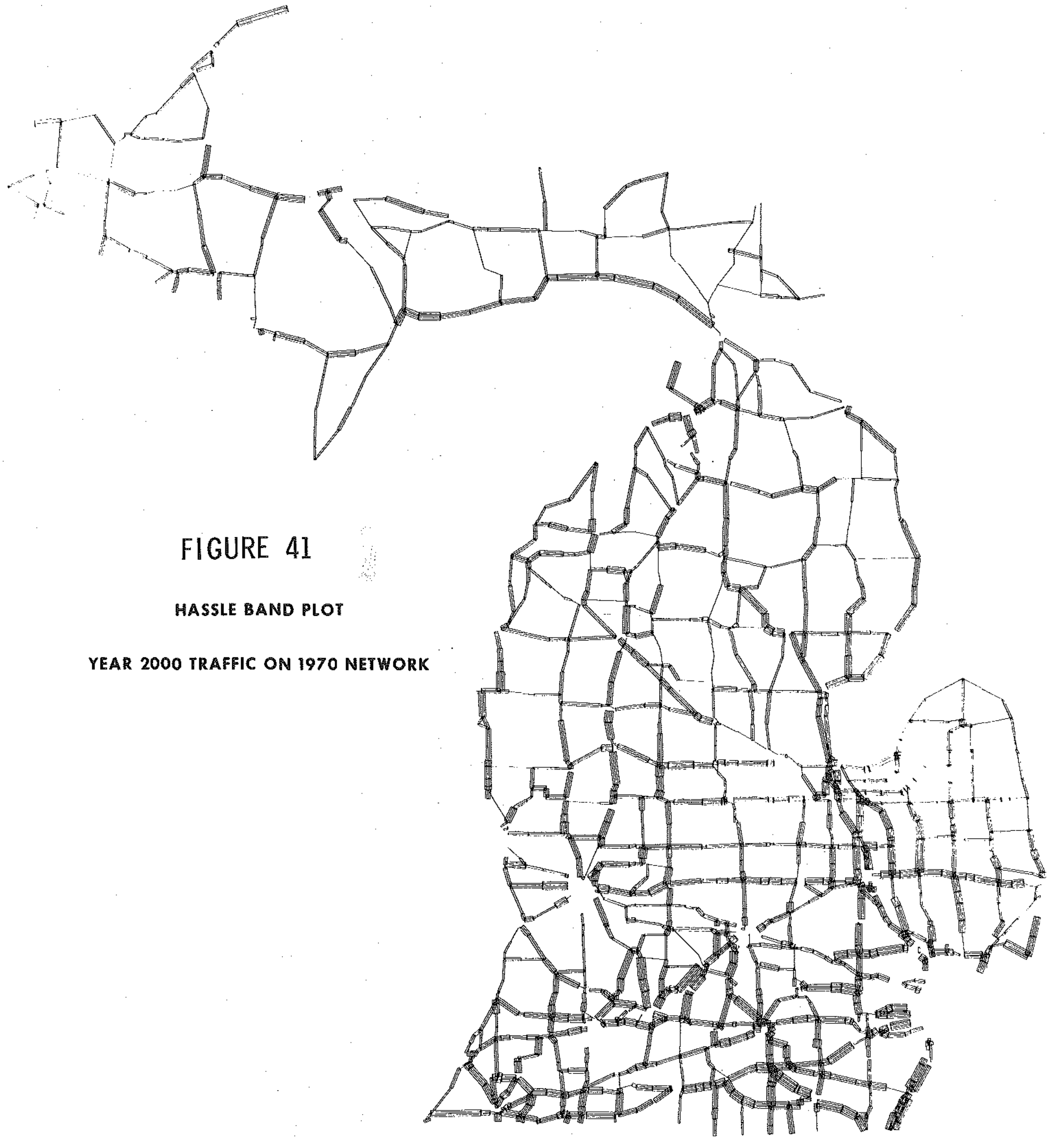


FIGURE 41

**HASSLE BAND PLOT**

**YEAR 2000 TRAFFIC ON 1970 NETWORK**

# STATEWIDE MODELING BIBLIOGRAPHY

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| | | |
|---|---|---|
| Volume | I | Objectives and Work Program |
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| Volume | IC | Model Application: Turnbacks |
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| Volume | IIIA | Semi-Automatic Network Generator Using a "Digitizer" |
| Volume | IV | Total Model Calibration - 547 Zone Travel Model |
| Volume | VA | Travel Model Development Reformation - Trip Data Bank Preparation |
| Volume | VB | Development of the Statewide Socio-Economic Data Bank for Trip Generation-Distribution |
| Volume | VI | Corridor Location Dynamics |
| Volume | VII | Design Hour Volume Model Development |
| Volume | VIII | Statewide Public and Private Facility File |
| Volume | IX | Statewide Socio-Economic Data File |
| Volume | X | Level of Service Impact Analysis Model (July 73) |
| Volume | XI | Service Area Model (July 73) |
| Volume | XII | Highway Capacity Deficiency Frequency Analysis Model (July 73) |
| Volume | XIII | Statewide Land Use Analysis (August 73) |

# STATEWIDE MODELING SYSTEM APPLICATION BIBLIOGRAPHY

Regional Park Proximity Analysis

Rifle Range Proximity Analysis

Airport Proximity Analysis

Hospital Proximity Analysis

Industrial Park Proximity Analysis

Graphic Display of Accident Data

Proximity of Automobile Injury Accidents to Hospitals