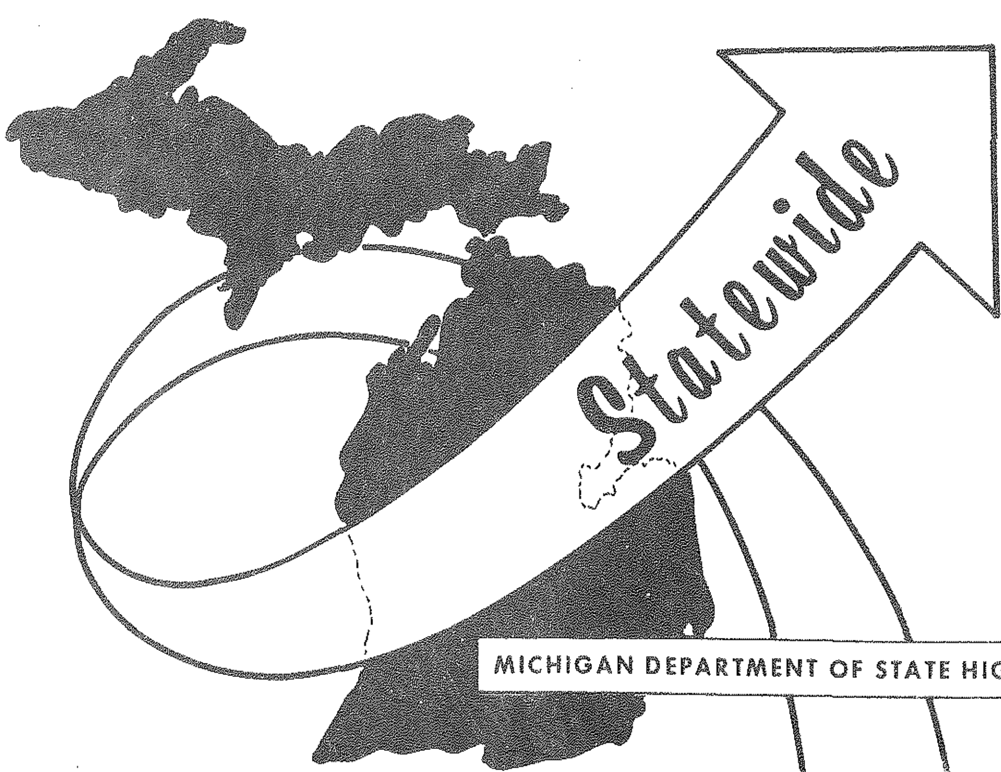
Statewide Transportation Analysis & Research

Michigan's
Statewide Transportation
Modeling System

Volume X-B

MODEL-RELATED
STATEWIDE SOCIAL IMPACT
ANALYSIS PROCEDURES
Statewide Research and Development
July 18, 1974



MICHIGAN DEPARTMENT OF STATE HIGHWAYS AND TRANSPORTATION

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OF

STATE HIGHWAYS AND TRANSPORTATION

BUREAU OF TRANSPORTATION PLANNING

Michigan's
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July 18, 1974

STATE OF MICHIGAN

WILLIAM G. MILLIKEN, GOVERNOR

DEPARTMENT OF STATE HIGHWAYS AND TRANSPORTATION

STATE HIGHWAYS BUILDING – POST OFFICE DRAWER K – LANSING, MICHIGAN 48904

JOHN P. WOODFORD, DIRECTOR

Mr. Sam F. Cryderman
Deputy Director
Bureau of Transportation Planning

Dear Mr. Cryderman:

The Transportation Survey and Analysis Section of the Transportation Planning Division is pleased to present Volume X-B in a series of reports that explain ways in which the "Statewide Transportation Modeling System" can be used to perform impact analyses. This volume documents how the model and related analysis tools can be applied to the problem of determining the relative social impacts of alternative highway patterns at the statewide and regional analysis levels. Specifically, the report contains an explanation of how seven analysis techniques can be applied to measure the relative social impacts of three highway alternatives in the Northwest Region of Michigan's lower peninsula.

The emphasis is not on making definitive selection of one of the Alternates relative to the others based on social criteria, rather it is on explaining how the Modeling System can be utilized to provide the information needed to make various social impact analyses as required by Federal law. Because the Modeling System offers a systematic method of data compilation and analysis, it is our belief that it provides the most efficient and expeditious process for acquiring the needed data.

The seven impact measurement techniques explained here do not define all the capabilities of the Modeling System for performing social impact analyses. On the contrary, these techniques are only an indication of the multiplicity of ways in which the Model can be applied. The Model is constantly being refined to make analyses more accurate and expanded to provide as much data as is needed for comprehensive transportation planning. We feel that the potential of this Modeling System is substantial and that with growing demand for a wide range of data it will be increasingly valuable in the planning process.

The report was prepared by Mr. Jeffrey L. Walters of the Statewide Studies Unit with the supervision of Mr. Richard E. Esch.

Sincerely,

R. J. Lilly

Richard J. Lilly, Administrator
Highway Planning Division

MICHIGAN
THE GREAT LAKE STATE

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STATEWIDE ECONOMIC IMPACT ANALYSIS PROCEDURES

BY

Jeffrey L. Walters

PREFACE

PREFACE

This is the second in a series of three reports that deal with ways in which the Michigan Statewide Transportation Modeling System can be utilized to perform impact studies. The other two reports in this weries are:

Volume X-A: Statewide Travel Impact Analysis Procedures

Volume X-C: Statewide Economic Impact Analysis Procedures

This report, Volume X-B, describes ways in which the model can be use to measure social impacts of alternative road proposals. Previous reports about the Statewide Model have dealt primarily with how it was developed to create an intergrated system of information retrieval and analysis, and with how certain analytical routines could be utilized to provide information about specific problem areas. This series, however, is designed to demonstrate that the Statewide Model, through the utilization of a number of its constituent elements, can be used to accomplish a multi-faceted study such as a social impact study. A great number of different measurements can be taken using the various system component models.

The Federal Aid Highway Act of 1970 requires that state highway departments consider fully the economic, social and environmental impacts of new road alternatives in relation to the existing road system. A dynamic, systemic model process could perform many of these tasks comprehensively or accurately. Michigan's Statewide Transportation Modeling System is such a model. The results of studies using the Social Impact Analysis procedures outlined in this report should be beneficial to administrators and planners working in a wide variety of disciplines. Most importantly, such results should be beneficial to the highway department in supplying the information required by law.

OTHER REPORTS IN THE STATEWIDE TRAVEL MODELING SERIES

Volume	I	Objectives and Work Program
Volume	I-A	Region 4 Workshop Topic Summaries
Volume	I-B	Single and Multiple Corridor Analysis
Volume	I-C	Model Applications: Turnbacks
Volume	I-D	Proximity Analysis: Social Impacts of Alternate Highway Plans on Public Facilities
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Volume	I-K	Effective Speed Model: A Public Interaction Tool
Volume	II	Development of Network Models
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Volume	V	Part A - Travel Model Development: Reformation - Trip Data Bank Preparation
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Volume	IX	Statewide Socio-Economic Data File
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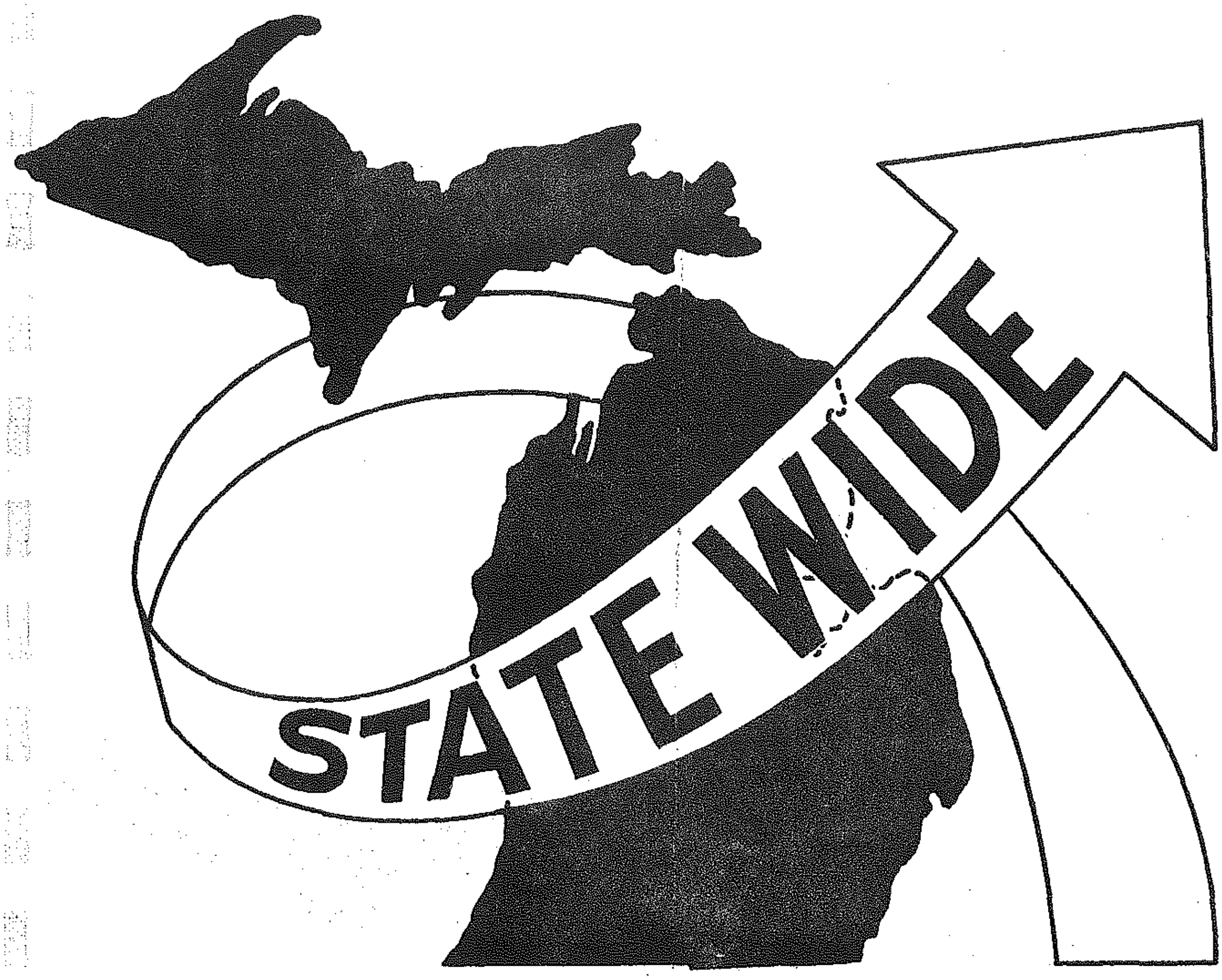
Volume	X-B	Statewide Social Impact Analysis Procedures
Volume	X-C	Statewide Economic Impact Analysis Procedures
Volume	XI	Computer Run Times - An Aid in Selecting Statewide Travel Model System Size

INTRODUCTION

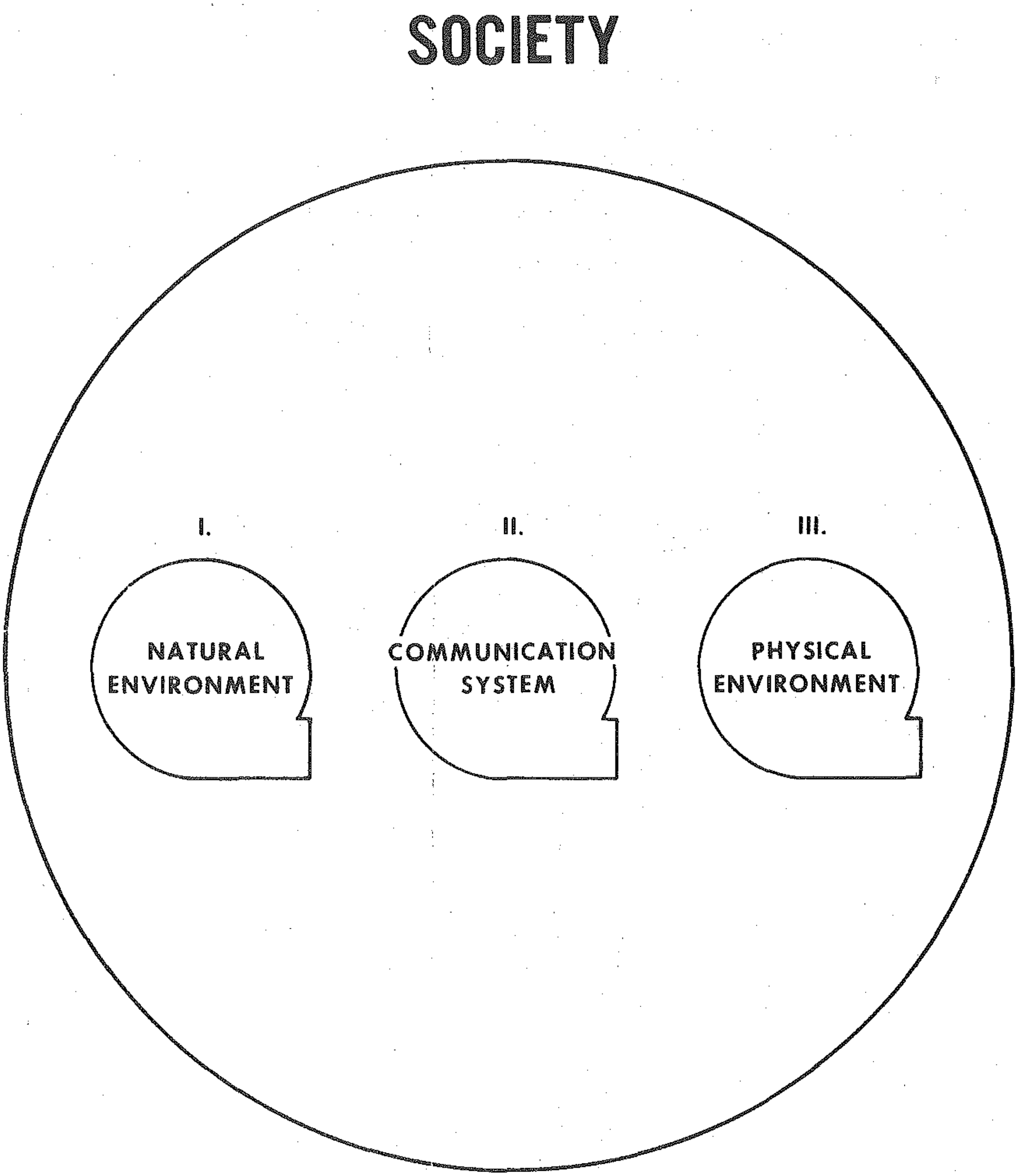


INTRODUCTION

The Statewide Transportation Modeling System

The Statewide Transportation Model has been described in detail in a separate report entitled "A Statewide Transportation Modeling System Effectively meets the Transportation Challenge of the 70's". Therefore, the description of it here is only a bare outline. Stated concisely, the Statewide Transportation Model is a dynamic tool for information compilation and analysis. It is dynamic in two ways. First, it is capable of rapid information renewal. New data can be fed into the information files as it is received and old data can be eliminated or stored in secondary files. Second, it is capable of indicating the secondary effects of Highway Network changes as well as the primary effects. Few Transportation Models have such dynamic characteristics at this time.

It is the basic simplicity of the system that allows it to be such a dynamic tool. For data compilation the real world is divided into two environments; the Natural Environment and the Physical Environment (See Figure 1). The Natural Environment is conceived to be all parts of the real world not physically created by man, including man himself; the Physical Environment is considered to be the man-made physical environment. Connecting these two environments is a communication system. This system connects not only the two environments but also parts within each of them.



I. STATEWIDE SOCIO-ECONOMIC DATA FILE

II. STATEWIDE TRANSPORTATION NETWORK

III. STATEWIDE PUBLIC & PRIVATE FACILITY FILE

FIGURE 1

The functional base of the system reflects this conception of reality. A Statewide Socio-Economic Data file contains information about the natural environment. A sample of the information contained within that file is listed in Figure 2. A Statewide Public and Private Facilities File contains information about the physical, man-built environment. The information contained within that file is listed in Figure 3. Both of these files are capable of rapid updating and enlargement as new data becomes available. Finally, and most importantly, a Statewide Transportation Network File contains information about the Communication System. This file includes information about the existing highway network and possible alternative networks. See Figure 4 for an example. This file too is capable of rapid updating and enlargement.

For data analysis a number of component models have been created (See Figure 5). These models interrelate to create a unified analysis system. Each model utilizes at least one of the environmental information files as well as the statewide network file; some models utilize all three files.

All information is related to geographical areas in the State thru a zone system. The State and contiguous areas outside the state are broken into 547 zones of which 508 are instate zones (See Figure 6). Zone sizes and boundaries have been determined on the basis of population, land area, political boundaries and other relevant factors. In each file, data are related to zones by zone numbers and facilities are located

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 2

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

STATEWIDE FACILITY FILE

FIGURE 3

AIRPORTS
AMBULANCE SERVICE
BUS TERMINALS
CAMP GROUNDS, PUBLIC AND PRIVATE
CERTIFIED INDUSTRIAL PARKS
CITIES OVER 30,000 POPULATION
CITIES OVER 5,000 POPULATION
CIVIL DEFENSE TERMINALS
COLLEGES, NON-PUBLIC
COLLEGES, PUBLIC COMMUNITY
COLLEGES AND UNIVERSITIES, PUBLIC 4 YEAR
CONVENTION CENTERS
GAME AREAS
GOLF COURSES
HIGH SCHOOLS
HISTORIC SITES
HOMES FOR THE AGED
HOSPITALS
MAJOR COMMERCIAL CENTERS
MANUFACTURERS
MENTAL HEALTH CENTERS
NEWSPAPERS, DAILY
NEWSPAPERS, WEEKLY AND BIWEEKLY
NURSING HOMES
PORTS
RAIL TERMINALS
SECRETARY OF THE STATE OFFICES
SEWAGE TREATMENT FACILITIES
SKI RESORTS
SNOWMOBILE TRAILS
STATE PARKS
STATE POLICE POSTS
TOURIST ATTRACTIONS
TREASURY OFFICES
TRUCK TERMINALS
UNEMPLOYMENT OFFICES
WEATHER SERVICE STATIONS-NATIONAL
WHOLESALE TRADE CENTERS

STATEWIDE HIGHWAY NETWORK

LINK FILE

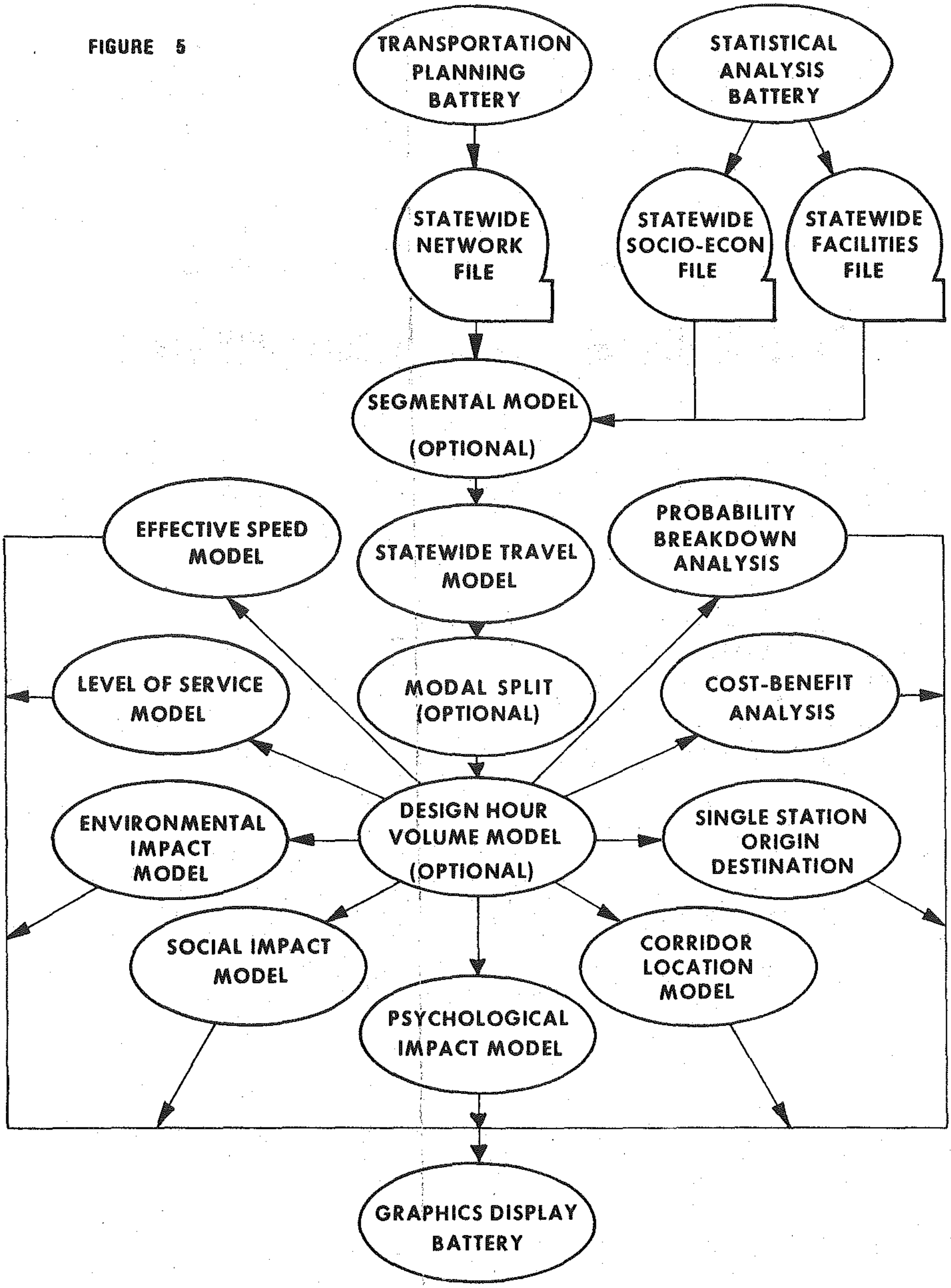
CONTENTS OF EACH HIGHWAY SEGMENT OR LINK

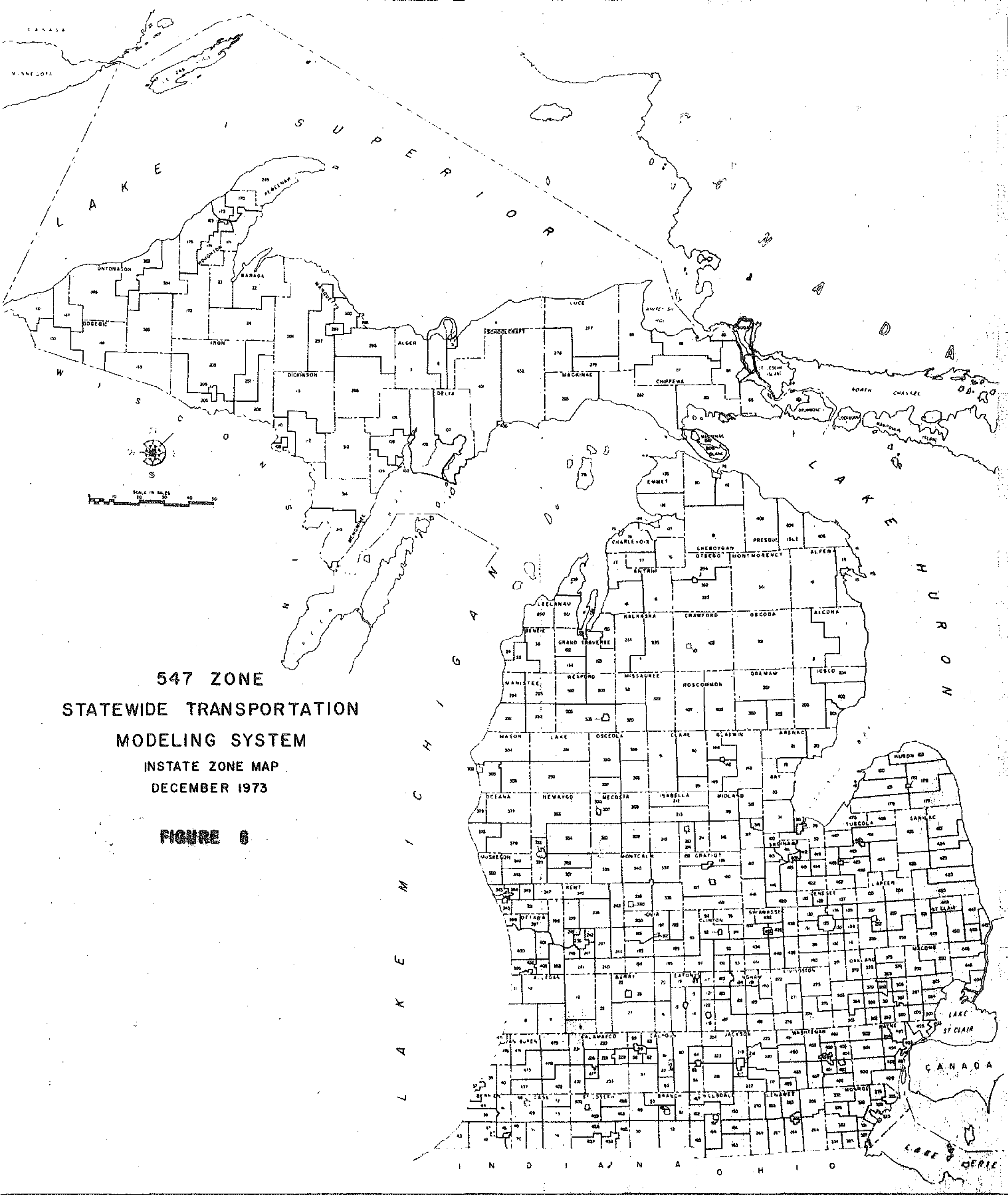
AVERAGE SPEED
DISTANCE
URBAN-RURAL DESIGNATION
TYPE OF ROUTE
TRAFFIC VOLUME CAPACITY
AVERAGE ANNUAL DAILY TRAFFIC VOLUME
COMMERCIAL TRAFFIC VOLUME
DESIGN HOUR VOLUME
ACCIDENT FATAL RATE
ACCIDENT INJURY RATE
ACCIDENT RATE
NUMBER OF LANES
LANE WIDTH
SURFACE CONDITION
RIGHT OF WAY
SIGHT RESTRICTION

FIGURE 4

STATEWIDE MODELING SYSTEM COMPONENTS

FIGURE 5





547 ZONE
STATEWIDE TRANSPORTATION
MODELING SYSTEM
INSTATE ZONE MAP
DECEMBER 1973

FIGURE 6

within zones by a grid system that is similar to latitude and longitude lines.

The discussion in this report will center around those components of the Transportation Modeling System that can be utilized in making social impact studies. The following components can be used: the Environmental Impact Model, the Social Impact Model, and the Statewide Travel Model, the Psychological Impact Model, Graphics Display Battery.

PROBLEM OF DEFINING SOCIAL IMPACT

In compliance with section (109h) of Title 23. U.S. code, state highway departments are required to study fully the economic, social and environmental impacts of new road alternatives in relation to the existing road system. Highway departments have been hard pressed to meet the challenge presented by these requirements. Not the least of the problem has been the confusion about what such studies should contain. In the case of the social impact study the major probelms have been to (1) define what is meant by social; (2) determine what impacted phenomena to use to measure social impact and (3) determine what basic units of measurement can be used to determine the extent of impact on any phenomena.

Actually, the answers to these three questions are highly interrelated and finding them depends more upon orienting ones mind to a certain perspective than upon discovering which activities are inately social as distinct from economic or environmental. The perspective utilized in this study is quite rightly called the social perspective. It requires that events be viewed using a value system based upon the health, safety and general welfare of the individual and of the communities within which the individual lives.

SOCIAL IMPACT AREAS AND MEASURES

Using the "social perspective" the Statewide Studies Unit has chosen a number of impact areas that can be used to illustrate clearly the impact of new road alternatives on health, safety and the general welfare. These impact areas are noise, health services, recreational opportunities, educational opportunities, psychological health, road safety and social disruption.

Having chosen these impact areas, the unit then faced the problem of choosing specific measures that would indicate to what extent alternative road networks would impact these areas. In dealing with noise as a social factor the measure chosen was the number of persons exposed to noise above 70 decibels. This level is considered to be psychologically distrubing and physically damaging. In dealing with the area of health services the measure chosen was the accessibility of persons to hospitals within certain travel times. Each measure for each impact area will be discussed in the section: Social Impact Analysis Procedures.

THE TEST AREA AND ALTERNATIVES

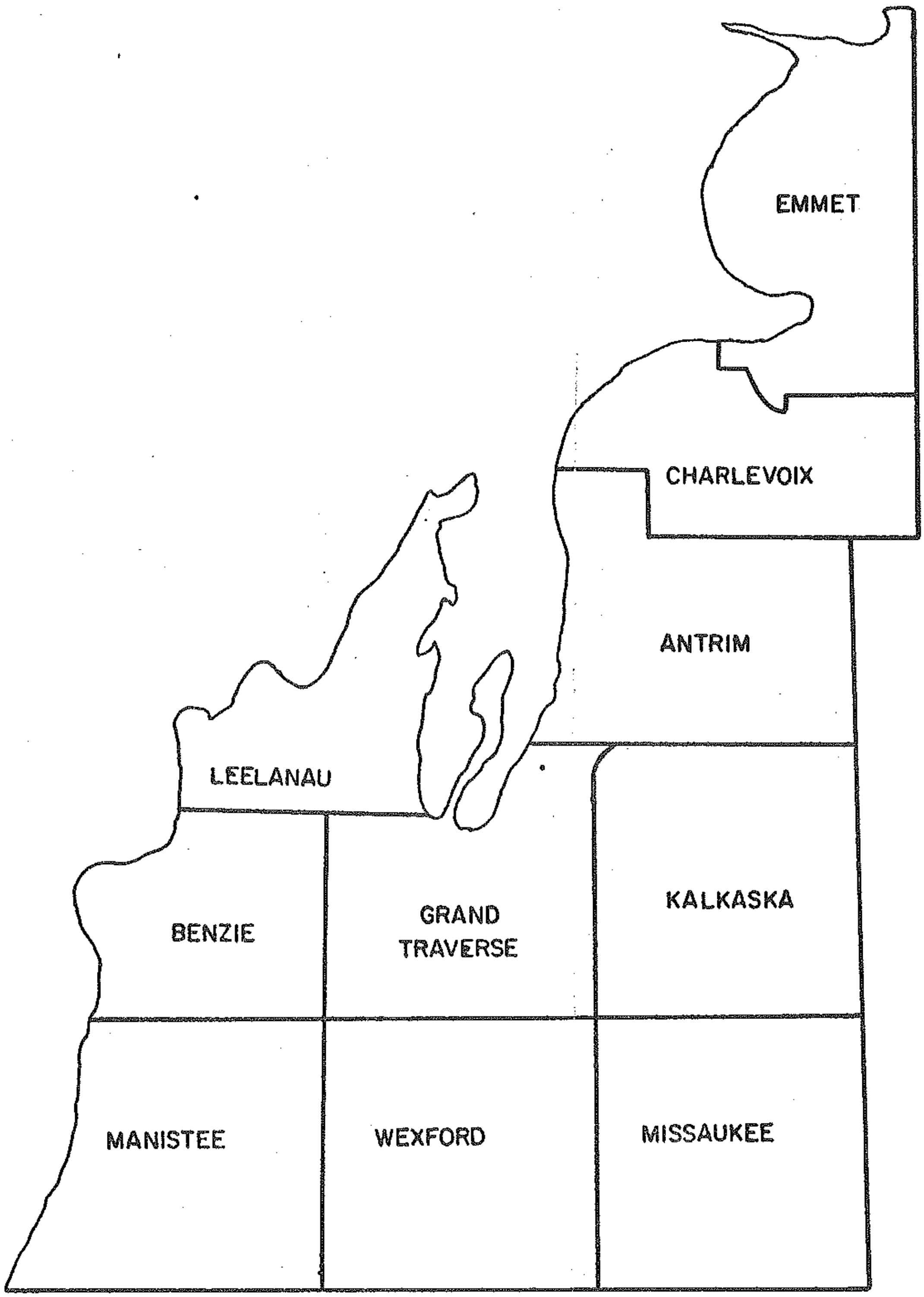
The best way to test the effectiveness of any modeling system is to apply it to a real world situation. To demonstrate how the Statewide Transportation Modeling System can be used to aid social impact studies the Statewide Studies Unit chose to analyze the impact of three alternative road systems in the northwest corner of Michigan's lower peninsula. See Figure 7.

Federal law requires that highway departments give serious consideration to not building any new roads. Therefore Alternate A is the existing road system. It is the "no-build" alternative. Alternates B and C represent two new possibilities as illustrated in Figure 8.

Each of these possibilities will impact the region differently. Traffic will flow differently with the different alternatives. Some areas will be more accessible than others; some areas will experience more air and noise pollution than others; some areas will have safer driving conditions than others depending upon which alternatives are chosen. That the impact of these alternatives will be different is obvious. What is not obvious, and what the Statewide Transportation Modeling System can help to determine, is the extent to which the alternatives will impact the region and the state in general. The model enables the highway planner to estimate with considerable speed and accuracy, the relative impacts of a number of different alternatives in the effort to determine which alternatives will be best according to predetermined criteria.

ANALYSIS AREA

FIGURE 7



SOCIAL IMPACT ANALYSIS PROCEDURES

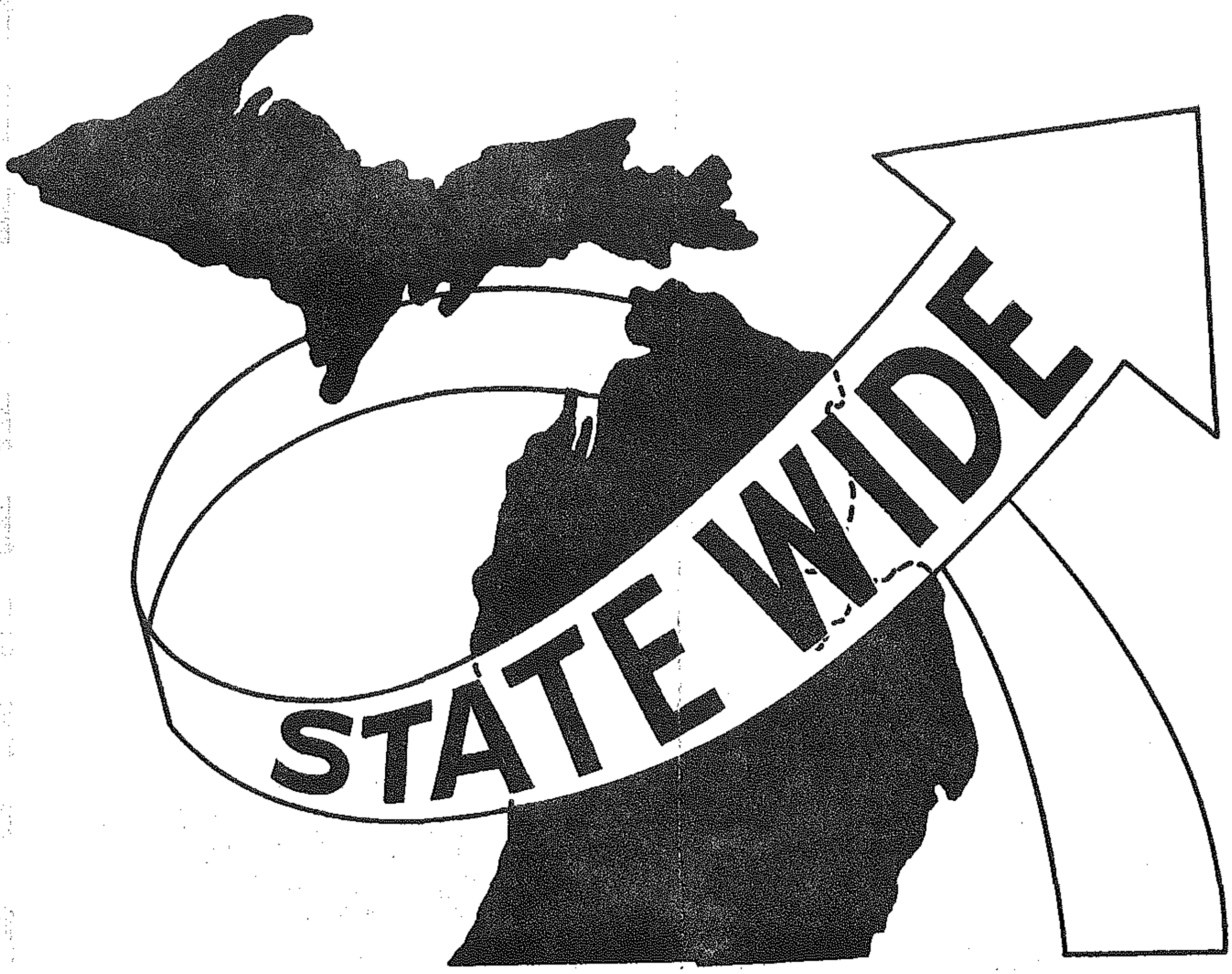
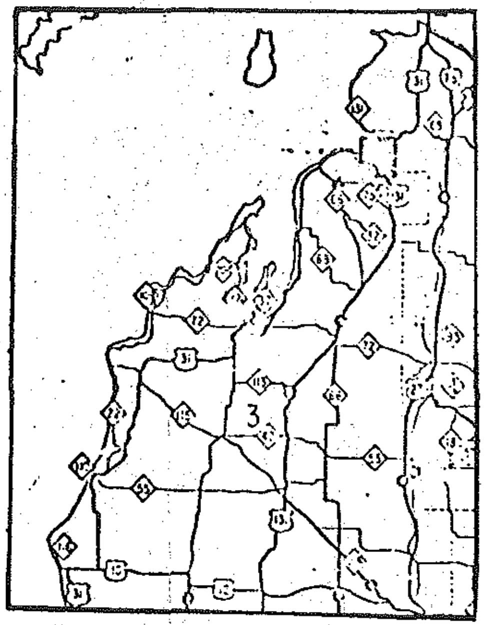
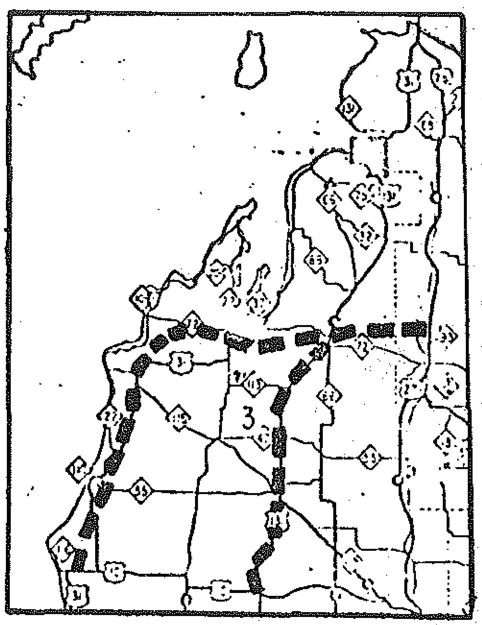


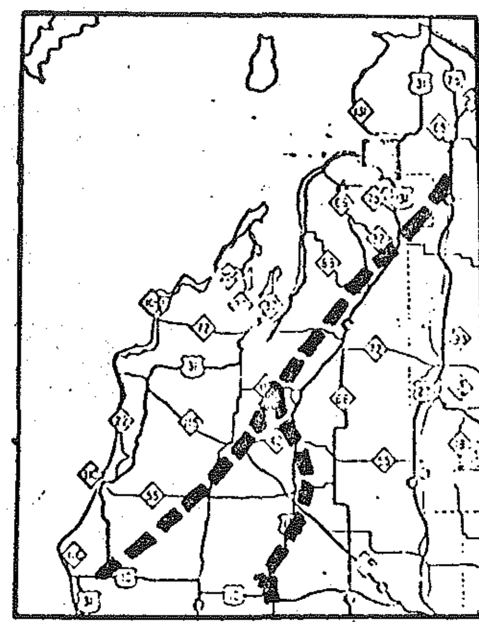
FIGURE 8



ALTERNATE "A"



ALTERNATE "B"



ALTERNATE "C"

SOCIAL IMPACT ANALYSIS PROCEDURES

Introduction

In this section each of the analysis procedures used in the study is explained in general terms. The emphasis is on explaining the relationships between the relevant variables and not on describing each analysis process in detail. Each of the processes has had a detailed report written about it and the reader is referred to these reports at the beginning of the discussion of each analysis technique.

The Social Impact Measures listed in Figure 9 are those discussed in this report. The order of these measures on the list is the order in which they are explained in this section. However, because the same analysis procedure is used for all four accessibility measures and because the technique is the same for each, it is explained only once here and not with specific reference to any particular measure.

PROXIMITY ANALYSIS

Within the Social Impact Model of the Statewide Transportation Modeling System is an automated routine called Proximity Analysis. This routine is designed to measure accessibility. Accessibility is an indefinite term that has been defined in a number of different ways. As used in the Statewide Transportation Modeling System accessibility is defined as the ease with which one can travel from a zone of origin to other zones called destination zones. The proximity analysis routine can be run using any one of three

SOCIAL IMPACT MEASURES

PROXIMITY ANALYSIS

- ACCESSIBILITY OF PEOPLE TO HEALTH SERVICES
- ACCESSIBILITY OF PEOPLE TO RECREATIONAL OPPORTUNITIES
- ACCESSIBILITY OF PEOPLE TO EDUCATIONAL OPPORTUNITIES
- ACCESSIBILITY OF PEOPLE BY AGE GROUP TO NECESSARY SERVICES

NOISE POLLUTION ANALYSIS

SAFETY ANALYSIS

SOCIAL DISRUPTION ANALYSIS

PSYCHOLOGICAL IMPACT ANALYSIS

RIGHT-OF-WAY ANALYSIS

PEDESTRIAN DEPENDENCY ANALYSIS

FIGURE 9

measures of Accessibility: (1) travel time between the zone of origin and zones of destination; (2) distance between these zones; (3) cost of travel between these zones. A detailed description of the possible applications of this routine is contained in the report, "Proximity Analysis; Social Impacts of Alternate Highway Plans on Public Facilities" (September 1972). Therefore, the description here will be brief and related to the ways in which proximity analysis can be used to measure the social impact of the chosen alternates.

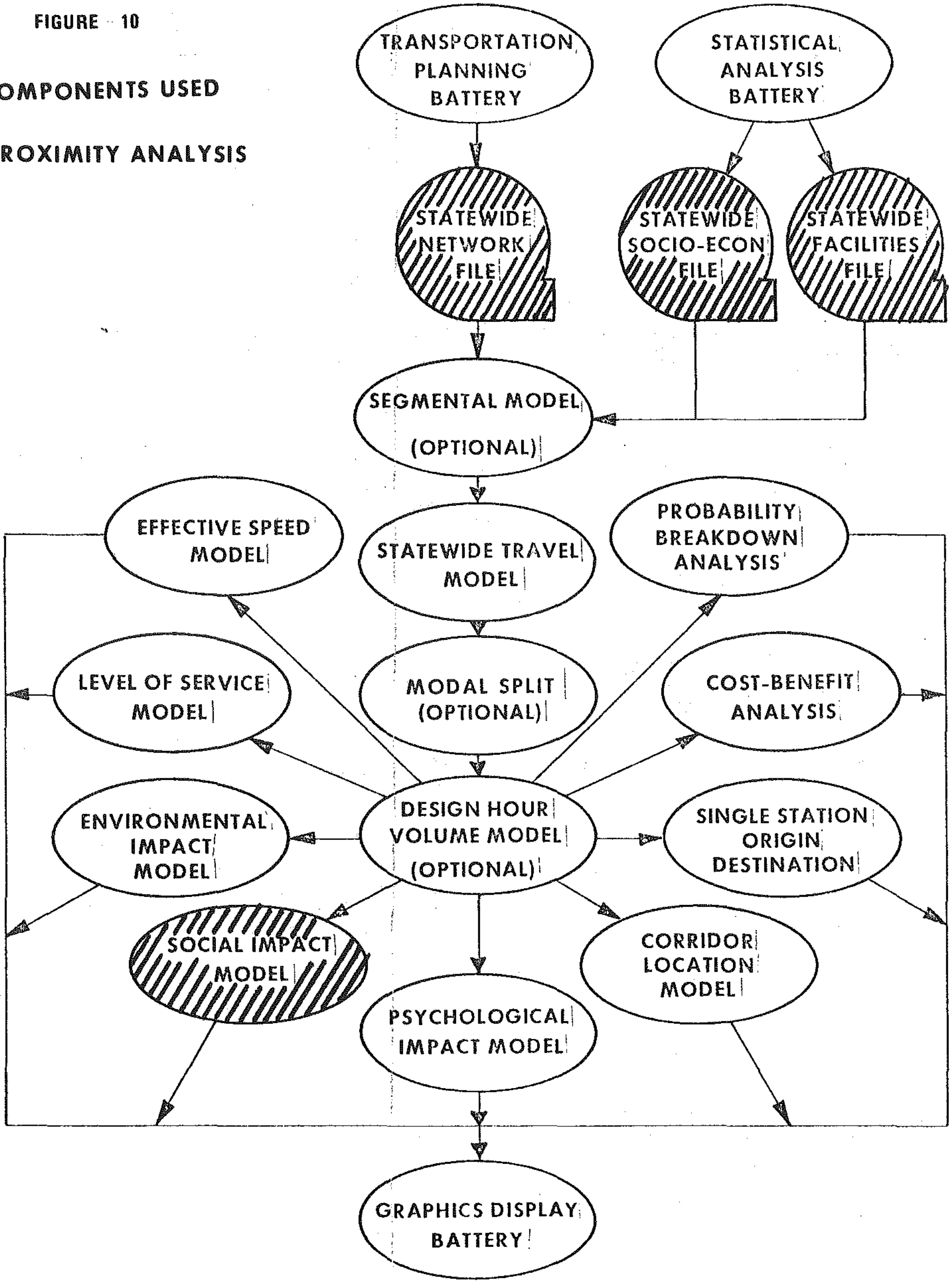
Figure 10 indicates the components of the Statewide Transportation Modeling System that are utilized in proximity analysis. For the purposes of this report the accessibility measure chosen was that of travel time between zones. Average travel times on links on all major county roads, state trunklines and interstate roads are recorded in the Statewide Network File. In determining the travel time between any two zones the computer scans this information and determines the route requiring the shortest travel time between the centroid of the origin zone and the centroid of any desired destination zone. These times are then used in determining accessibility of one zone to another.

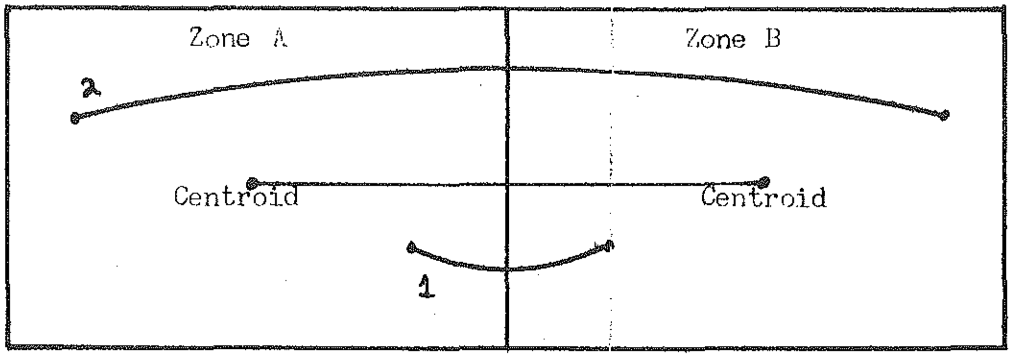
It should be remembered that the centroids of the zones are the key to all analysis using the zone system. In determining the travel time between zones the analysis utilizes travel times between two contiguous zones A and B as shown below will always be considered ten minutes.

STATEWIDE MODELING SYSTEM COMPONENTS

FIGURE 10

COMPONENTS USED IN PROXIMITY ANALYSIS





In reality a trip could originate at the eastern edge of zone A and end at the western edge of zone B (Trip 1) requiring only a minute or less of travel. Conversly, however, a trip could originate at the western edge of zone A and end at the eastern edge of zone B (Trip 2) requiring nineteen minutes of travel. The justification for the use of centroids is that they lie midway between such extremes and thereby represent the median point of accessibility to all population and facilities in the zone. When all zones in the system are used in an analysis the error created by the use of centroids is minimal. When regional and local analyses are made the possibility of error is greater but still not so great that the analysis is not useful.

For the purposes of proximity analysis all data from the socio-economic file and all data from the facility file is related to the centroid of each zone. Thus in a proximity scan zonal information is summated in quantum jumps. No population or facilities in a destination zone are considered to be within a certain time of any centroid of origin until the centroid of the destination zone is reached in the time scan.

There is a direct relationship between the geographical analysis level at which one is working and the need for centroids associated with smaller aggregates of information. At the level of statewide impacts a model using larger zones and therefore, fewer centroids can simulate reality quite well. For regional or local analyses there is a need for smaller zones, implying more centroids and smaller aggregates of information per centroid. The user must determine the number of zones, and consequently, centroids he wishes to use and which his hardware will allow him to use.

The proximity analysis routine is capable of relating and summarizing data in a number of ways. The user has three options each of which relates or summarizes data differently. The reader should consult the report on proximity analysis mentioned earlier for a detailed description of these three options. Two options were chosen for the purposes of this report. Option 1 allows the analyst to choose a server zone, one in which a facility is located, and scan around that zone using the shortest time path matrix and a chosen series of travel time intervals. The scan is designed to perform two functions. It determines the number of people with selected socio-economic characteristics who are within the specified travel time of the server zone, and it indicates how many other server facilities are within the specified travel times of the server zone. An example of the output from Option 1 is in Figure 11.

FIGURE 11

STATEWIDE PROXIMITY ANALYSIS

PROXIMITY OF POPULATION

DATA FOR ZONE 151
POPULATION = 20690
NUMBER OF HOSPITALS = 2
TOTAL CAPACITY = 328

	0- 15	0- 15
POPULATION	20690	20690
PERCENT OF TOTAL POPULATION	0.233	0.233
HOSPITALS	2	2
POPULATION /HOSPITALS	10345.00	10345.00
	15- 30	0- 30
POPULATION	22912	43602
PERCENT OF TOTAL POPULATION	0.258	0.491
HOSPITALS	0	2
POPULATION /HOSPITALS	0.00	21801.00
	30- 45	0- 45
POPULATION	23806	67408
PERCENT OF TOTAL POPULATION	0.268	0.760
HOSPITALS	2	4
POPULATION /HOSPITALS	11903.00	16852.00
	45- 60	0- 60
POPULATION	13715	81123
PERCENT OF TOTAL POPULATION	0.155	0.914
HOSPITALS	1	5
POPULATION /HOSPITALS	13715.00	16224.60

The format of the output is predicated on the idea that the user will be measuring the accessibility of socio-economic data to facility file data. In this particular example the socio-economic file data is population and the facility file data is hospitals. The first column of information presents the accessibility of people to hospitals by time bands. Thus within 0-15 minutes of Zone 151 there are 20,690 people who represent .233 percent of the total state population. There are also two hospitals within 0-15 minutes travel time of zone 151, and the ratio of hospitals to people is 10,345 to 1. The second column presents cumulative totals of the information provided by time band in column 1.

Option 2 allows the analyst to determine how many server facilities are within specified travel times of the population in each zone given a particular travel alternative. The routine takes each zone in the state individually and scans around that zone in the same way it does for option one. However, instead of scanning around a facility zone to determine the number of people within specified travel times of that facility zone, the routine scans around the population in each zone to determine the number of facilities within specified travel time of that population. The routine then takes this information and relates it in a number of ways. An example of the output from Option 2 is in Figure 12.

In considering the listing for Zone 6 the output should be interpreted in the following way within 0-15 minutes travel

STATEWIDE PROXIMITY ANALYSIS

SERVER PROXIMITY

ZONE	SERVICE ZONES	HOSPITALS	CAPACITY	POPULATION /HOSPITALS	POPULATION /
1 0- 15MIN.	0	0	0	0.00	0.00
1 0- 30MIN.	0	0	0	0.00	0.00
1 0- 45MIN.	1	1	165	5928.00	35.93
1 0- 60MIN.	2	2	209	2964.00	28.36
2 0- 15MIN.	0	0	0	0.00	0.00
2 0- 30MIN.	0	0	0	0.00	0.00
2 0- 45MIN.	0	0	0	0.00	0.00
2 0- 60MIN.	0	0	0	0.00	0.00
3 0- 15MIN.	1	1	34	3677.00	108.15
3 0- 30MIN.	1	1	34	3677.00	108.15
3 0- 45MIN.	1	1	34	3677.00	108.15
3 0- 60MIN.	1	1	34	3677.00	108.15
4 0- 15MIN.	0	0	0	0.00	0.00
4 0- 30MIN.	0	0	0	0.00	0.00
4 0- 45MIN.	0	0	0	0.00	0.00
4 0- 60MIN.	0	0	0	0.00	0.00
5 0- 15MIN.	0	0	0	0.00	0.00
5 0- 30MIN.	0	0	0	0.00	0.00
5 0- 45MIN.	1	1	34	2276.00	66.94
5 0- 60MIN.	2	4	441	569.00	5.16
6 0- 15MIN.	1	1	34	577.00	16.97
6 0- 30MIN.	1	1	34	577.00	16.97
6 0- 45MIN.	1	1	34	577.00	16.97
6 0- 60MIN.	2	4	441	144.25	1.31

FIGURE 12

time from Zone 7 there is one service zone that contains at least one hospital. There is one hospital in that zone. That hospital has a capacity of 34 beds. There are 3,677 people in Zone 6 thus the ratio of people to hospitals that can be reached in 15 minutes is 3677 to 1. Because there are 34 beds in the hospital the ratio of people in the zone to hospital beds that are available within 15 minutes is 108.15 to 1. Each of the time bands in this output contains cumulative data, thus to determine relationships within a given time band, other than the first, one simple takes the difference between the band under consideration and the one immediately preceeding it.

NOISE POLLUTION ANALYSIS

The Air and Noise Pollution Model developed by the Statewide Studies Unit in July 1973 (Volume 1-F) is now part of the Statewide Transportation Modeling System. It is contained within the Environmental Impact Model. This model is an integral part of the overall system. It cannot function independently of the system because it relies upon other system components for input. (See Figure 13 for components utilized). It utilizes the Statewide Socio-Economic data file for population data input. The population data is recorded by zone and forecasts are available for every 5 years from 1970 to 2000. It calls upon the Statewide Network File for information about various aspects of the road network: link types, link distances, location of links. It also relies upon the Statewide Travel Model to provide forecasts of future traffic volumes on the various links under consideration. The overall system is absolutely necessary for an analysis of this sort. No partial model can obtain the same results.

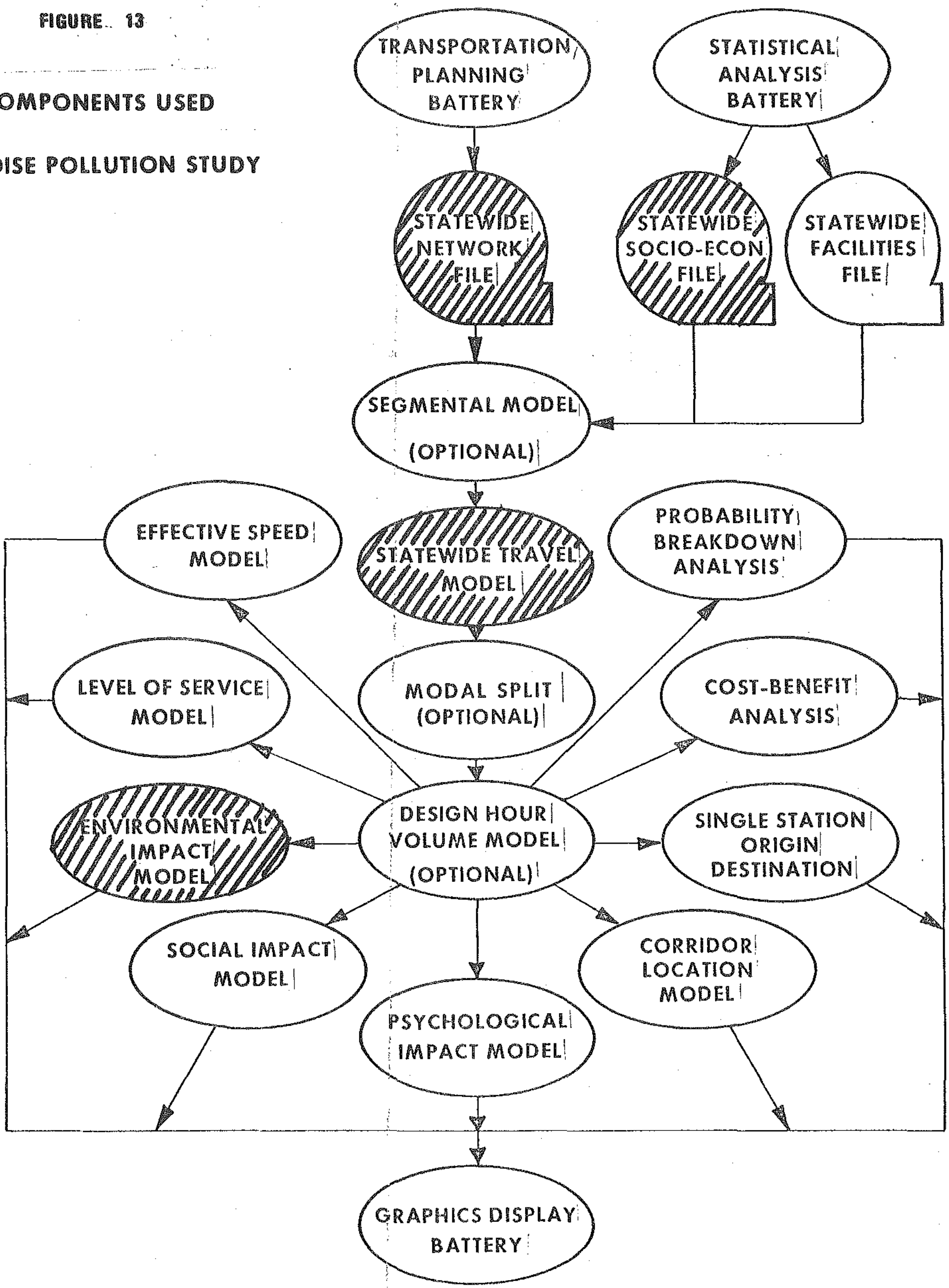
In determining the social impact of noise, the model measures the number of people exposed to a noise level of 70 decibels or more using different highway alternatives. Briefly, the model works as follows. Noise levels are considered to be a function of two major variables: speed of traffic on the link, and the number of vehicles on the link. (An additional variable, the percent of the traffic that is commercial, will be added to the model in the near future). Depending upon the values of these two variables noise of 70 decibles or more will be generated a certain number of feet from the center of the road right-of-way.

STATEWIDE MODELING SYSTEM COMPONENTS

FIGURE 13

COMPONENTS USED

IN NOISE POLLUTION STUDY



The routine calculates this distance for each link and determines the area impacted along each link by multiplying the width of the impact area by the length of the link. If then subtracts the area taken by the right-of-way of the link because no one can live or work within the right-of-way. This net area then is the potential area in which people living and working along the link could be impacted by the selected noise level.

The only problem then was one of determining how many live or work within the impact area. Since there are no surveys indicating the exact number of people within given distances of all links in the Statewide network, it was necessary to creat a method to estimate the number of people who live or work within the impact areas.

A method was created based upon application of an average density figure for each zone. An assumption was made that all population in a zone is relatively evenly distributed throughout the zone. Thus the average population density for each zone was assumed to be the density for any part of that zone. To determine the number of people impacted by noise along each link, therefore, it was only a matter of multiplying the net land area impacted by the chosen noise level, 70 decibels, by the average density figure for the zone under consideration. The total number of people impacted then could be determined by suming the number of people impacted per link.

The average density figure was applied with the realization that a certain degree of error could be involved. Error could arise because the zone under analysis could be characterized by clearly defined rural and urban areas and not by a uniformly distributed population. Even this error would not be significant, however, if the analysis zone was predominantly urban and the urban areas were scattered relatively uniformly throughout the zone. The largest error would come in larger zones that contained extensive rural areas with pockets of urban population. In these cases, an average population density figure applied to the noise impact areas would not reflect the real density situation of relatively low density in almost all of the zone and high density in one or two isolated areas.

Given that the Statewide Transportation Modeling System was designed to perform statewide and large region highway impact analyses, the use of the average population density figure and large zones is adequate. This is true because overcounting in some zones is counterbalanced by undercounting in others. However, in making smaller area analyses using fewer zones, the errors created could be significant. Therefore, the user should determine the zone size necessary for accuracy at his analysis level. A 2,300 zone system is currently being created to replace the 547 zone system for smaller region analyses in Michigan. By using smaller zones there will be less chance of error in applying average population density figures to the noise pollution routine.

SAFETY ANALYSIS: VEHICLE MILES AND ACCIDENTS

The Statewide Studies Unit has created a program that utilizes the Statewide Network File and the Statewide Travel Model (see Figure 14) to create county, regional, or state summaries of vehicle miles and accidents. Through a series of simple logical steps the computer creates summaries that can be used to determine the relative safety and time savings of alternate road systems. The program works as follows:

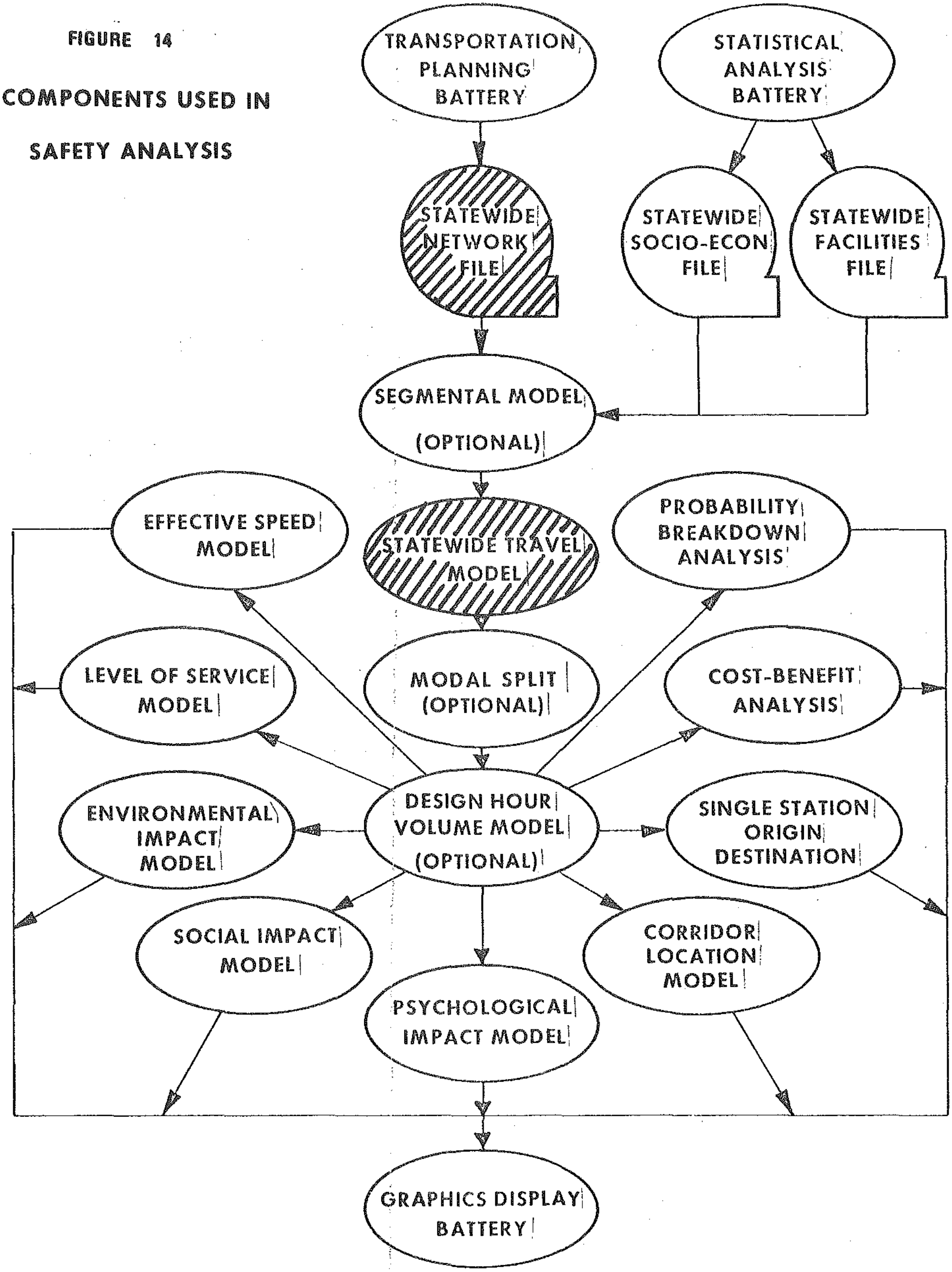
The Statewide Network File contains the following pertinent information: (1) the length of each link in the statewide network, in miles; (2) average annual daily traffic, given as the number of vehicles that use each link per day, and (3) the accident rate per link, given as a ratio of the number of accidents for every 100,000,000 vehicle miles traveled. By multiplying the length of each link by the number of vehicles using the link per day the computer determines the number of vehicle miles traveled per link per day. It next multiplies these daily vehicle mile figures by 365 to determine yearly vehicle miles traveled per link. Then, by adding the yearly vehicle miles of all the links within a county or region or the state, the computer can provide vehicle mile summaries for any of these geographical choices.

To obtain the number of accidents per link by the number of vehicle miles traveled on each link per year. To obtain accident summaries by specified geographical areas the computer adds the yearly number of accidents for each link in the summary area.

STATEWIDE MODELING SYSTEM COMPONENTS

FIGURE 14

COMPONENTS USED IN SAFETY ANALYSIS



Current link data is based upon field information derived from origin and destination studies and accident reports. Future link data is derived from a trip generation and distribution model (part of the statewide travel model) which was synthesized from basic gravity model concepts. The trip generation and distribution model can assign trips to theoretical alternative road networks. Accident rates can be assigned using rates for links that have similar characteristics. Vehicle mile and accident summaries can then provide aggregates of information which include these theoretical links. These aggregates can then be used to make comparisons of economy and safety.

SOCIAL DISRUPTION ANALYSIS

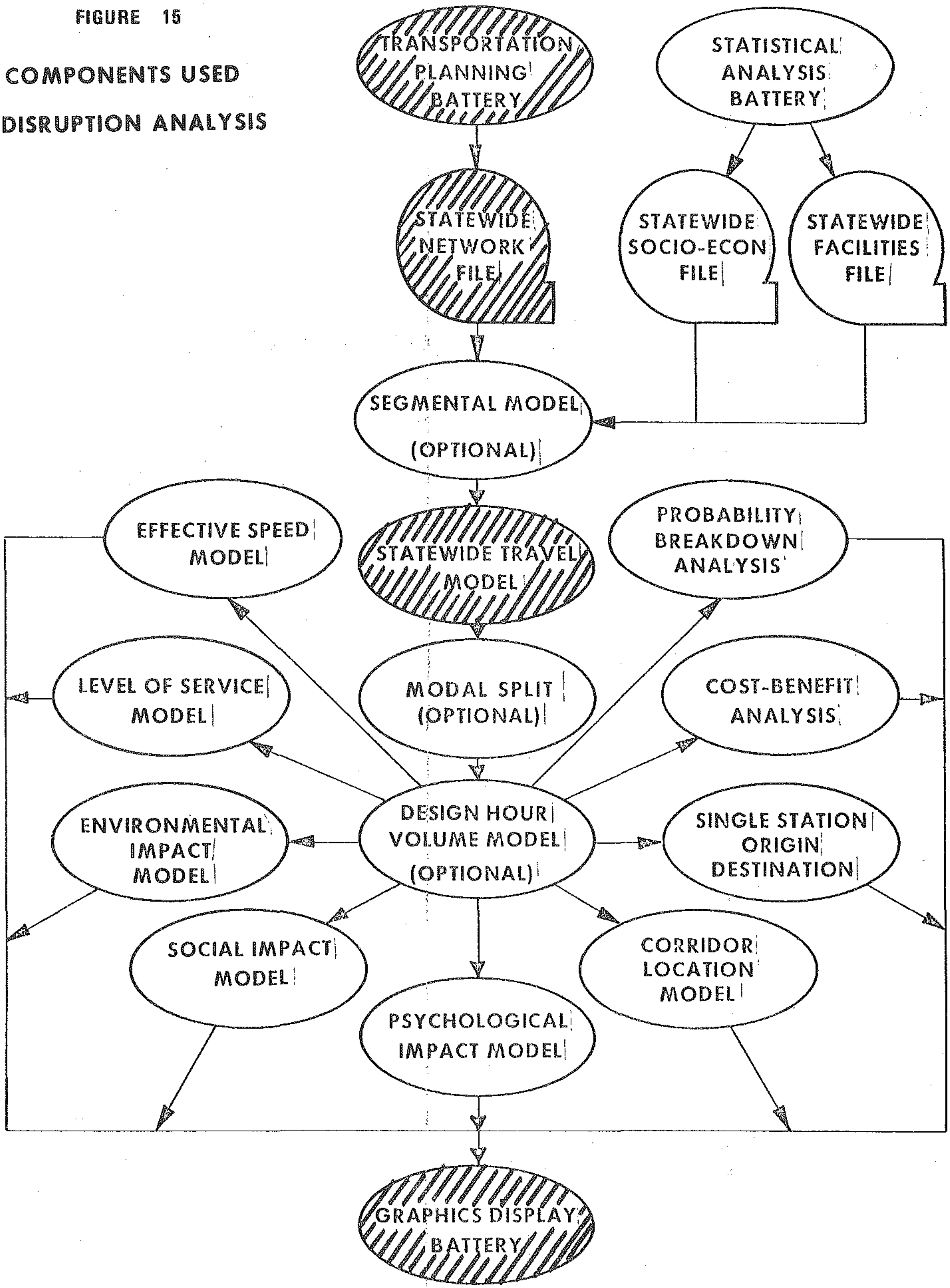
Although social disruption can be defined in a number of different ways, in general, it can be viewed as the creation of a disequilibirum in an existing setting. When a new highway is constructed in a region new travel alternatives are created and disruption occurs. Travel patterns are changed because different attraction areas have new accessibility times. In most cases a new highway will make all attraction centers closer, in time, to the population of a region, and in such cases no negative disruption is considered to have been caused. However, there are cases in which new highways create barriers that prevent people from traveling to an attraction zone as quickly as they could before the highway was built. For example, if a highway were built that cut an existing road, prohibiting through traffic, people who once used the road for through-travel purposes might find themselves forced to take a longer time route to their desired destination. In such a case it can reasonably be assumed that a negative disruption has been created.

Few roads are closed in such a manner at the statewide network level. Generally, new intercity highways are constructed with overpasses and underpasses for significant rural roads. However, sometimes rural roads are cut and negative disruptions may occur. At such times the Statewide Transportation Modeling System can help to determine if negative disruptions are created. More importantly, this technique for determining negative disruption

STATEWIDE MODELING SYSTEM COMPONENTS

FIGURE 15

COMPONENTS USED IN DISRUPTION ANALYSIS



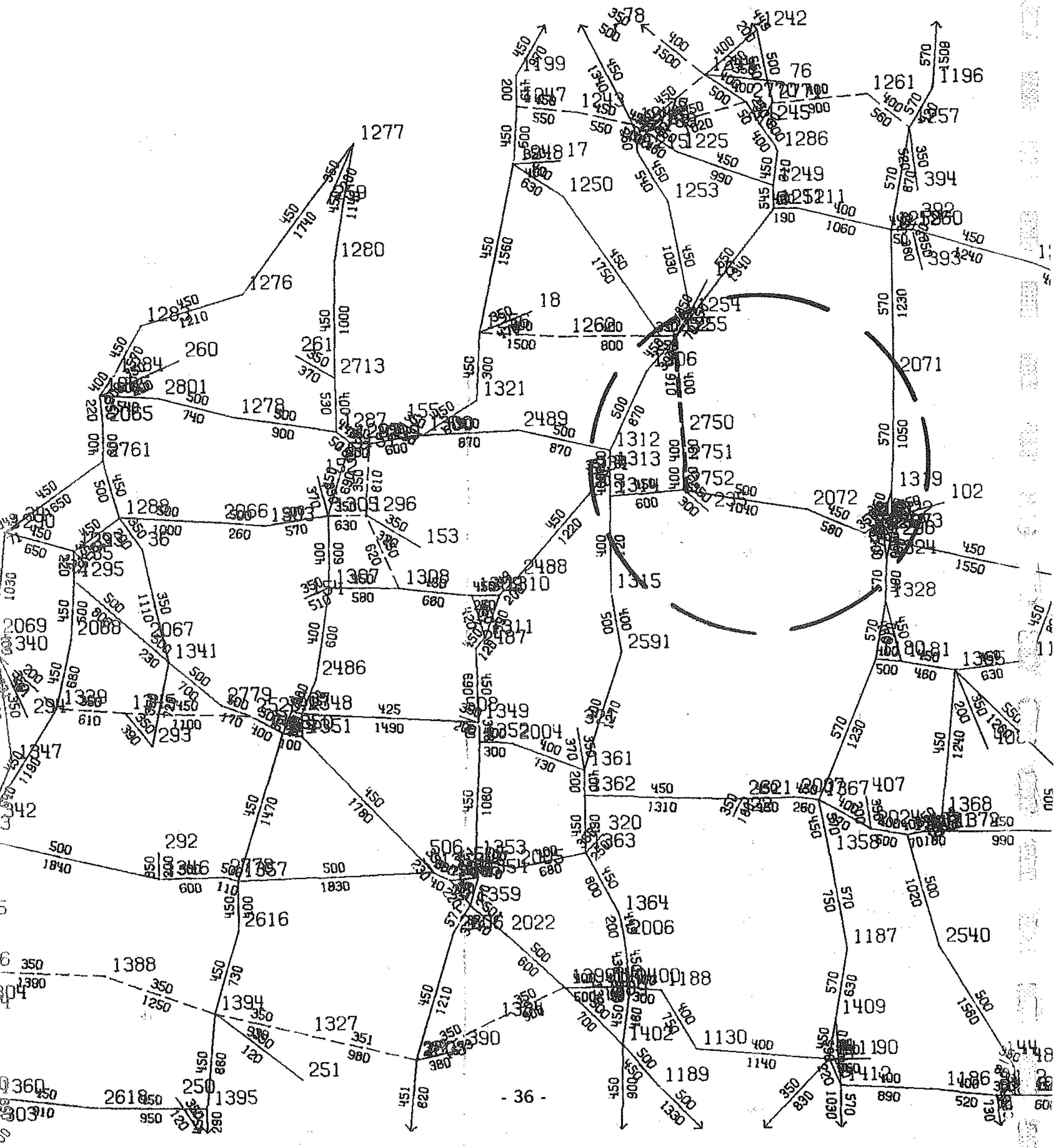
should be useful to urban transportation analysts in analyzing the effects of such road cuts in urban areas where they occur much more often because it is not possible to build overpasses or underpasses for all intersected roads.

To show how the Statewide Transportation Modeling System can be used to determine if negative disruption occurs when a road is closed, a hypothetical highway was built in the northwest region of the lower peninsula of Michigan. Figure 16 portrays the road network before the hypothetical highway was built and Figure 17 portrays the network which contains the new highway. Note that the links between Nodes 2752 and 2255 are no longer in existence in the second figure. These links were cut by the new highway, thus prohibiting traffic flow from 2752 to 2255 along these links.

To make the disruption analysis the basic elements of the modeling system are employed. See Figure 15 for a pictorial display of the system components used. Detailed reports, listed on Page 2 of this report describe the various system components that are utilized, therefore, the description here is brief.

First, the analyst utilizes the transportation planning battery and the statewide network file to create a new network. He deletes the links that are cut by the new highway and then adds the links that represent the new highway. For each new link the following data is recorded: the length of the link, the coordinates of both nodes of the link, the type of road which the link represents, and the average speed of the traffic on the link.

FIGURE 16



1277
1276
1280
2713
1321
1250
1253
1199
1242
1261
1196
394
2071
2750
2751
2752
2072
102
1328
2591
2489
2488
1315
153
1296
1308
1295
2067
2068
2069
1341
2486
2779
1349
2004
1361
362
320
363
1364
2006
1187
2540
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1409
1190
1402
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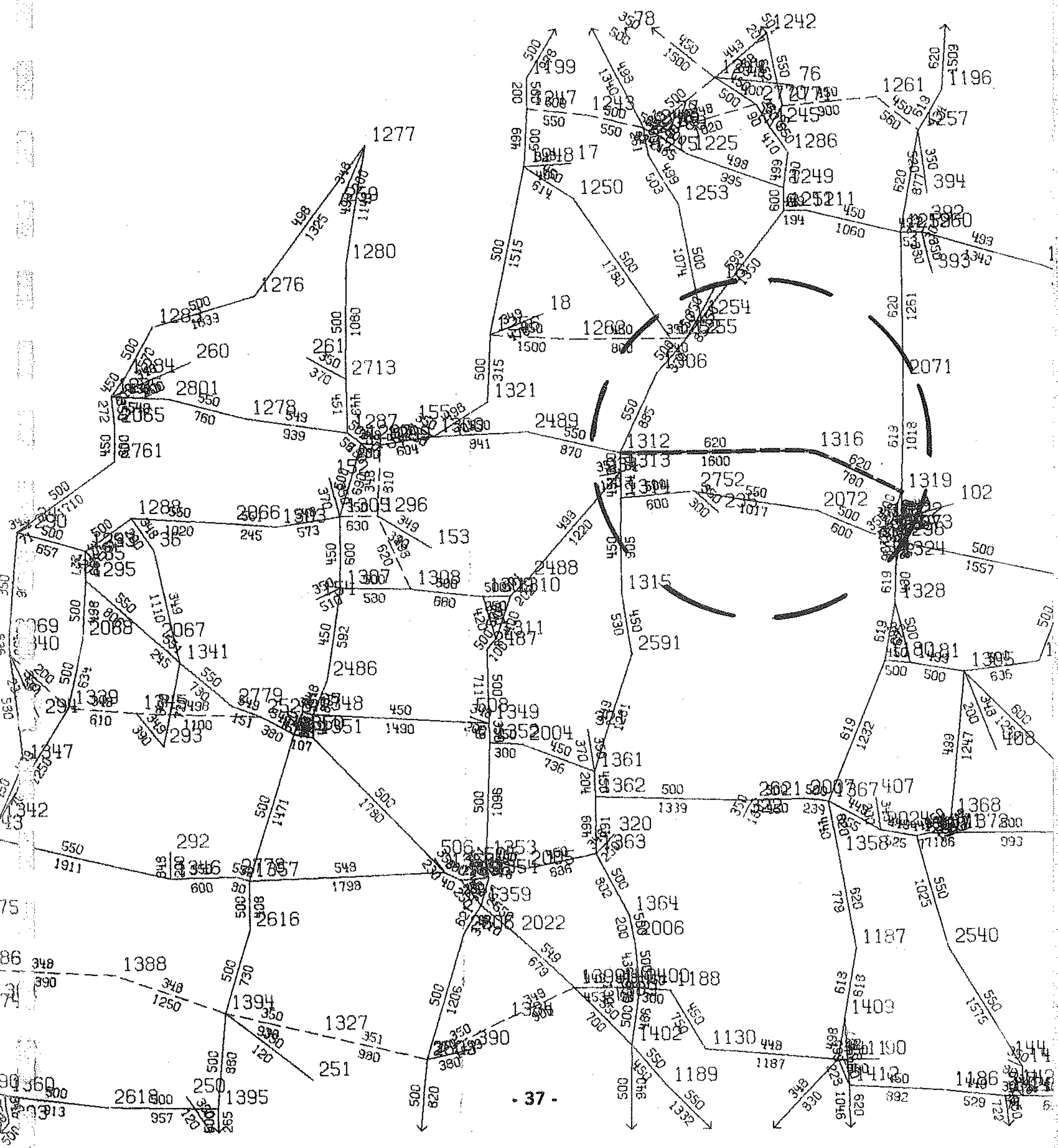
2022
1359
292

FIGURE 17


1242
76
1196
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1199
1247
1243
1225
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17
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2801
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2085
2761
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2713
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18
1254
1255
1306
2071
2489
1312
1313
1316
1319
102
2752
2072
1324
1328
1288
2066
1296
153
1307
1308
2488
1315
2591
2088
2067
1341
2486
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2779
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2004
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2618
1395

The new network obtained can then be plotted to enable the analyst to visualize the system with which he is working. The nethwork data is fed into a graphic display system that plots the new network as shown in Figure 17. As can be seen in the figure, there are two numbers associated with each link. The one written above the link represents the average speed of a vehicle on the link, and the one written below represents the length of the link in miles. Thus on link 1312-1316 the average speed is 62 miles per hour and the length of the link is 16.00 miles.

In the second phase of the analysis the analyst again uses the transportation planning battery and the statewide network file only in this case he uses these tools to build new trees and skim-trees based upon the new network. Trees are matrices of various travel times from any given zone to all other zones in the analysis system. Skim trees are matrices of minimum travel times from any given zone to all other zones in the system.

The skim trees are the important elements in the social disruption analysis. A skim tree is created for the old network as well as for the new network. In each case under the given conditions each matrix represents the minimum time, on the average, that it takes to travel from any zone to any other zone in the system. Once the skim trees are built it becomes a simple matter of subtracting one matrix from the other to determine which network provides the shortest travel time between any of the zones in the system.

Once this basic subtraction of skim trees has been accomplished further manipulations are possible. For instance, if it is determined that the travel time has increased from one zone to another by a certain number of minutes, it is then possible to multiply the number of additional travel minutes by the number of trips made between the two zones, then multiply that product by the number of persons carried in an average trip to determine the number of man minutes lost because of the change in the network. Both the additional time needed per trip and the aggregate time lost by all travelers between the affected zones are indices of social disruption.

Psychological Impact Analysis: The Hassle Factor

The Psychological Impact Model, another component of the Statewide Transportation Modeling System, works in conjunction with a number of other components of the system to analyze the impact of various road conditions on the psychological comfort of those who drive the roads of the State. (See Figure 18). This Model, which was developed in 1973 by the Statewide Studies Unit, and about which there is a detailed report, Volume I-G, Transportation Planning Psychological Impact Model, July 20, 1973) can be applied to a network on a link-by-link basis to determine a "Hassle Factor" for each link. This factor is an index of the relative psychological comfort or discomfort of a person driving on the link.

The Index was created as follows. Five variables were chosen that could be directly related to the subjective feelings of comfort or discomfort of a random groups of drivers. These variables are:

(1) Traffic volume: As traffic volume increased on a link there is a corresponding increase in anxiety or psychological discomfort of the driver.

(2) Lane width: The wider each lane is, the more comfortable the driver feels on the link.

(3) Percent of commercial traffic: As heavy trucks become a larger percent of the traffic on the link there is a corresponding increase in driver psychological discomfort.

(4) Sight distance: The shorter the view ahead the greater the driver psychological discomfort.

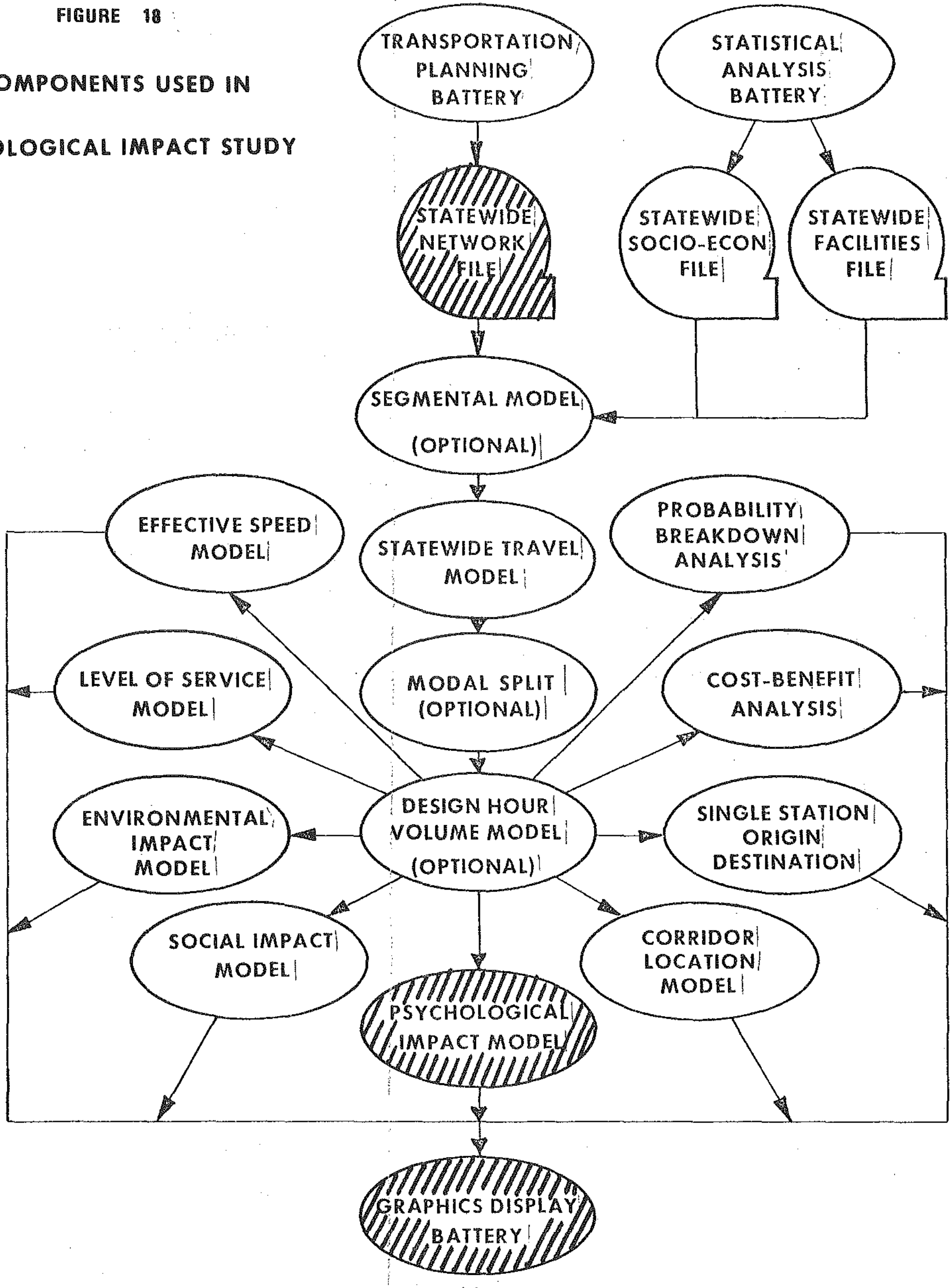
(5) Surface condition of the road: The more uneven the road surface the greater the psychological discomfort.

STATEWIDE MODELING SYSTEM COMPONENTS

FIGURE 18

COMPONENTS USED IN

SYCHOLOGICAL IMPACT STUDY



Because psychological discomfort increases or decreases with changes in these variables, an impact range was determined for each variable and values of 1 to 5 were assigned to discreet portions of each range. For each variable a value of 1 was deemed to indicate a comfortable, or at least minimal discomfort, situation; and a value of 5 was chosen to indicate a very uncomfortable psychological situation. Values were assigned to the segments of the variable ranges in the following manner.

Percent Commercial

It was determined through a survey that driver psychological comfort decreases as the number of trucks on a link increases relative to the number of automobiles. Thus values were assigned to the variable range as follows:

Percent trucks within the total	Value
1-5%	1
6-10%	2
11-15%	3
16-20%	4
20% and more	5

Lane Width

It was determined that driver psychological comfort decreases with a decrease in the width of the lane in which an auto is traveling. Therefore, values were assigned to the variable range as follows:

Land Width in feet	Value
Over 12 feet	1
11 feet	2
10 feet	3
9 feet	4
8 feet	5

Surface Condition

It was determined that driver psychological comfort decreases as the surface of the road along which they auto travels becomes less smooth. Five different road types were identified that impact psychological comfort to an increasing degree. These types were taken from the State Highway Sufficiency Record tapes and given values of from 1 to 5. The reader is referred to the Psychological Impact Report cited earlier for a detailed explanation of these ratings.

Sight Distance

It was determined that psychological comfort decreases as a driver's ability to see ahead decreaes. Therefore, values were assigned to the variable range as follows:

Sight Distance: Percent Restricted	Value
1-20%	1
21-40%	2
41-60%	3
61-80%	4
Over 80%	5

Traffic Volume

It was determined that psychological comfort decreases as the link upon which an individual is driving becomes more congested. Congestion is measured by a ratio of the volume of traffic to the design capacity of the link. Using this ratio as the measure of congestion, values were assigned to the variable range as follows:

Volume as Percent of Capacity	Value
1-49%	1
50-79%	2
80-109%	3
110-139%	4
140% & Over	5

A survey taken by the Statewide Studies Unit indicated that each of these variables does not impact psychological comfort with the same force. In fact, each variable has a different impact force. Therefore, in creating the Hassle Factor Index each variable was given a weight that reflects its relative impact on psychological comfort. Given a cumulative impact of 100 for the five variables the relative impact of each variable was determined to be:

Percent Commercial	10
Lane Width	15
Surface Condition	20
Sight Distance	17
Traffic Volume	38
	100

The Hassle Factor itself is then determined for each link as follows: F = Value of Psychological Impact of the Variable

$$\frac{10(F) + 17(F_2) + 15(F_3) + 38(F_4) + 20(F_5)}{100} = \text{Hassle Factor}$$

A Hassle Factor of 1.00 indicates that conditions on the link have a minimum negative impact on psychological comfort. A factor of 5.00 indicates a high degree of driver psychological discomfort on that link.

To obtain the Hassle Factor Index for any link under consideration the analyst must take only two simple steps. The first step entails obtaining the relevant variable information for each link. This is done by utilizing computer programs designed to take information from highway sufficiency record tapes and traffic vehicle mile record tapes that are provided by the Interstate and Sufficiency Units of the State Highways Department. This information is transferred to network tapes that are part of the Statewide Transportation Modeling System Network File.

Once this information has been placed on the proper network tapes, the second step must be taken. The tapes must be input into the psychological impact routine which ascertains the psychological impact value of each variable for each link and computes the Hassle Factor itself. The Hassle Factor assigned to each link can then be plotted using band widths to indicate the relative degrees of psychological discomfort experienced by drivers on the links of the statewide network.

RIGHT-OF-WAY ANALYSIS

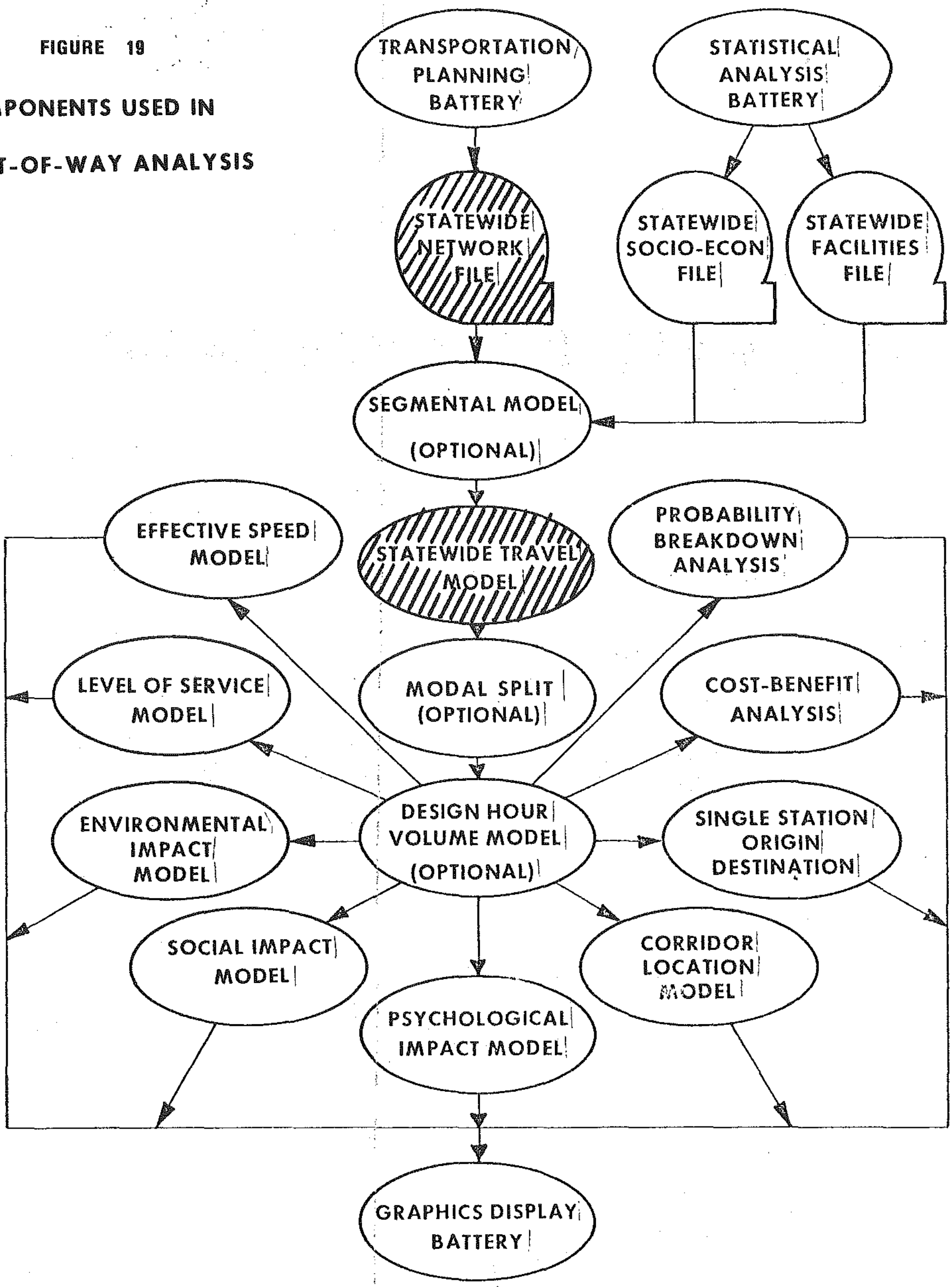
The newest routine created to utilize components of the Statewide Transportation Modeling System, the Right-of-Way program can be used to estimate either economic or social impact of highway rights-of-way. For economic impact analyses it can be used to estimate the amount of money that will be needed to purchase land for new alternatives. For social impact analyses it can be used to estimate both how much land will be removed from the tax roles when rights-of-way are purchased and how much tax loss this removal will represent. Only its application to social impact analyses will be discussed here, its application to economic impact analyses will be discussed in a later report.

Briefly, the routine works as follows. As net network alternatives are proposed new links are coded into the existing network to create alternative networks. These alternatives are stored in the Statewide network file. The right-of-way routine takes the new link data for each alternative from the network file and processes it to determine the number of acres in each zone that must be purchased for rights-of-way. Specifically, for each new link added, the routine computes the taxable acreage to be purchased by multiplying the length of the links in miles by the width of the needed right-of-way in miles and then multiplying by the number of acreas in a square mile. Following this computation, the area to be acquired for each link is multiplied by a figure representing the average tax per acre for

STATEWIDE MODELING SYSTEM COMPONENTS

FIGURE 19

COMPONENTS USED IN RIGHT-OF-WAY ANALYSIS



zone in which it is located. Then two county summaries are created. One presents an estimate of the total number of acres that will have to be purchased for rights-of-way, and the other an estimate of the total tax revenues that will be lost because this land will be moved into the public domain. These county estimates can then be summed to create an estimate of the tax dollars lost for each new alternative proposed. The total tax loss figures for each alternate can then be compared to see which alternate places the least additional tax burden on the land left on the tax roles.

This analytical procedure has been created to be part of a complete right-of-way related analysis package. A number of studies have indicated that although initially the tax base of an area is decreased as a result of state purchases of rights-of-way expands the tax base beyond what it would have been without the presence of the highway. (See "Social and Economic Effects of Highways", U.S. Department of Transportation, 1974). Assessed values grow most dramtically at freeway interchanges where greatly increased accessibility stimulates intensive use of the land. A Land Value Model is now being considered as part of the Statewide Transportation Modeling System to estimate how land values are redistributed in an area as a result of the construction of new highways. This model will be keyed to estimating land values around freeway interchanges and should be very valuable in helping to determine both social and economic effects of new highway alternatives as they are manifested through land value changes over an extended period of time.

Together the Right-of-Way analysis which shows land needs of various alternates and initial tax roll losses, and the Land Value Model which will indicate longer run changes in land values and hence land revenues, should operate to portray the dynamic right-of-way related effects of new highway alternatives. These analytical techniques will be even more accurate when the Statewide Transportation Modeling System is completely converted to the 2300 zone system that is being built. Admittedly at this time estimates of tax loss based on the average tax value per acre for each zone are somewhat rough. Nevertheless, because the model is built to perform Statewide and large region analyses the results are fine enough to provide some basis for discriminating between alternatives at this level. The 2300 zone system will allow analyses to be performed over much smaller areas and as each zone will encompass a smaller land area, average tax per acre figures will more closely approximate tax loss on the land that will be purchased for rights-of-way. Actually because the modeling system has been created on such a sound analytical base there is no reason that as it is applied with an increasingly fine zone system the tax loss estimations could not be exceedingly accurate, especially if average tax values are determined for a series of land use classifications such as industrial, residential and commercial; and estimates are made of how much of each type of land will need to be purchased.

PEDESTRIAN DEPENDENCY ANALYSIS

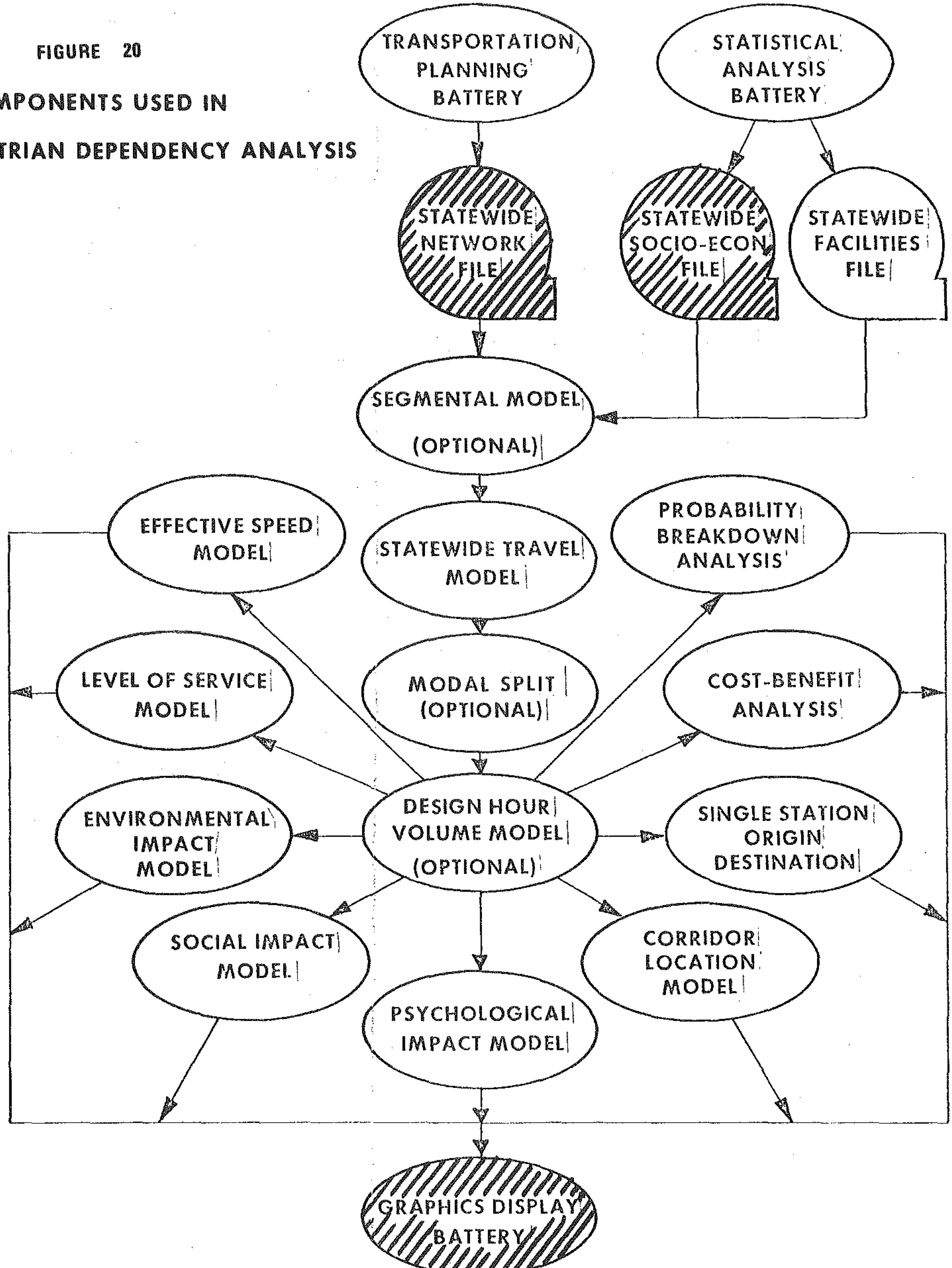
A basic tenet of urban and regional planning is that cohesive human activity areas should be preserved whenever possible. To preserve these areas, however, it is first necessary to identify where they exist. There is a need for some quantifiable index that is highly correlated with community cohesiveness. Studies have shown that where people depend a great deal on walking to attend activities or to obtain various needs activity areas of high cohesiveness usually exist. Therefore, a pedestrian dependency index can be used as a measure of community cohesiveness. It is only necessary then to create an index that portrays the degree of pedestrian dependency in an area.

Four indices of pedestrian dependency, created by Marshall Kaplan, Gans and Kahn of the Universal Engineering Corporation, can be used as measures of community cohesiveness. These indices, explained in detail in a U.S. Department of Transportation report entitled, "Social Characteristics of Neighborhoods as Indicators of the Effects of Highway Improvements (1972)", are designed to measure General Pedestrian Dependency, School Pedestrian Dependency, Local Shopping Pedestrian Dependency, and Social Institution Pedestrian Dependency. Because these indices are designed to utilize census information, any of them can be programmed for computation within the context of the Statewide Transportation Modeling System. However, given that the Statewide Model is designed for statewide and regional analysis purposes, the most useful pedestrian dependency index to use in the system at this time is that which gives

STATEWIDE MODELING SYSTEM COMPONENTS

FIGURE 20

COMPONENTS USED IN PEDESTRIAN DEPENDENCY ANALYSIS



the most general indication of pedestrian dependency. That index is the General Pedestrian Dependency Index (GPD). The index refers to the dependence of residents on walking for general activities or needs. The GPD Index, as adapted to the Statewide Transportation Modeling System is computed as follows:

$$GPD = \frac{(h\% \times p \times I)}{i}$$

where;

h% = households with no cars, portion thereof

p = persons/household, average number

I = Income, median household for the state

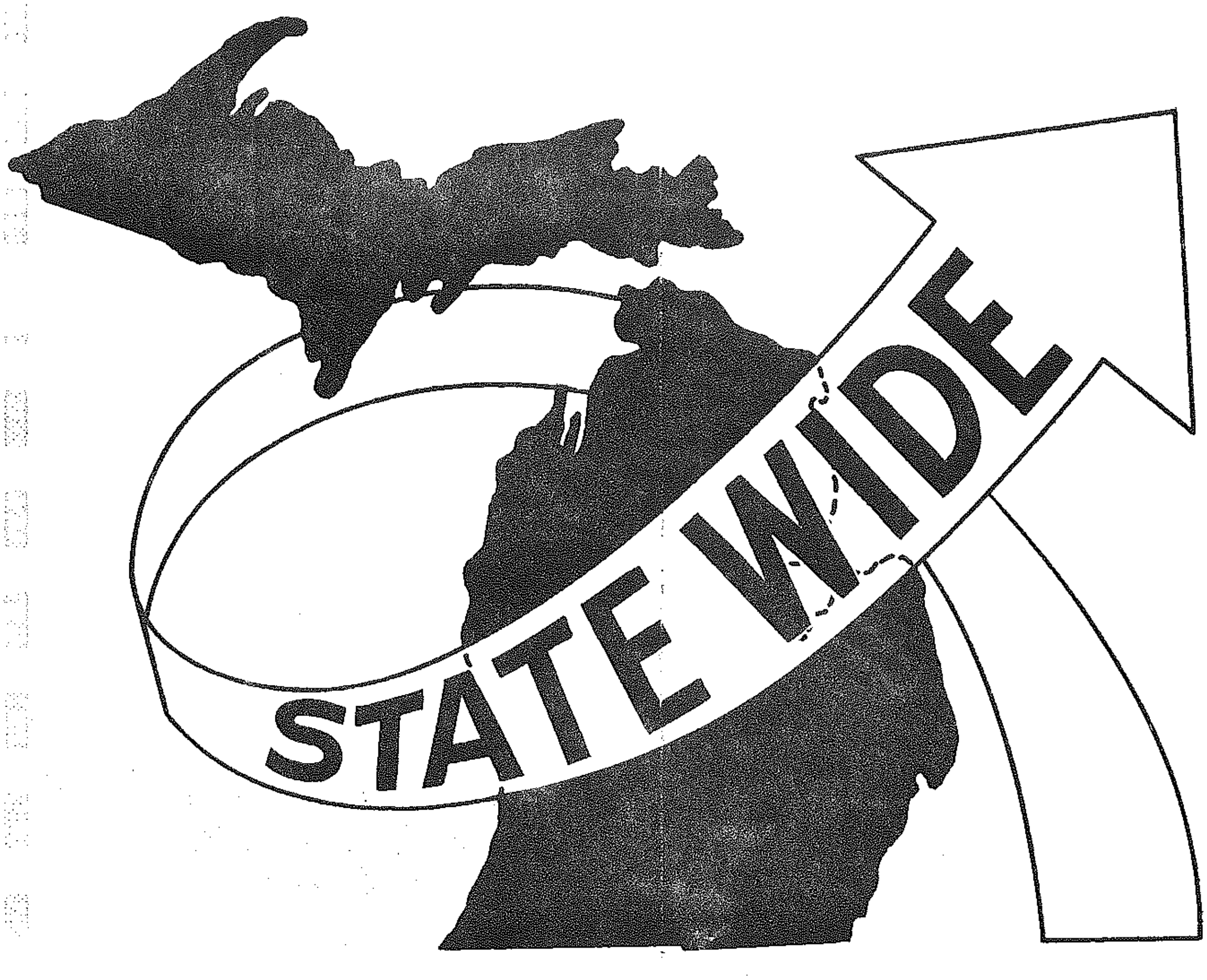
i = income, median household for the study area (zone or zones)

Implicit in this equation are the assumptions that: (1) pedestrian dependency is inversely related to automobile ownership (i.e. those who do not have automobiles are more likely to walk to obtain needs or attend activities); (2) pedestrian dependency is inversely related to income (i.e. those with lower incomes are more likely not to use mechanized means of transportation and thus will walk more often for needs).

By applying this analysis technique on a zonal basis throughout the state or a region it is possible to obtain a series of index numbers, one for each zone, that allows the analyst or planner to determine which zones will be impacted beneficially or adversely according to this social impact measure. The zones which have high GPD scores, indicating that people in that zone are more dependent on walking to go places, are those which will be impacted adversely by new highways, and those with low GPD scores, which implies higher dependency on automobile transportation, will be impacted less adversely and perhaps beneficially according to this criteria. New highways are likely to adversely impact areas of high pedestrian dependency because these roads may create barriers to pedestrian movement and thus disrupt socially cohesive areas.

To facilitate the analysis and planning process, the GPD indices obtained for each zone can be plotted by SYMAP, a plotting routine contained within the Graphic Display Battery of the Statewide Transportation Modeling System. An example of these indices plotted by SYMAP is located in the Analysis Results section of this report in the subsection on Pedestrian Dependency Analysis Results.

ANALYSIS RESULTS



INTRODUCTION

Analysis Results

The previous section of this report contained a brief explanation of the procedural steps required to utilize each of the seven basic model related social impact analysis techniques. Because the primary purpose of this document is to demonstrate the application of these techniques this section deals with the actual testing of three highway proposals and their social impacts. The three highway plans used for the impact analyses appear in Figure 8.

Each impact measurement application is discussed independently in this document, but the user of a total statewide transportation modeling system should be aware that these procedures can be used independently only when attempting to determine the relative achievement of any specific planning goal. Most often these social impacts need to be weighed with economic and environmental impacts to complete a total system analysis at the regional level.

Results of Proximity Analysis

The Proximity analysis routine provides output that can be used for a number of different purposes. The following results are presented in various formats to demonstrate different ways in which the data can be aggregated and interpreted.

Accessibility of People to Health Services (Hospitals)

Tables 1, 2, and 3 present output from Option 1 of the proximity analysis routine. The detailed data from this output are transcribed to this tabular form to allow the analyst to compare accessibility differences created by the different alternates at both the zonal and regional levels. The table indicate the location of the hospitals in the region by zone and tell how many hospitals are in each zone. They also indicate how many people are within the specified travel time of each of the zones that contain hospitals. It should be remembered that scans around each server zone (zone with a hospital in it) are independent of scans made around any other server zone. Therefore, in aggregating the population figures from each zonal scan to a regional summary there may be multiple counting of people. Thus the regional summary population total in Table 1 of 289,079 is a relative index of accessibility of people to hospitals and does not indicate that 289,079 different people can travel to the six hospitals in the region within one hour.

In comparing accessibility differences between the three alternates at either the zonal or regional level one can see that within the first 30 minutes of travel time the data indicates that there are no differences. However, it should not be inferred from these

TABLE 1

PROXIMITY OF PEOPLE TO HOSITALS

ALTERNATE A

ZONE	NUMBER OF HOSPITALS	NUMBER OF PEOPLE WITHIN				
		0-15 MINUTES	16-30 MINUTES	31-45 MINUTES	46-60 MINUTES	0-60 MINUTES
34	1	6467	2126	9900	50,139	68,632
35						
36						
151	2	20,690	22,912	23,806	13,715	81,123
152						
153						
154						
155						
259	1	3,849	0	25,117	14,438	43,404
260						
261						
291	1	13,422	10,105	23,075	13,544	60,146
292						
293						
294	1	3650	13,422	8,184	10,518	35,774
505						
506						
507						
508						
ALL ZONES	6	48,078	48,565	90,082	102,354	289,079

TABLE 2

PROXIMITY OF PEOPLE TO HOSPITALS

ALTERNATE B

ZONE	NUMBER OF HOSPITALS	NUMBER OF PEOPLE WITHIN				
		0-15 MINUTES	16-30 MINUTES	31-45 MINUTES	46-60 MINUTES	0-60 MINUTES
34	1	6467	2126	23,322	43,602	75,517
35						
36						
151	2	20,690	22,912	23,806	15,432	82,840
152						
153						
154						
155						
259	1	3849	0	25,117	14,438	43,404
260						
261						
291	1	13,422	10,105	27,772	24,779	76,098
292						
293						
294	1	3650	13,422	10,310	24,841	52,223
505						
506						
507						
508						
ALL ZONES	6	48,078	48,565	110,327	123,112	330,082

TABLE 3

PROXIMITY OF PEOPLE TO HOSPITALS

ALTERNATE C

ZONE	NUMBER OF HOSPITALS	NUMBER OF PEOPLE WITHIN 0-15 MINUTES	16-30 MINUTES	31-45 MINUTES	46-60 MINUTES	0-60 MINUTES
34	1	6467	2126	9900	50,139	68,632
35						
36						
151	2	20,690	22,912	23,806	23,705	91,113
152						
153						
154						
155						
259	1	3489	0	25,117	14,438	43,404
260						
261						
291	1	13,422	10,105	23,075	22,175	68,777
292						
293						
294	1	3,650	13,422	8,184	10,518	35,774
505						
506						
507						
508						
ALL ZONES		48,078	48,565	90,082	120,975	307,700

results that the alternates do not have some affect on the travel times of people who live within 30 minutes of the hospital. On the contrary, it is rather certain that for each of the alternates there will be some people who will be benefitted. No differences are apparent for two major reasons. First, the 547 zone models is not built to make analyses involving such short travel times. Almost all zones in the system are at least fifteen minutes wide. Thus scans from one zone to another will infrequently show travel-time differences that occur for trips of less than 30 minutes. Second, in this test situation comparisons are being made only of major link differences involved with three regional highway alternatives. Local connector and feeder links are not included in the analysis.

When travel times get up to the 45 minute level, however, the model is fine enough and the impacts of the alternates become great enough so that accessibility differences can be recorded and analyzed. The fact that on all proximity analyses that have been run by the Statewide Studies Unit discernable differences occur with 45 minutes of travel time indicates that this routine is quite adequate for performing regional analyses and more than adequate for determining the statewide impacts of travel alternatives. (See the accompanying output data for verification).

In comparing accessibility differences between the three alternatives at the zonal level in the 45 minute and 60 minute time bands one can see that each of the alternatives impacts the hospitals differently. Only in the case of the hospital in Zone 259 is there no change in accessibility from the no-build to the build alternatives. Alternate B causes hospitals in Zones 291 and 294 to be much more accessible to people as compared with the no-build alternative, and causes the hospitals in Zones 34 and 151 to experience moderate accessibility increases. Alternate C, on the other hand, causes more moderate accessibility improvements in all cases.

The regional summaries in the three tables provide gross indices of accessibility. From these indices it appears that Alternates B makes hospitals most accessible. However, in remembering that the summary figure is a relative index of accessibility one should be wary of inferring that Alternate B is the best alternative to built to serve people in obtaining hospital care. In some cases gross aggregates of this nature can be misleading. For instance, health care planners may have determined that if people can reach one hospital within 60 minutes driving time then they are being adequately served. Under such circumstances it may be that the accessibility provided by Alternate A is already adequate and, therefore, the accessibility provided by Alternates B and C are excessive. By referring to the final listing of Option 2 in the proximity analysis output the analyst can determine immediately which of the alternatives are deficient by this criterion. This final print-out lists all of the zones in the state not located within an hour of a hospital. (See Table 4 for an example.) In this case for each alternate the zones not served are the same, therefore, the single print-out suffices to show the zones not served for each alternate. From the print-out we see that none of the zones in the Northwest Region are on the list. Therefore, all are served by a hospital within one hour driving time. Thus if the criterion for good health care provision is accessibility to one hospital within one hour, all three alternatives meet the criterion.

STATEWIDE PROXIMITY ANALYSIS

ZONES NOT SERVED

ZONE	POPULATION
2	1185
4	2038
85	987
86	1664
391	4726

POPULATION NOT SERVED BY ANY HOSPITALS = 10600

TABLE 4

PEOPLE IN THE STATE NOT SERVED BY ANY HOSPITAL

Suppose, however, that the criterion is accessibility to at least two hospitals, based on the idea that complete medical care can not be provided at any one hospital. Then it is not enough for the planner to know only that the zones under consideration are served by at least one hospital and the final listing in Option 2 is not adequate for analysis purposes. Some indication is needed of how many hospitals are available to people in each zone in the region.

The first series of listings in the output from Option 2 provides this indication. See Table 5. This listing shows how many hospitals are within selected travel times of each zone for Alternate A. In the example we can see that people who live in Zone 151 can reach 2 hospitals within 15 minutes. Two more within 45 minutes, and another one within 60 minutes. Table 6, which presents this zonal data for all three alternates, shows that no zones in the region are served by fewer than two hospitals within 60 minutes driving time on any alternate. Thus all alternates are adequate by this criterion.

However, suppose health planners need indices other than these one which to decide which alternate is best for providing health care. An index commonly used by planners is the ratio of people in the service zone to the number of beds in the hospital. Since a service zone is based on travel time, the ratio could be:

$$\frac{\text{people within 60 minutes travel time (service zone)}}{\text{Number of beds available}}$$

By accessing the facility file data the proximity analysis routine provides ratio information of this sort as well. In the facility file, data is stored about each hospital in each zone. Part of that data is the number of beds in each hospital. This

TABLE 5

PROXIMITY OF HOSPITALS TO PEOPLE

ALTERNATE A

ZONE	NUMBER OF PEOPLE	NUMBER OF HOSPITALS WITHIN 0-15 MINUTES	16-30 MINUTES	31-45 MINUTES	46-60 MINUTES	0-60 MINUTES	POPULATION HOSPITALS
34	2571	1	0	1	3	5	514.20
35	3896	1	0	4	0	5	779.20
36	2126	0	1	2	2	5	425.20
151	20,690	2	0	2	1	5	4138.00
152	9,384	0	2	0	3	5	1876.80
153	5,485	0	2	0	2	4	1371.25
154	1158	0	2	0	2	4	289.50
155	2458	0	3	0	3	6	409.66
259	3849	1	0	2	0	3	1283.00
260	2596	0	0	3	1	4	649.00
261	4427	0	2	1	1	4	1106.75
291	13422	1	1	1	1	4	3355.50
292	1305	0	1	0	1	2	652.50
293	1717	0	0	3	0	3	572.33
294	3650	1	1	1	0	3	1216.66
505	9990	0	0	1	2	3	3330.00
506	5128	0	0	1	2	3	1709.33
507	1937	0	0	3	3	6	322.83
508	2662	0	0	1	3	4	665.50
ALL ZONES	98,451	7	15	26	30	78	1262.19

TABLE 6

PROXIMITY OF HOSPITALS TO PEOPLE

ALL ALTERNATES

NUMBER OF HOSPITALS WITHIN 60 MINUTES OF INDICATED ZONE

ZONE NUMBER	POPULATION IN ZONE	ALTERNATE A	ALTERNATE B	ALTERNATE C
34	2571	5	5	5
35	3896	5	5	5
36	2126	5	6	5
151	20,690	5	5	5
152	9,384	5	5	5
153	5485	4	4	4
154	1158	4	4	4
155	2458	6	7	6
259	3849	3	3	3
260	2596	4	6	4
261	4427	4	5	4
291	13,422	4	6	5
292	1305	2	3	3
293	1717	3	5	3
294	3650	3	4	3
505	9990	3	3	5
506	5128	3	4	3
507	1937	6	6	6
508	2662	4	4	4
ALL ZONES	98,451	78	90	82

information is presented as part of the listing in the Option 2 output. In Table 7, which contains an example of Option 2 output, the third column of information headed by the word "Capacity" contains the number of beds in the hospitals that can be accessed within the given travel time from the zone under analysis. Thus, for example, with Alternate B people living in Zone 6 have access to 441 hospital beds within 60 minutes travel time of their homes. These beds are in five different hospitals. By combining the capacity information in this list with population data from Output 1 it is possible to obtain the ratio cited above. Thus the population that can reach the two hospitals in Zone 6 within 60 minutes is 37.824. Since the total number of beds available in these two hospitals is 441, the ratio of people to beds is 37,824/441 indicating 85.77 people for every bed.

By using the same technique this ratio can be obtained for each set of hospitals in each zone for each alternative. Thus planners can determine how each of the alternatives affects these ratios for each hospital in the region and thereby determine which alternative provides the best health care situation by this criterion.

As can be seen from example of the output data, considerable other information is provided by output Options 1 and 2. However, the purpose of this report is not to demonstrate every particular circumstance to which the models can be applied, but to show that the models are capable of providing a great deal of detailed information in an analysis format that has not previously been available. By using their imaginations planners can utilize this tool in many ways. For example, instead of using gross population and hospitals as the socio-economic and facility file parameters, they could use

STATEWIDE PROXIMITY ANALYSIS

TABLE 7

SERVER PROXIMITY

ZONE	SERVICE ZONES	HOSPITALS	CAPACITY	POPULATION	/HOSPITALS	POPULATION
1 0- 15MIN.	0	0	0	0.00		0.00
1 0- 30MIN.	0	0	0	0.00		0.00
1 0- 45MIN.	1	1	165	5928.00		35.93
1 0- 60MIN.	2	2	209	2964.00		28.36
2 0- 15MIN.	0	0	0	0.00		0.00
2 0- 30MIN.	0	0	0	0.00		0.00
2 0- 45MIN.	0	0	0	0.00		0.00
2 0- 60MIN.	0	0	0	0.00		0.00
3 0- 15MIN.	1	1	34	3677.00		108.15
3 0- 30MIN.	1	1	34	3677.00		108.15
3 0- 45MIN.	1	1	34	3677.00		108.15
3 0- 60MIN.	1	1	34	3677.00		108.15
4 0- 15MIN.	0	0	0	0.00		0.00
4 0- 30MIN.	0	0	0	0.00		0.00
4 0- 45MIN.	0	0	0	0.00		0.00
4 0- 60MIN.	0	0	0	0.00		0.00
5 0- 15MIN.	0	0	0	0.00		0.00
5 0- 30MIN.	0	0	0	0.00		0.00
5 0- 45MIN.	1	1	34	2276.00		66.94
5 0- 60MIN.	2	4	441	569.00		5.16
6 0- 15MIN.	1	1	34	577.00		16.97
6 0- 30MIN.	1	1	34	577.00		16.97
6 0- 45MIN.	1	1	34	577.00		16.97
6 0- 60MIN.	2	4	441	144.25		1.31

people over 65 as the socio-economic parameter and geriatric facilities as the facility file parameter. The routine could then test the accessibility of people over 65 to geriatric wards. Moreover, having made analyses using any two chosen parameters the analysts can then utilize the data to make any number of value decisions. For instance, the data can be utilized to answer the following questions: (1) Does a given highway alternative create overloads on the facilities given certain optimum ratios of people to units of service? (2) Does the alternative create excess server capacities in some zones and overload facilities in others? (3) Does one alternative provide access to enough facilities on not enough? (4) Are some alternatives "better" than others?

A good test can be made of the value of this routine for performing social impact analyses by asking, what does one need to know in order to determine the social impact of a given highway alternative? There is little doubt that a number of questions will be answerable by use of data output from the proximity routine.

Accessibility of People to Recreational Opportunities

The data obtained from the proximity analysis runs that computed the accessibility of people to golf courses, games areas and campgrounds are in Tables 8, 9, and 10. In each case the number of bands chosen and the total time distances used were related to the activity under analysis by consideration of how far the average facility user would travel to use that type of facility.

The data indicate, as they did in the hospital proximity output, that the various alternative highway patterns have little effect on the accessibility of people to recreational opportunities within 30 minutes travel time. These results are consistent with the output for all test runs made. The model is built for statewide and regional analyses and, because of factors already explained, is not now sensitive to accessibility impacts below 30 minutes travel time. However, starting with the 30 minute travel band significant accessibility differences are indicated in every case the build alternatives, B and C, offer increased accessibility relative to the no-build alternative. As the travel time increases, networks B and C alternately offer better accessibility relative to one another and both offer increasing accessibility relative to the Alternate A network. Overall, the Alternate C network offers better accessibility to game areas and campgrounds than the Alternate B network, but Alternate B provides slightly better access to golf courses.

A major positive aspect of this data is that it allows accessibility comparisons at any number of travel times. Partial data provides the analyst with an opportunity to make judgements about the relative impact of alternates at chosen travel times

PROXIMITY OF GOLF COURSES TO PEOPLE **TABLE 8**

ALL ALTERNATES

ALTERNATE	POPULATION IN REGION	0-15 MINUTES	16-30 MINUTES	31-45 MINUTES	46-60 MINUTES	61-75 MINUTES	76-90 MINUTES	91-105 MINUTES	106-120 MINUTES	0-120 MINUTES	POPULATION GOLF COURSES
A	98,451	11	28	47	78	97	170	175	188	794	123.99
B	98,451	11	38	56	97	120	190	187	181	880	111.87
C	98,451	11	33	57	95	125	191	200	180	892	110.37

PROXIMITY OF GAME AREAS TO PEOPLE
ALL ALTERNATES

TABLE 9

ALTERNATE	POPULATION IN REGION	0-15 MINUTES	16-30 MINUTES	31-45 MINUTES	46-60 MINUTES	61-75 MINUTES	76-90 MINUTES	91-105 MINUTES	106-120 MINUTES	0-120 MINUTES	POPULATION / GAME AREAS
A	98,451	21	36	64	83	110	136	145	174	769	128.02
B	98,451	21	37	79	103	145	147	213	227	972	101.28
C	98,451	21	37	67	105	130	180	199	231	970	101.49

PROXIMITY OF CAMPGROUNDS TO PEOPLE

ALL ALTERNATES

TABLE 10

ALTERNATE	POPULATION IN REGION	0-15 MINUTES	16-30 MINUTES	31-45 MINUTES	46-60 MINUTES	61-75 MINUTES	76-90 MINUTES	91-105 MINUTES	106-120 MINUTES	0-120 MINUTES	POPULATION / CAMPGROUNDS
A	98,451	103	269	462	534	669	579	430	379	3,425	28.74
B	98,451	103	315	532	586	720	603	365	351	3,575	27.53
C	98,451	113	322	523	651	693	531	423	421	3,677	26.77

FIGURE 20

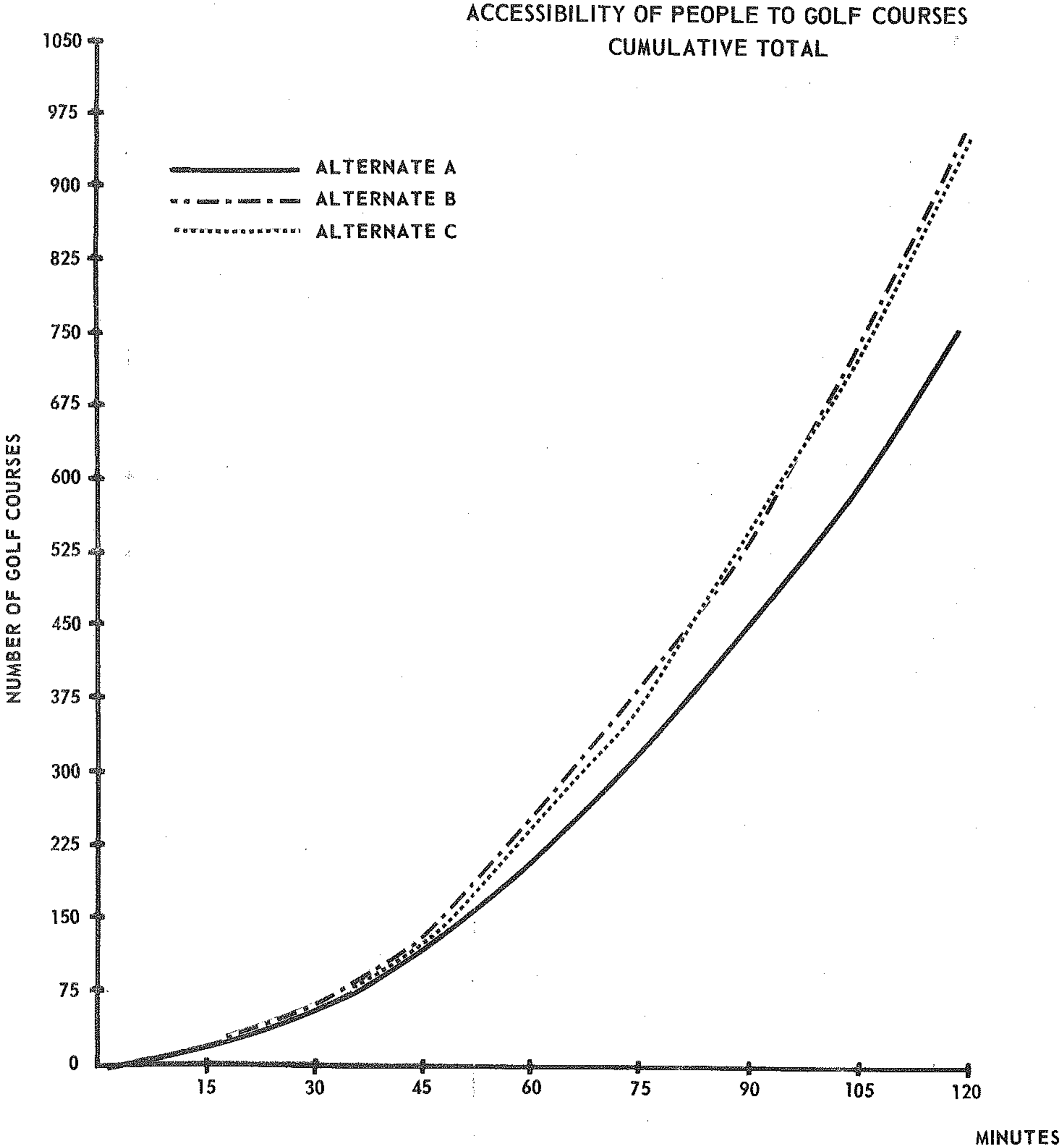

ACCESSIBILITY OF PEOPLE TO GOLF COURSES
CUMULATIVE TOTAL
1050
975
900
825
750
675
600
525
450
375
300
225
150
75
0
NUMBER OF GOLF COURSES
ALTERNATE A
ALTERNATE B
ALTERNATE C
15
30
45
60
75
90
105
120
MINUTES

FIGURE 21

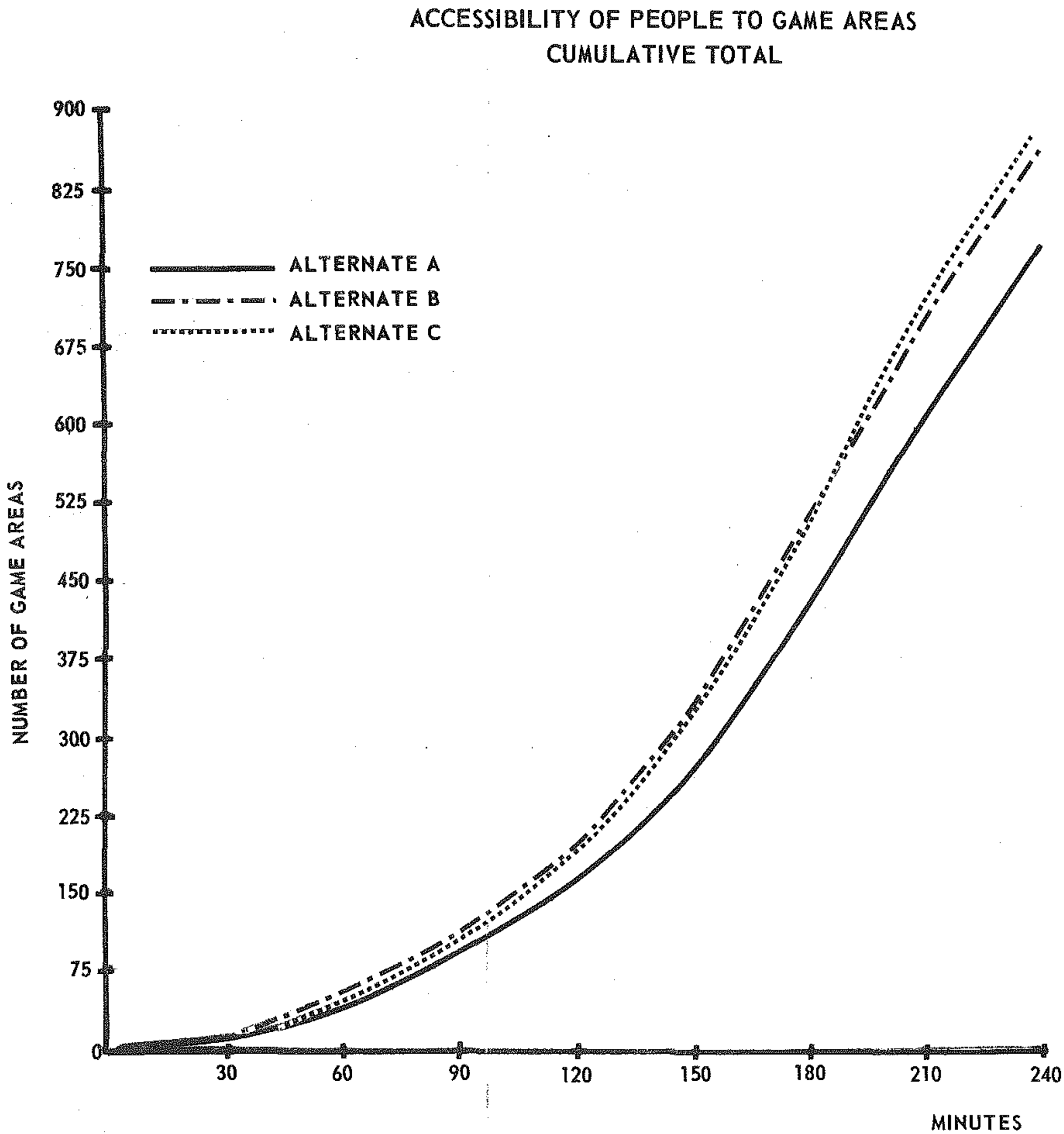
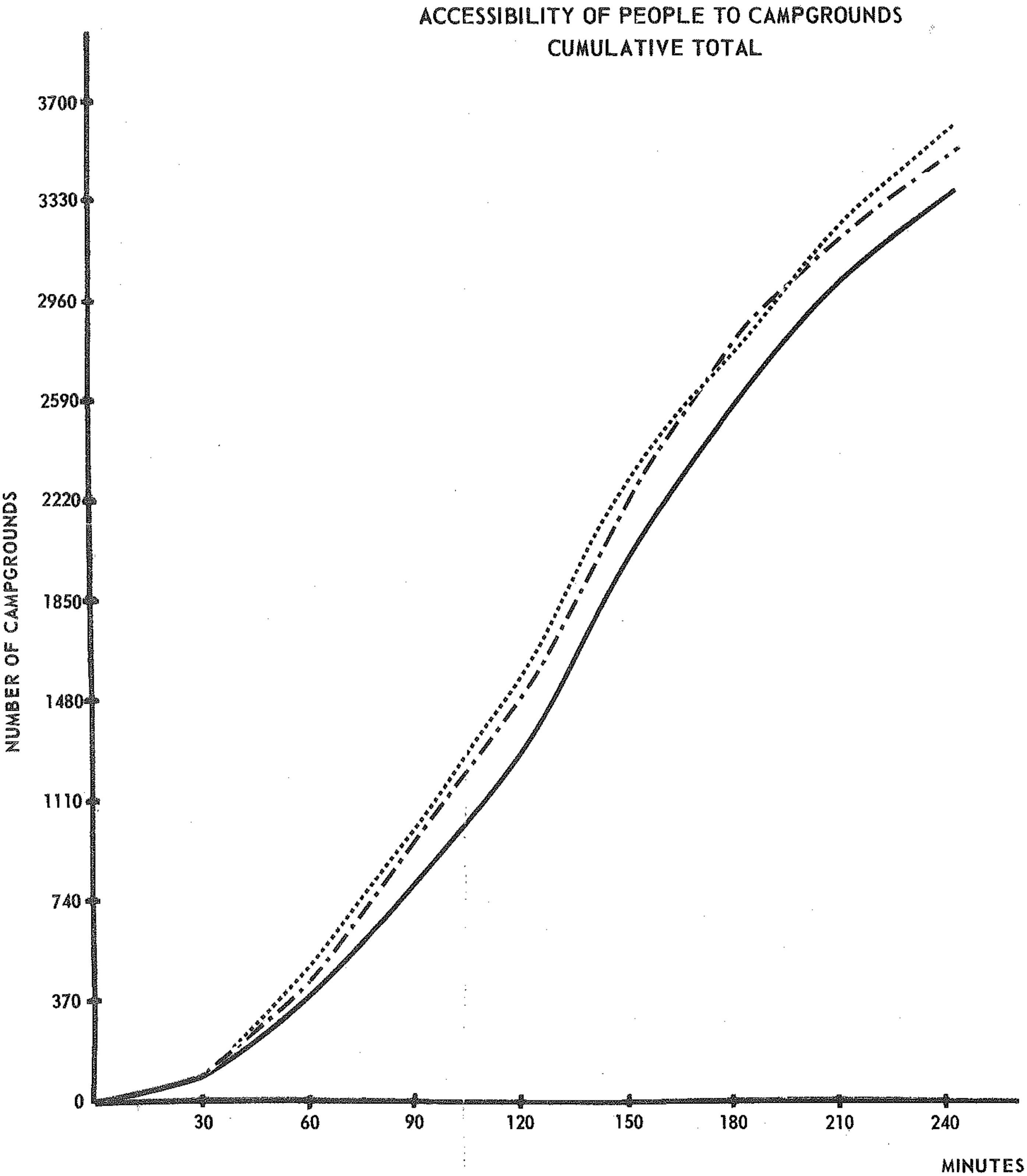

ACCESSIBILITY OF PEOPLE TO GAME AREAS
CUMULATIVE TOTAL
900
825
750
675
600
525
450
375
300
225
150
75
0
NUMBER OF GAME AREAS
ALTERNATE A
ALTERNATE B
ALTERNATE C
30
60
90
120
150
180
210
240
MINUTES

FIGURE 22



ACCESSIBILITY OF PEOPLE TO CAMPGROUNDS
CUMULATIVE TOTAL
NUMBER OF CAMPGROUNDS
3700
3330
2960
2590
2220
1850
1480
1110
740
370
0
30
60
90
120
150
180
210
240
MINUTES

within the maximum travel time chosen for analysis. Thus although overall Alternate C provides better accessibility to campgrounds then Alternate B, at the two hour travel mark Alternate B offers access to 26 more campgrounds then Alternate C. This data should be useful to recreation planners and is available for the first time as a result of this analysis technique.

A plotting technique is also available that allows for impact comparisons. Figures 20, 21, and 22 are examples of the application of this technique. The data from Tables 8, 9 and 10 are presented so that the relative accessibilities provided by the three alternates are plotted on a cumulative basis. These plots allow the analyst to quickly determine the impact of each of the alternates relative to the others at any given travel time. The graphic method is excellent for both presentation of the data in formal meetings and for daily analysis and reference purposes.

Accessibility of People to Educational Opportunities

The results of this set of proximity runs are not very dramatic, but are useful nevertheless. These runs, which were set up to test the accessibility of people in the Northwest Region to four-year, public universities, indicate no appreciable changes in accessibility from one alternate to the nex. The results are presented in Tables 11 and 12.

There are no universities accessible to anyone in the region under 40 minutes travel time, and only in Zones 505, 506, 507, and 508 are people able to travel to a four-year university in less than one hour and twenty minutes, the maximum travel time considered feasible for commuting. Moreover, it is indicated that no significant

TABLE 11

PROXIMITY OF UNIVERSITIES TO PEOPLE

ALTERNATE A

ZONE NUMBER	POPULATION IN ZONE	0-20 MINUTES	21-40 MINUTES	41-60 MINUTES	61-80 MINUTES	0-80 MINUTES
34	2571	0	0	0	0	0
35	3896	0	0	0	0	0
36	2126	0	0	0	0	0
151	20,690	0	0	0	0	0
152	9,384	0	0	0	0	0
153	5485	0	0	0	0	0
154	1158	0	0	0	0	0
155	2458	0	0	0	0	0
259	3849	0	0	0	0	0
260	2596	0	0	0	0	0
261	4427	0	0	0	0	0
291	13,422	0	0	0	0	0
292	1305	0	0	0	0	0
293	1717	0	0	0	0	0
294	3650	0	0	0	0	0
505	9990	0	0	1	0	1
506	5128	0	0	1	0	1
507	1937	0	0	0	1	1
508	2662	0	0	0	1	1
TOTAL	98,451	0	0	2	2	4

TABLE 12

PROXIMITY OF UNIVERSITIES TO PEOPLE

ALL ALTERNATES

ALTERNATE	POPULATION IN REGION	0-20 MINUTES	21-40 MINUTES	41-60 MINUTES	61-80 MINUTES	0-80 MINUTES
A	98,451	0	0	2	2	4
B	98,451	0	0	2	2	4
C	98,451	0	0	2	2	4

improvement in accessibility is created by the B and C alternates relative to Alternate A, the existing highway network. Thus by this criterion there appears to be no reason to build new highways on these alignments. Of course a more sophisticated analysis is possible with the data available, but such analyses will be left for route location teams.

<u>Accessibility of People Over 65 to Treasury Offices</u>

These runs were made to show how the Statewide Transportation Modeling System can be utilized to make selective proximity analyses. A considerable portion of the data in the Socio-Economic Data File has been taken directly from the 1970 Census. Therefore, the data groupings provided by the Census can be used in making selective proximity analysis runs. One of the data categories provided is the number of people over 65. It was this grouping that was chosen for these sample runs. Treasury Offices were chosen as the facility group in the analysis because elderly people receive welfare and social security payments and services through these facilities. Other facilities such as cardiac care units or nursing homes could easily have been chosen.

Tables 13 and 14 present data summarized from Output formats one and two of the proximity runs. Table 13 shows the number of people who can reach at least one treasury office with the indicated travel time, whereas Table 14 shows the converse, how many Treasury Offices are within the indicated travel time of at least some of the people. Together these data provide an indication of the relative impacts of the alternates under consideration. If one were to consider only the data in Table 14 it would appear that

TABLE 13

NUMBER OF PEOPLE OVER AGE 65 WITHIN INDICATED TRAVEL TIMES OF TREASURY OFFICES

	0-15 MINUTES	16-30 MINUTES	31-45 MINUTES	46-60 MINUTES	TOTAL WITHIN 60 MINUTES
ALTERNATE A	2661	2095	1876	806	7438
ALTERNATE B	2661	2095	1876	1118	7750
ALTERNATE C	2661	2095	1876	2041	8673

TABLE 14

ACCESSIBILITY OF TREASURY OFFICES TO PEOPLE OVER AGE 65

	POPULATION	0-15 MINUTES	16-30 MINUTES	31-45 MINUTES	46-60 MINUTES	TOTAL	POPULATION / TREASURY OFFICE
ALTERNATE A	11,905	1	5	5	2	13	915.76
ALTERNATE B	11.905	1	5	5	3	14	850.35
ALTERNATE C	11,905	1	5	5	3	14	850.35

although Alternates B and C offer slightly increased accessibility to Treasury Offices, neither offers better accessibility relative to the other. Thus the conclusion might be that a build alternative is preferable to the no-build, but that either of the builds is equally acceptable. However, the data in Table 13 provide the addition information to allow discrimination between the build alternatives. Because of the alignments Alternate C, although it does not offer accessibility to more Treasury Offices, does create the opportunity for more elderly people to use them relative to Alternate B. Moreover, the data in Table 13 reinforce the conclusion that both Alternates B and C offer better accessibility than does Alternate A.

This data, and much more like it that can be obtained through the Statewide Transportation Modeling System, should be valuable not only to highway planners, but also to those who are responsible for seeing that services are provided conveniently and safely to various aggregates of people who share needs or desires.

NOISE POLLUTION ANALYSIS RESULTS: COUNTY AND REGIONAL SUMMARIES

Output from the automated routine that performs air and noise pollution analyses is displayed in Figures 23 and 24. Figure 23 is a listing of the output for each county in the state, whereas Figure 24 is an example of the regional summaries that the routine can provide. A regional summary can be provided for any number of zones that the user choses to examine.

The information relevant to this report is provided in the column on the extreme right in Figure 23 and in the last line in Figure 24. The furthest right column in Figure 23 indicates the number of people in the county affected by noise of 70 decibels or more. The output in Figure 23 is from an analysis of the effects of the network containing Alternate C. A similar listing is printed from analysis on any alternative chosen for analysis. The last line in Figure 24 gives the total number of people affected by 70 decibels of noise in the region under consideration. In Figure 24 the regional summary data comes from an impact analysis of the network containing Alternate A.

Table 15 presents the regional summary data for each alternate in a format that facilitates comparisons of all three alternates. The air pollution data is included simply because it is available. If a complete analysis were being made of the three alternatives this air pollution data would be needed as part of an environmental impact study. Both air and noise pollution are environmental issues, and no doubt both noise and air pollution can be considered social problems in the context of their physiological effects. However, in this report the concern is only with noise because it is being considered relative to its psychological effects on man rather than

COUNTY	EMISSIONS (POUNDS) PER SQ. MILE CO	HC	NOX	NO. PEOPLE EXPOSED TO NOISE LEVELS > 70DBA
1	1.91159	0.09904	0.19449	35
2	0.43127	0.02221	0.03989	1
3	10.61864	0.54970	1.06641	166
4	2.11385	0.10906	0.20092	49
5	2.66908	0.13770	0.25394	0
6	11.59007	0.60075	1.18618	32
7	0.83170	0.04284	0.07685	1
8	2.99717	0.15420	0.27264	1
9	13.46974	0.69464	1.27977	20
10	2.95744	0.15267	0.28422	13
11	17.08243	0.88166	1.64356	359
12	6.15713	0.31829	0.60532	28
13	10.89353	0.56329	1.07418	76
14	6.82429	0.35168	0.63725	57
15	1.51805	0.07809	0.13777	0
16	2.07440	0.10743	0.20944	3
17	0.89676	0.04613	0.08168	4
18	3.32789	0.17161	0.31490	29
19	9.67026	0.50043	0.96564	462
20	4.18019	0.21667	0.42796	0
21	2.69089	0.13887	0.25715	30
22	2.56694	0.13188	0.22929	42
23	13.42576	0.69222	1.27086	37
24	3.84797	0.19785	0.34685	15
25	42.75783	2.19792	3.66541	3243
26	1.68880	0.08702	0.15745	0
27	1.49273	0.07666	0.13240	1
28	5.35802	0.27736	0.53780	192
29	4.98463	0.25651	0.45837	39
30	4.14286	0.21329	0.38109	55
31	0.99267	0.05099	0.08800	2
32	2.03557	0.10481	0.18728	13
33	25.10432	1.29368	2.35137	68
34	7.99430	0.41348	0.79257	30
35	6.56740	0.33893	0.63042	14
36	0.34164	0.01759	0.03153	6
37	4.90723	0.25322	0.47008	15
38	16.35822	0.84605	1.62202	19
39	16.34806	0.84316	1.55588	667
40	1.06992	0.05532	0.10517	12
41	18.56756	0.95863	1.78779	348
42	0.05770	0.00297	0.00533	0
43	0.33189	0.01709	0.03066	0
44	8.94889	0.46323	0.89742	210
45	0.48691	0.02507	0.04493	1
46	4.59729	0.23711	0.43537	270
47	8.99673	0.46621	0.91724	133

FIGURE 23

AIR AND NOISE POLLUTION OUTPUT BY COUNTY

FIGURE 24

```
THE SPECIAL STUDY COUNTIES ARE
                                    5
                                   10
                                   15
                                   24
                                   28
                                   40
                                   45
                                   51
                                   57
                                   83
    CO =  21.60158  LBS PER SQ MILE
    HC =   1.11129  LBS PER SQ MILE
    NOX=   1.96332  LBSPER SQ MILE
    NUMBER OF PEOPLE AFFECTED BY NOISE          72


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

AIR AND NOISE POLLUTION OUTPUT FOR MULTI-COUNTY REGION

TABLE 15

REGIONAL SUMMARIES: AIR AND NOISE POLLUTION ANALYSIS

ALL ALTERNATES

ALTERNATE	CARBON MONOXIDE ADMISSIONS (POUNDS PER SQUARE MILES)	HYDROCARBON EMMISSIONS (POUNDS PER SQUARE MILES)	NITROUS OXIDE EMMISSIONS (POUNDS PER SQUARE MILES)	PEOPLE AFFECTED BY NOISE OF 70 DECIBELS OR MORE
A	21.60158	1.11129	1.96332	72
B	23.88790	1.23289	2.28975	316
C	20.52183	1.05786	1.92876	246

its physiological effects. A discussion of how the Statewide Transportation Modeling System can be utilized to assist in the development of environmental impact statements for regional and statewide analyses will be made at a later date.

From Table 15 it can be seen that the network that contains Alternate A, the no-build alternate, exposes the fewest number of people in the northwest region to noise levels of 70 decibels or more. Alternate B exposes the most people to that level of noise. This result was perhaps intuitively predictable. The proximity analysis output indicated that Alternate B provides the greatest accessibility for almost all purposes. It provides the greatest accessibility partially because it lies closer to the centers of population, and for this very reason it exposes more people to noise levels of 70 decibels or more. However, although this result may have been predictable, never before has there actually been a way to actually measure the relative noise impacts of alternates. Now this information can be utilized by highway planners in the process of deciding which alternate should be built.

SAFETY ANALYSIS RESULTS VEHICLE MILES AND ACCIDENTS

An example of the vehicle summaries output is presented in Figure 23. Summaries are presented for four type of roads: (1) Interstate (2) Federal Aid Primary - Freeway (3) Federal Aid Primary, Non-Freeway; and (4) Federal Aid Secondary. The Total Miles figures indicate the miles of the indicated road type that are in the chosen alternate within the county under study. The "Total Miles LS" figures represent the miles of a given road type that provide a certain level of service. (The reader is referred to Level of Service - System Analysis Model A Public Interaction Application July 1973 for definition of the various levels of service within road type).

The routine provides these summaries for every county in the region, as in Figure 25, and then provides the same information in a regional summary table as in Figure 26. These summaries provide the analyst with an indication of the relative safety of alternative networks. In Table 16, the northwest regional summary data is compiled for each of three alternative networks. This table is a convenient vehicle for comparison of the figures. Two ratios are included that do not appear on the sample print-outs but which are being programmed to appear in the listings. These ratios are: (1) the number of accidents for every 1,000,000 hours of travel. Both of these ratios can be used to judge the relative safety of the alternates.

The major conclusion to be drawn from the data is that the Alternate B network is the safest of the three alternates under consideration. It has the fewest number of accidents and the

FIGURE 25

VEHICLE SUMMARY: ALTERNATE A

COUNTY NO. 28
VEHICLE SUMMARY FUR ALTERNATE 23 NORTHWEST REGION

	INTER STATE	FAP FWY	FAP NON-FWY	FAS	TOTAL
TOTAL MILES	0	0	55	19	74
ANNUAL VEHICLE-MILES (THOUSANDS)	0	0	169514	13231	182745
ANNUAL VEHICLE-HOURS (THOUSANDS)	0	0	226097	17639	243736
ANNUAL ACCIDENTS	0	0	871	47	918
ANNUAL GASOLINE CONSUMPTION (THOUSANDS GALS.)	0	0	7963	619	8582
MILES LS=1	0	0	0	2	2
MILES LS=2	0	0	0	10	10
MILES LS=3	0	0	20	6	26
MILES LS=4	0	0	15	0	15
MILES LS=5	0	0	6	0	6
MILES LS=6	0	0	13	0	13

FIGURE 26

REGIONAL VEHICLE SUMMARY, ALTERNATE 24
INCLUDES COUNTIES NOS 51, 83, 57, 10, 45, 28, 40, 5, 15, 24
RUN 3-25-74 W/ OUTPUT TO TAPE

	INTER STATE	FAP FWY	FAP NON-FWY	FAS	TOTAL
TOTAL MILES	0	141	391	314	846
ANNUAL VEHICLE-MILES (THOUSANDS)	0	535560	721726	216496	1473782
ANNUAL VEHICLE-HOURS (THOUSANDS)	0	563725	925666	305491	1794882
ANNUAL ACCIDENTS	0	963	2742	847	4552
ANNUAL GASOLINE CONSUMPTION (THOUSAND GALS.)	0	29613	34776	9972	74361
MILES LS=1	0	92	49	35	176
MILES LS=2	0	33	50	214	297
MILES LS=3	0	12	144	20	176
MILES LS=4	0	0	19	26	45
MILES LS=5	0	2	30	10	42
MILES LS=6	0	0	91	3	94

VEHICLE SUMMARY: ALTERNATE B

SAFETY ANALYSIS: VEHICLE SUMMARIES, ACCIDENTS

ALTERNATE		INTERSTATE	F.A.P. - FWY	F.A.P. - NON-FWY	FAS	TOTAL
A	TOTAL MILES	0	3	459	314	776
	ANNUAL VEHICLE MILES	0	14,921	973,502	239,618	1,228,041
	ANNUAL VEHICLE HOURS	0	15,689	1,266,955	338,560	1,621,204
	ANNUAL ACCIDENTS	0	16	3903	965	4884
	ANNUAL ACCIDENTS / ANNUAL VEHICLE MILES (1,000,000)	0	1.07	4.01	4.03	3.98
	ANNUAL ACCIDENTS / ANNUAL VEHICLE HOURS (1,000,000)	0	1.02	3.08	2.85	3.01
B	TOTAL MILES	0	141	391	314	846
	ANNUAL VEHICLE MILES	0	535,560	721,726	216,496	1,473,782
	ANNUAL VEHICLE HOURS	0	563,725	925,666	305,491	1,794,882
	ANNUAL ACCIDENTS	0	963	2742	847	4552
	ANNUAL ACCIDENTS / ANNUAL VEHICLE MILES (1,000,000)	0	1.80	3.80	3.91	3.08
	ANNUAL ACCIDENTS / ANNUAL VEHICLE HOURS (1,000,000)	0	1.71	2.96	2.77	2.54
C	TOTAL MILES	0	114	470	314	898
	ANNUAL VEHICLE MILES	0	479,143	728,730	238,394	1,446,267
	ANNUAL VEHICLE HOURS	0	504,315	953,168	335,604	1,793,087
	ANNUAL ACCIDENTS	0	863	2913	941	4717
	ANNUAL ACCIDENTS / ANNUAL VEHICLE MILES (1,000,000)	0	1.80	4.00	3.95	3.26
	ANNUAL ACCIDENTS / ANNUAL VEHICLE HOURS (1,000,000)	0	1.71	3.06	2.80	2.63

TABLE 16

lowest ratios of accidents to vehicle miles traveled and accidents to vehicle hours traveled. The data allows for a comparison to be made between the Alternates, and provides a basis for this conclusion, is by itself a new and very useful addition to the information highway planners need to make informed and accurate decisions. However, as can be seen in the table, there is much more valuable information available. This information can be used to determine why, in fact, the Alternate B network is the safest.

For example, it can be seen that although the Alternate B network has fewer miles in it than the Alternate C network, it sustains more vehicle miles and hours traveled. On the basis of this information alone one might be tempted to conclude that the Alternate C network, sustaining fewer miles traveled per mile of road available, will be the safest alternative. Yet the accident figures and ratios indicate otherwise: Why? The answer can be found in the sub-total figures. In the Alternate B network there is both a higher percentage of freeway roads then in the Alternate C network, and a higher percentage of vehicle miles and hours traveled on these freeway miles. The configuration of the Alternate B network is such that people are inclined to travel more on the safest road type, the freeway roads, and less inclined to travel on the less safe road types, the FAP - Non-Freeway and Federal Aid Secondary Roads.

It is true that the freeway links in the Alternate B network do sustain more accidents than those in the Alternate C network, but the reduction in accidents on the FAP Non-freeway and F.A.S. roads relative to the accidents on the same road types in the Alternate C network more than offsets this increase and the shift results in both fewer total accidents and lower overall ratios of accidents to vehicle miles traveled and accidents to vehicle hours traveled.

Furthermore, the statistics indicate that for all road types, other than FAP Freeway links, in which case there is no valid basis for statistical comparison, both the Alternate B and C networks are safer than the no-build alternative for all road types. This result was perhaps to be expected because of the increased percentage of the safer freeway miles in each alternate, and in the past planners have made decisions based upon this expected result. However, now there is a routine that provides statistical summaries from a predictive model that enables planners to analyze the relative safety of links, and then make informed decisions about which of the build or no-build alternatives should be built.

SOCIAL DISRUPTION: ANALYSIS RESULTS

In analyzing the social disruption test results there is little need for manual manipulation of the data. The routines applied to this test perform a complete range of manipulations. A new network is built based upon new data that has been input to the system. From this network new trees and skim-trees are built that describe various time path alternatives between zones and determine a set of minimum time paths. Then the new skim-tree is subtracted from the one created from the old network. This subtraction creates a matrix of minimum time path differences which indicates whether travel times between zones have been shortened or lengthened. This matrix is then input to a selected tree routine which creates individual matrices for selected zones that show the travel time differences created between each selected zone and every other zone in the system. A series of listings which show these differences from each selected zone to every other zone can then be obtained for analysis. An example of such a listing is in Figure . This listing shows the differences in minimum travel times from Zone 235 to any other zone for the two networks portrayed in Figures 16 and 17.

Because the minimum travel times between zone 235 and all other zones is larger for the new network than for the old, and because the minimum travel time matrix along the new network is subtracted from that along the old network, the differences appear as negative numbers. The lack of positive numbers indicates that the new links do not make travel times shorter between zone 235 and any other zones. There is no appreciable change in driving times between

INTERCHANGE VALUES FROM ZONE 235 TO ALL OTHER ZONES TABLES NUMBER 101

	0	1	2	3	4	5	6	7
0		1	0	-3	-4	-4	-4	0
1	0	0	0	0	0	0	-7	-7
2	0	0	-4	-4	-4	0	0	0
7	0	0	0	0	0	-7	-7	-7
8	-3	0	0	-4	-4	-3	-4	-4
10	0	0	0	-4	-4	-4	-4	-4
11	-4	-4	-4	0	0	0	0	0
12	0	0	0	0	-7	-7	-8	-7
14	0	0	0	0	0	0	-4	-4
15	-4	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0
17	-4	-4	-4	-4	-4	-4	0	0
20	0	0	0	0	0	-4	-3	-4
24	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	-4
28	-3	-3	-4	-3	0	0	0	0
29	0	0	0	0	0	-4	-3	-4
30	-4	-3	0	0	0	0	0	0
31	0	-4	-4	-4	-4	0	0	0
38	0	0	0	-4	-3	-4	-4	0
43	-4	-4	-4	0	0	0	0	0
44	0	0	0	0	0	-3	0	0
51	0	-4	0	0	-4	-4	-4	-3
52	-4	-4	-4	0	0	0	0	0
54	0	0	0	0	0	-3	0	0

TOTAL = -373 MEAN = -0.682

FIGURE 27

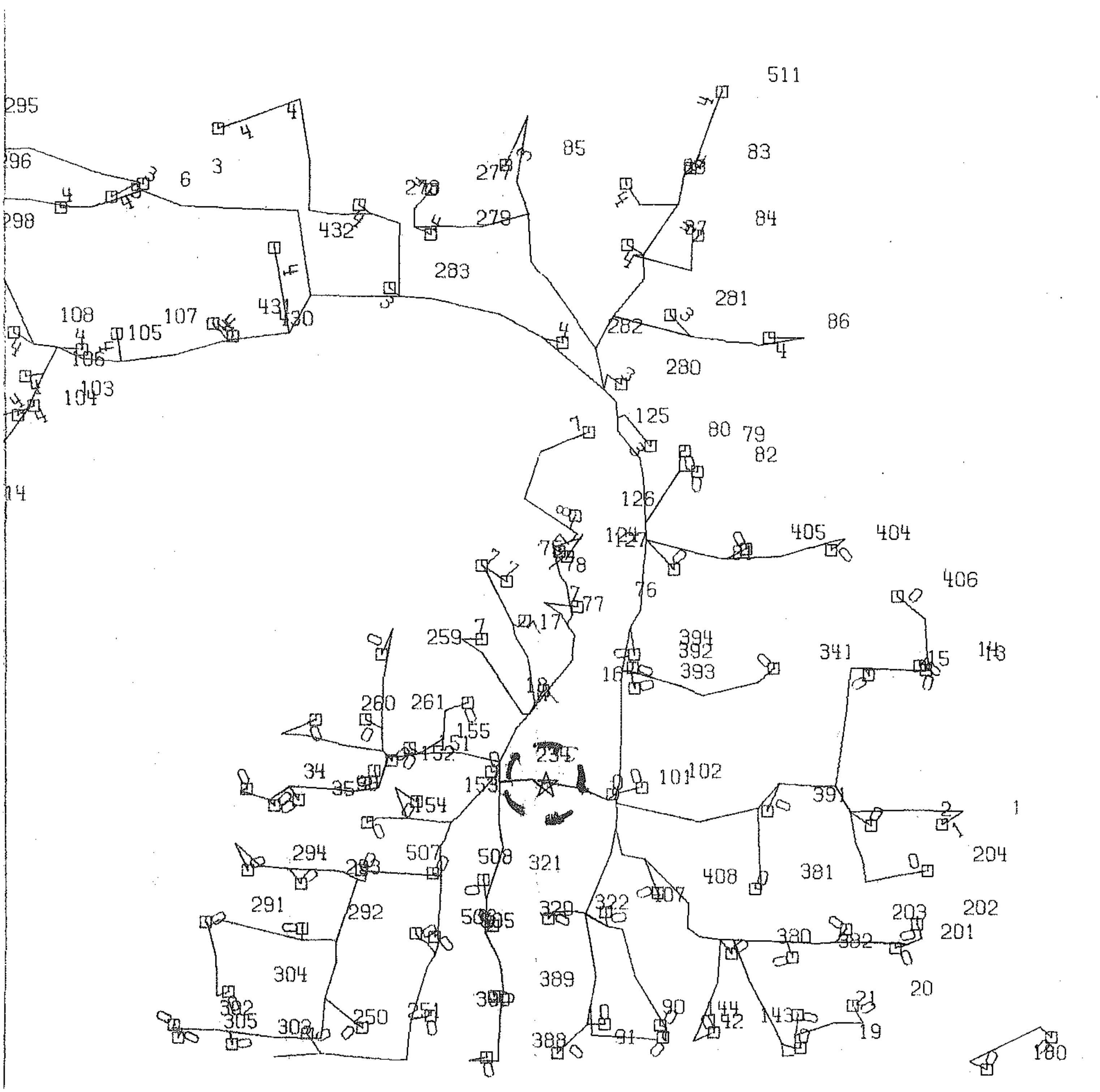
INCREASED TRAVEL TIMES DUE TO ROAD CLOSING zone 235 and many other zones and this fact is indicated by the zeroes in the matrix. However, between 235 and a number of zones driving times are lengthened anywhere from 4 to 8 minutes. The effect of the new network is clearly negative and this effect is indicated in the total travel-time difference of -373.

These travel differences can be plotted. The selected tree information is fed into a plotting routine along with other network data to create a graph which shows travel time differences between zone 235 and any other zone in the system. Figure 76 presents the information from Figure 25 in graphic form for all zones north of Zone 235. (The two and three digit numbers are zone numbers. The squares represent the centroids of each zone. The one digit number associated with each square represents the additional time needed to travel from zone 235, represented by the star, to each zone centroid). This graph helps planners and analysts to visualize the impact that the new network has on travel times across a geographical area. Note that the new network created longer travel times between zone 235 and almost all zones throughout the northern part of the State.

The importance of this analysis technique is obvious. Never before has it been possible to determine with speed and accuracy the effects of a road closing on the travel times throughout a network. In the past such a closing might have been considered to have only a local impact. Now, however, it can be seen that travel times between zone 235 and many other zones are definitely lengthened. This means that people will have to spend more time traveling between zone 235 and most of the northern part of the state.

FIGURE 28

PLOT OF INCREASED TRAVEL TIMES DUE TO ROAD CLOSING



The importance of this analysis technique is obvious. Never before has it been possible to determine with speed and accuracy the effects of a road closing on the travel times throughout a network. In the past such a closing might have been considered to have only a local impact. Now, however, it can be seen that travel times between zone 235 and many other zones are definitely lengthened. This means that people will have to spend more time traveling between zone 235 and most of the northern part of the state. With additional information about the number of trips taken between zone 235 and all other zones it becomes a simple matter of multiplying the additional travel time between zone 235 and all other zones by the number of trips to determine the number of additional minutes accumulated for all trips. Then by multiplying this product by the number of people per trip and dividing by 60, it is possible to determine the additional man-hours consumed in travel each year as a result of the selected road closing. These additional travel hours constitute a social disruption of considerable magnitude.

PSYCHOLOGICAL IMPACT MODEL RESULTS

Two forms of graphic output can be obtained from the Psychological Impact routine. Both forms are presented in this section. Figures 27, 28, and 29 present data in one of the output formats. In these figures the larger numbers denote nodes, the junctions of two or more links. The smaller numbers, those written along each link, represent the hassle factors that have been computed for each link. As can be seen the model is capable of computing the hassle factors for all projected links as well as the hassle factors for links already in existence. Note that in the network containing the new links from Alternates B and C not only can the psychological impact model compute the hassle factors for new links, it can also compute new hassle factors for existing links that reflect travel pattern changes resulting from the introduction of the new links. For example, for link 1307-1308 the Hassle Factor in the no-build Alternate, Alternate A, is 187, whereas for the same link in the Alternate B and C networks the hassle factor has risen to 225. Apparently because of the new highway alignment the link becomes more crowded or more heavily used by trucks in the Alternate B and C networks. Whatever the reasons, however, the fact that the Psychological Impact routing is capable of recomputing hassle factors as a result of systemic changes is significant. It enables the transportation analyst not only to model the existing highway network using psychological parameters, it also allows him to estimate the impact of possible new roads on drivers using these roads and on drivers using other links on which driving conditions will change as a result of these new roads. It enables the planner to observe how the introduction of new links in a system has an effect on the

FIGURE 28

PSYCHOLOGICAL IMPACT MODEL TEST
ALTERNATE A
PLOT OF HASSLE FACTOR BY LINK

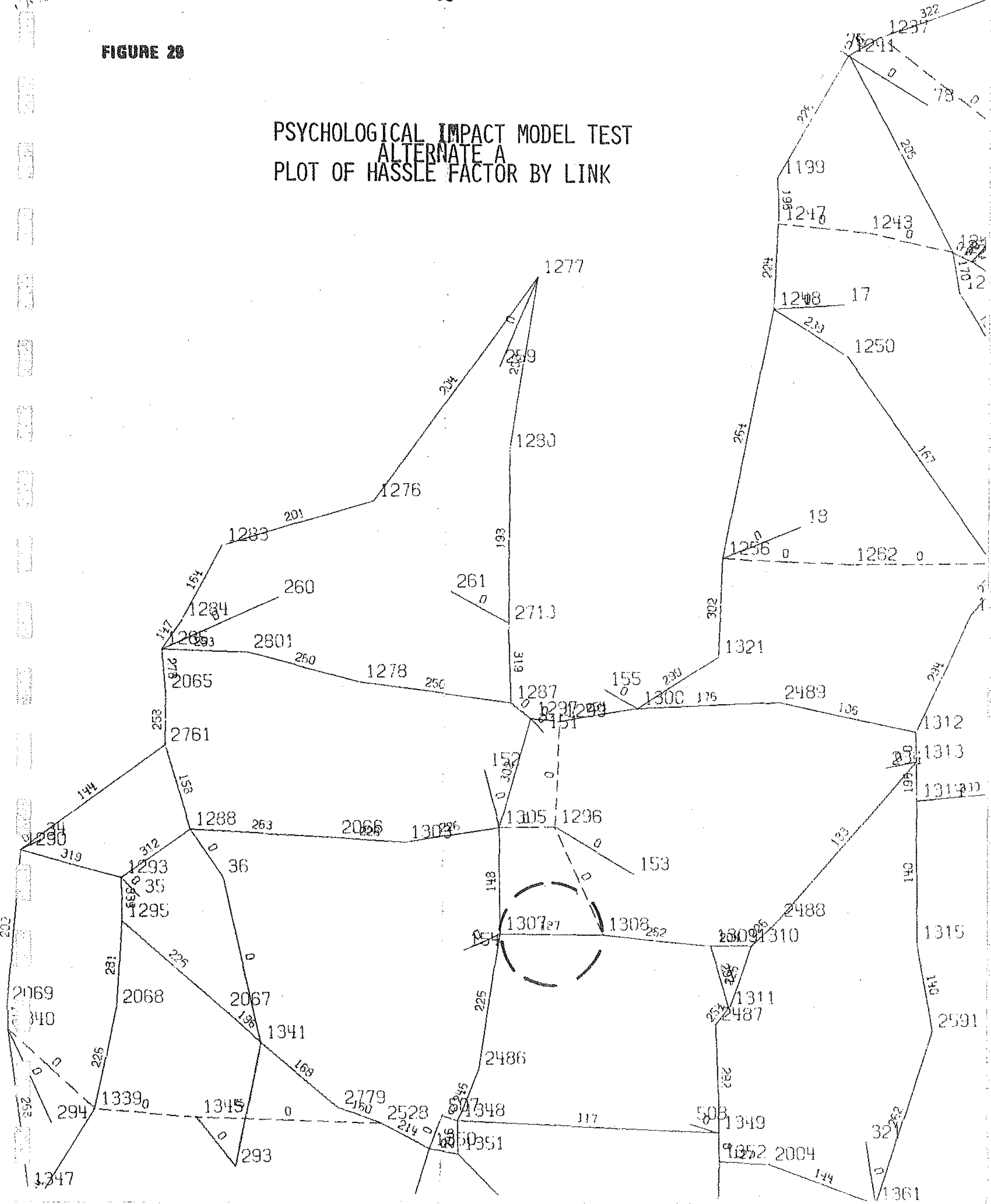


FIGURE 30

PSYCHOLOGICAL IMPACT MODEL TEST
ALTERNATE B
PLOT OF HASSLE FACTOR BY LINK

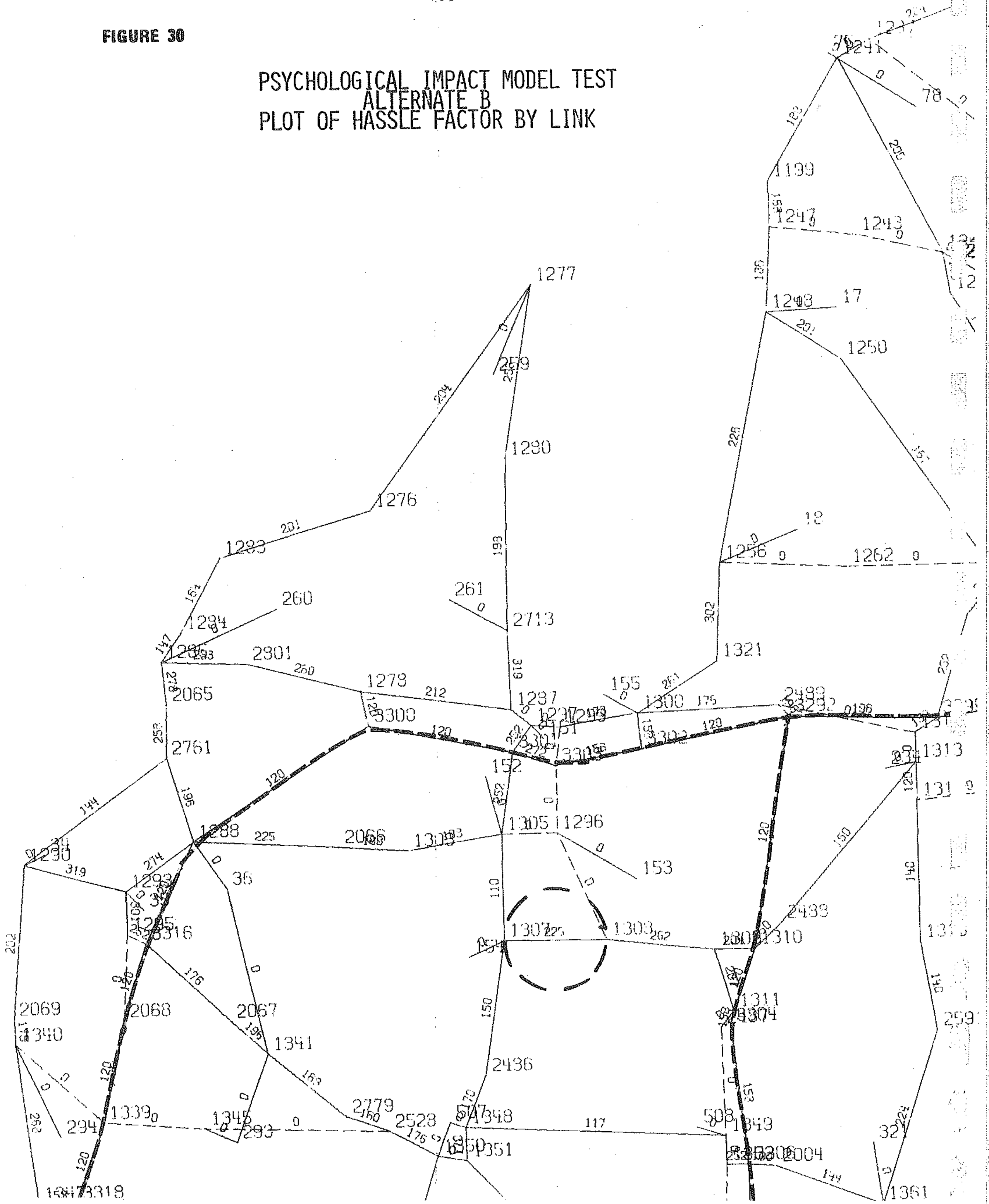
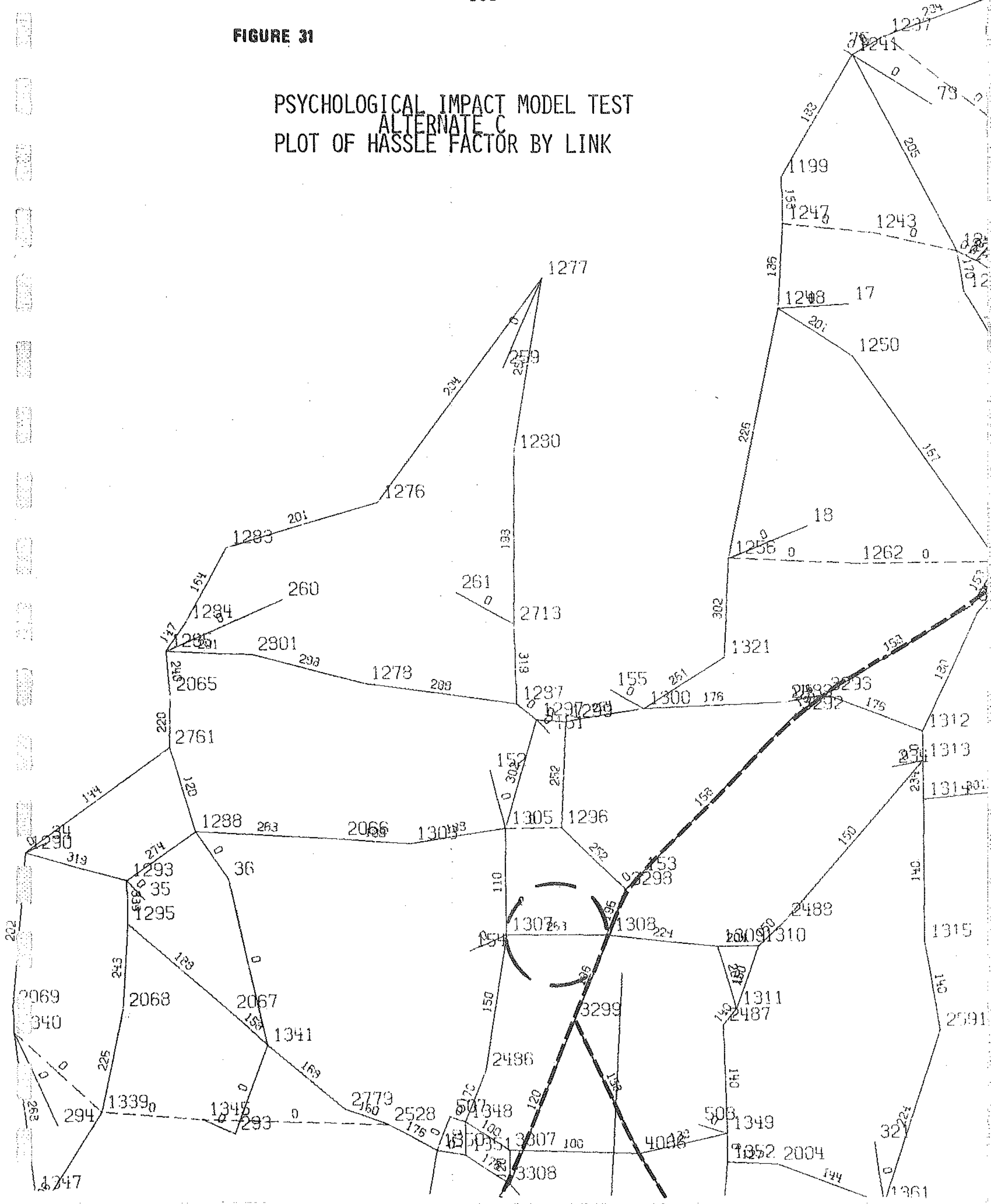


FIGURE 31

PSYCHOLOGICAL IMPACT MODEL TEST
ALTERNATE C
PLOT OF HASSLE FACTOR BY LINK



psychological driving conditions on links throughout a region or even the state.

The second form of graphic output that can be obtained from the Psychological Impact routine is presented in Figures 30, 31, and 32. This form presents the same data only in this case through the use of bandwidth plotting. Each bandwidth represents a range of psychological comfort or distress (depending upon one's perspective). The following values are associated with the given band width:

Bandwidth	Hassle Factor
1	1.00-1.79
2	1.80-2.59
3	2.60-3.39
4	3.40-4.19
5	4.20-5.00

Thus a narrow band indicates low psychological discomfort and a wider one indicates greater psychological discomfort.

Note on the figures that the new links in the Alternate B and C network are represented by bands having only one line. These new links are freeway links which have the best psychological comfort rating of any links built.

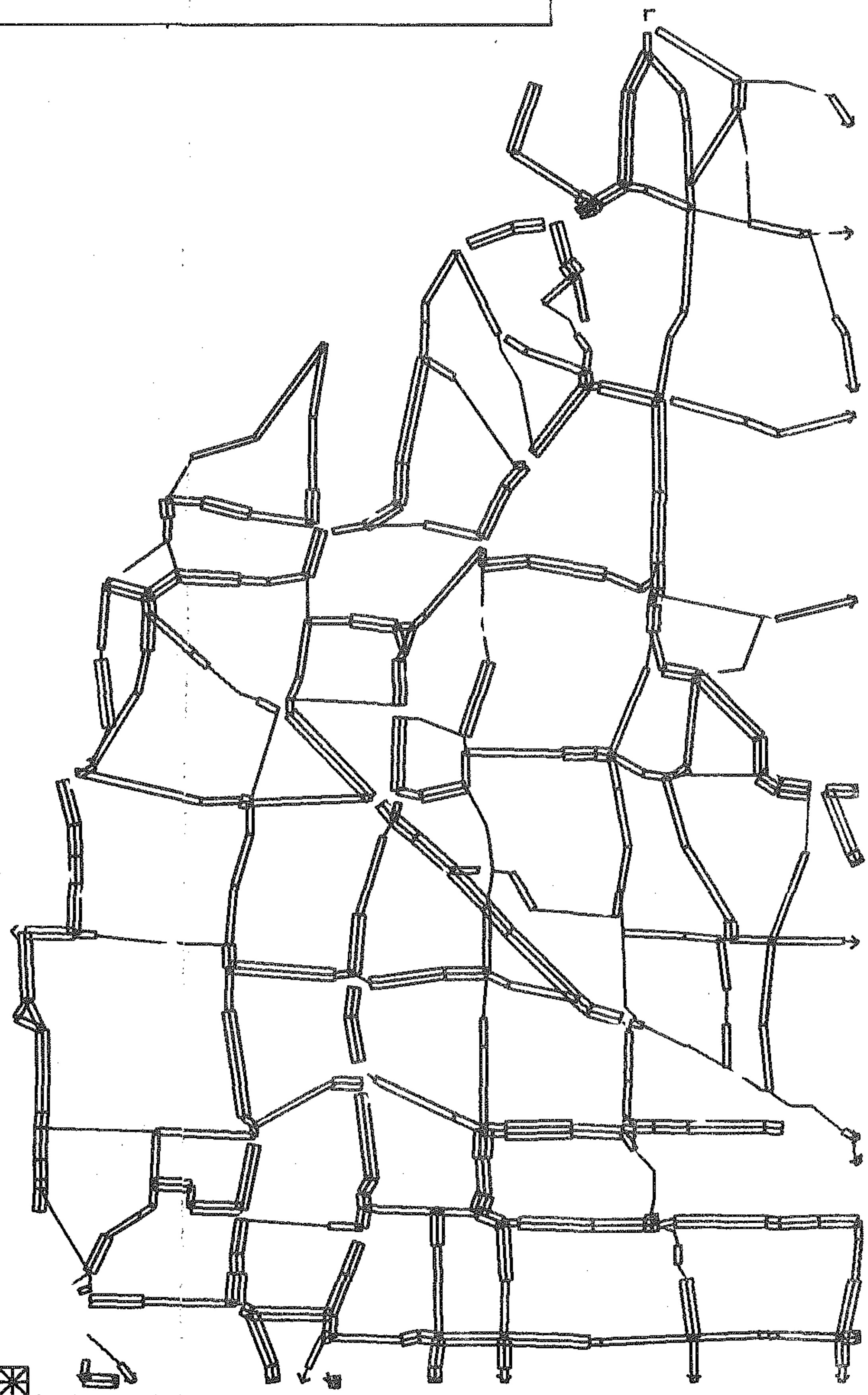
There are two major uses to which the Psychological Impact data may be put. Most obviously the data can be used to determine which links have combinations of factors that make driving on them both distressing and hazardous, and thus which links should be either improved in some ways or replaced or supplemented. Less obviously, the data can be used by the transportation analyst to create a better traffic assignment model. Once driver psychological discomfort rises to a certain level because of distressing circumstances such as traffic volume or percent of trucks on the link, a number of drivers (a percentage of the total yet to be determined by research) will shift

STATEWIDE TRANSPORTATION MODELING SYSTEM

*

PSYCHOLOGICAL IMPACT MODEL TEST
ALT. A (23)
BANDWIDTH PLOT OF
HASSLE FACTOR

FIGURE 32



STATEWIDE TRANSPORTATION MODELING SYSTEM

*

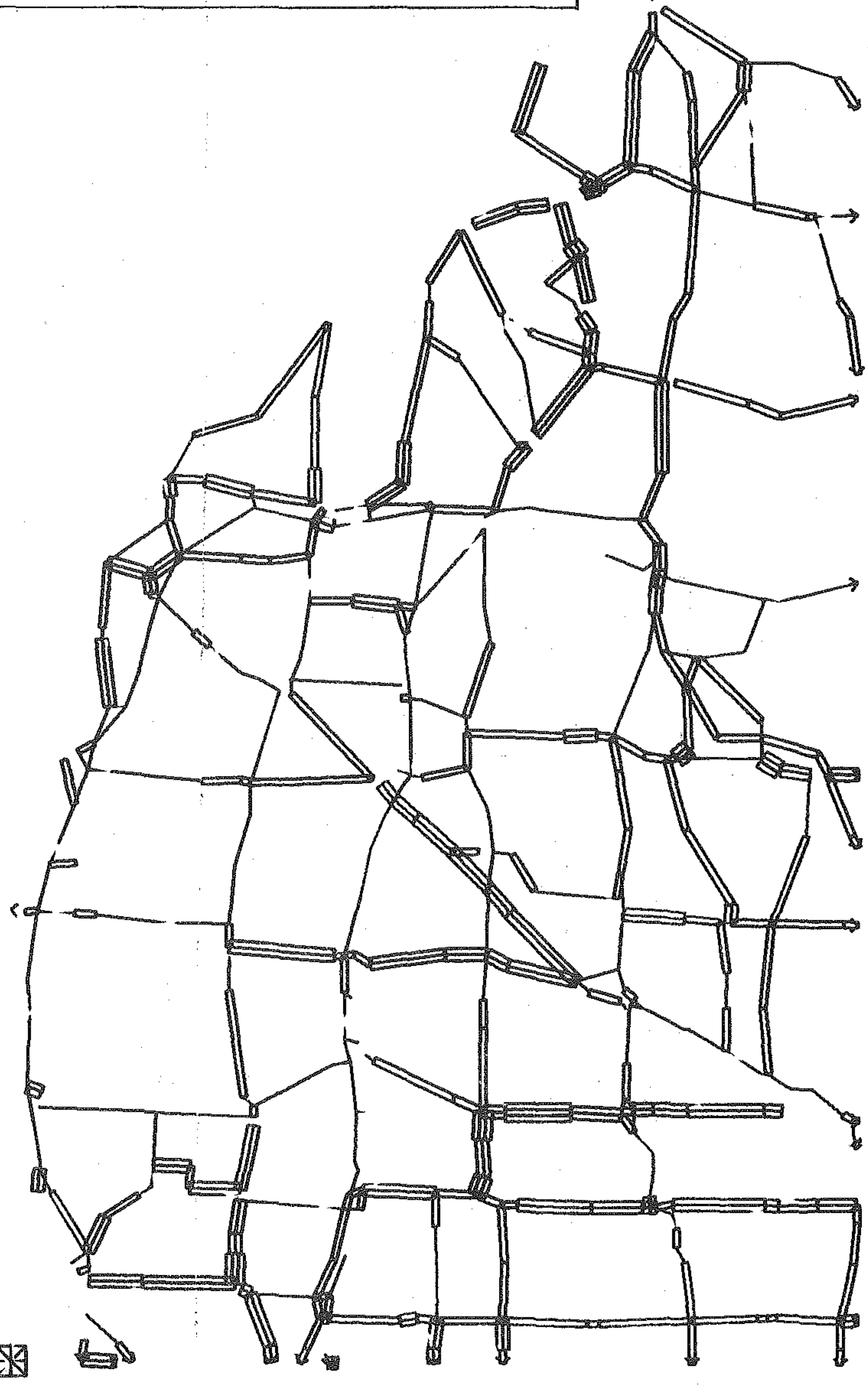
PSYCHOLOGICAL IMPACT MODEL TEST

ALT. B (24)

BANDWIDTH PLOT OF

HASSLE FACTOR

FIGURE 33



STATEWIDE TRANSPORTATION MODELING SYSTEM

*

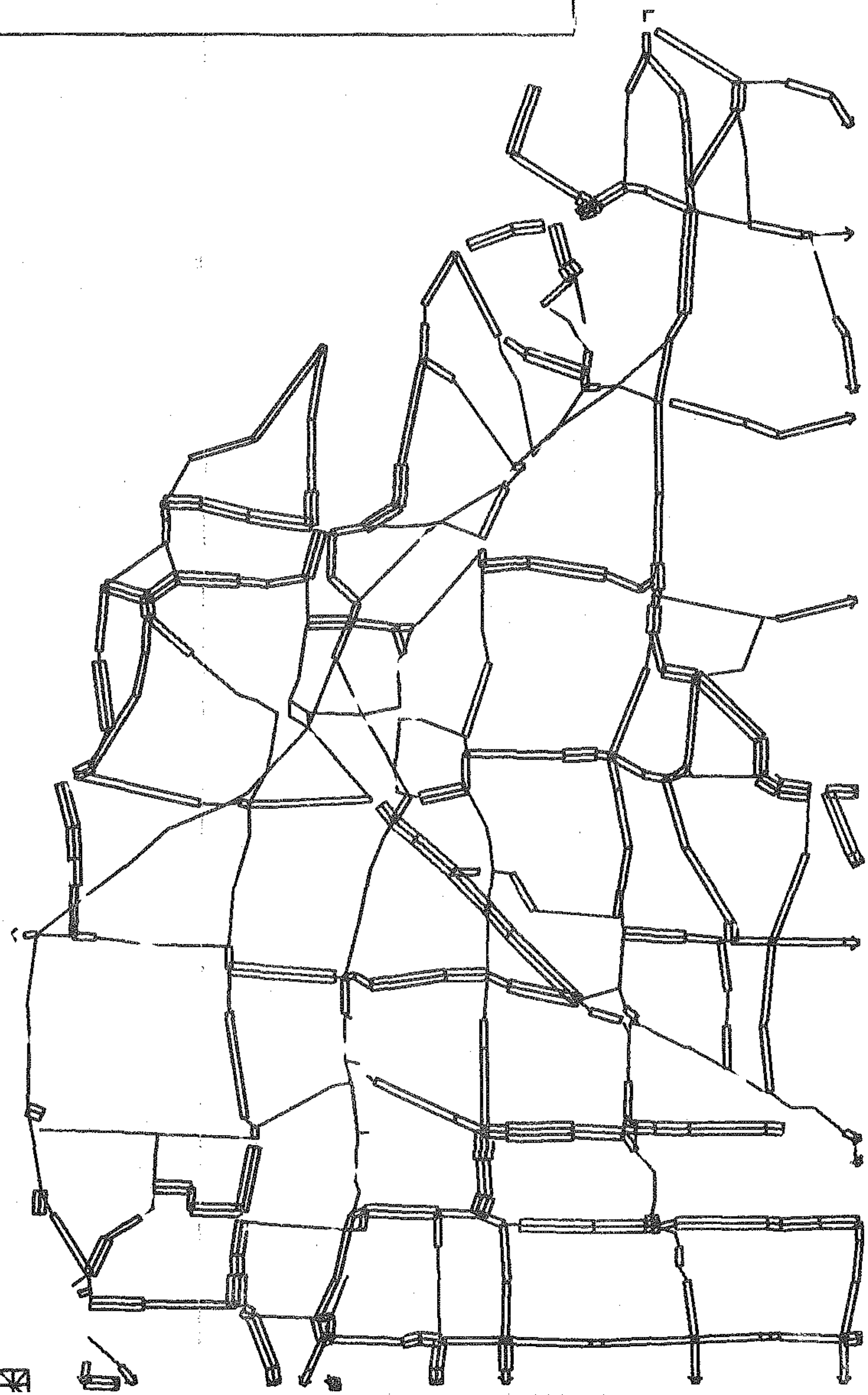
PSYCHOLOGICAL IMPACT MODEL TEST

ALT. C (26)

BANDWIDTH PLOT OF

HASSLE FACTOR

FIGURE 34



to other highway links to avoid the distress. The shift will occur even if it means moving to a slower travel route.

Regardless of the use to which the data is put, there is little doubt of its value as part of an overall program to assess the social impact of new highway alternatives. The data, which can also be output for each link through the usual listing format along with many other relevant social, economic, environmental and other data, provides the analyst or planner with additional information that should lead to definitive transportation planning.

GENERAL PEDESTRIAN DEPENDENCY: ANALYSIS RESULTS

In this section the discussion is centered, first, around the need for a slight revision in the concept of the GPD Index; second, around how to read the output data in the given presentation format; third, around how the GPD Index can be used in planning mass transit for rural areas; fourth, around how the GPD Index can be used in planning the location of highways in rural areas; and fifth, around how the GPD Index can be used to indicate where highways should not be located in urban areas.

Figure 35 is a plot of the General Pedestrian Dependency indices that were computed for each of the zones in the Northwes Region of the lower peninsula. The plot indicates which zones have a greater or lesser proportion of people who have a propensity to walk to obtain their needs or desires. The propensity concept is used here because in actuality the GPD Index cannot be used to determine the exact number of people who walk to obtain services, Rather it can only be used to indicate the relative predisposition of people in a given area to do so. This distinction is perhaps more important in larger, more rural area analysis than it may be for analyses of smaller, more densely populated urban areas. In urban areas, given the shorter distances between points of origin and destination for many trips, walking to obtain needs or desires may be a practical alternative to using an automobile, and therefore, there may be a close correlation between the number of people who walk and the proportion indicated by the General Pedestrian Dependency Index. However, in rural areas where average trip lengths are much greater, although people may wish to walk to obtain needs or may be so situated that they would walk if they had any choice, they may be forced to make arrangements to use an automobile because it is the only practical transportation mode under the circumstances. Therefore, when considering what the GPD Index implies about current or future demands for certain transportation modes in rural areas, it is wiser to work with the idea of propensities to walk then to attempt to compute the number of people who actually do walk for certain purposes. By viewing the plot in Figure 35 within this conceptual framework the results obtain considerably more credibility because it is virtually certain, given the rural character of the region and the virtual lack of any alternative to the automobile, that almost all of the people, regardless of what the indices say, depend upon the automobile for travel purposes.

The following key indicates which pedestrian Dependency Index values are associated with each of the symbols on the plot.

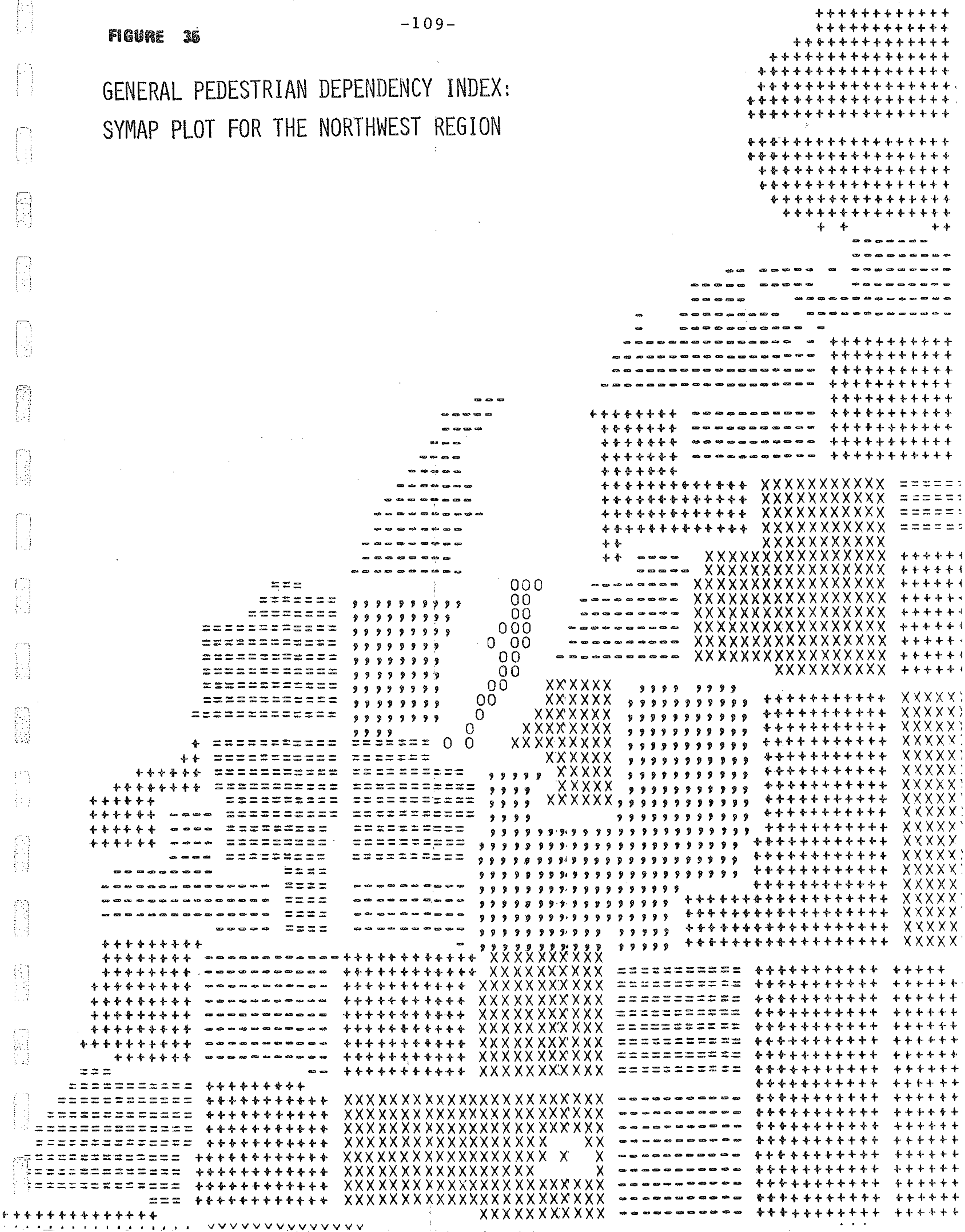
GPD Index Value

0.00-0.09	0.10-0.19	0.20-0.29	0.30-0.39	0.40-0.59	0.60-0.79	0.80-0.99	1.00-1.99	2.00-2.99	3.00-4.00
.....	,,,,,	-----	=====	+++++	XXXXX	00000	θθθθθ	▩▩▩▩▩	█████
.....	,,,,,	-----	=====	+++++	XXXXX	00000	θθθθθ	▩▩▩▩▩	█████

A lower index number represents greater dependence upon the auto. Thus the plot indicates that people in area 1 would be more likely to walk, if they had the opportunity, or, more importantly for rural analysis, ride a form of public transit if it were practical, than those people in area 2 where the GPD Index is lower.

FIGURE 35

GENERAL PEDESTRIAN DEPENDENCY INDEX:
SYMAP PLOT FOR THE NORTHWEST REGION



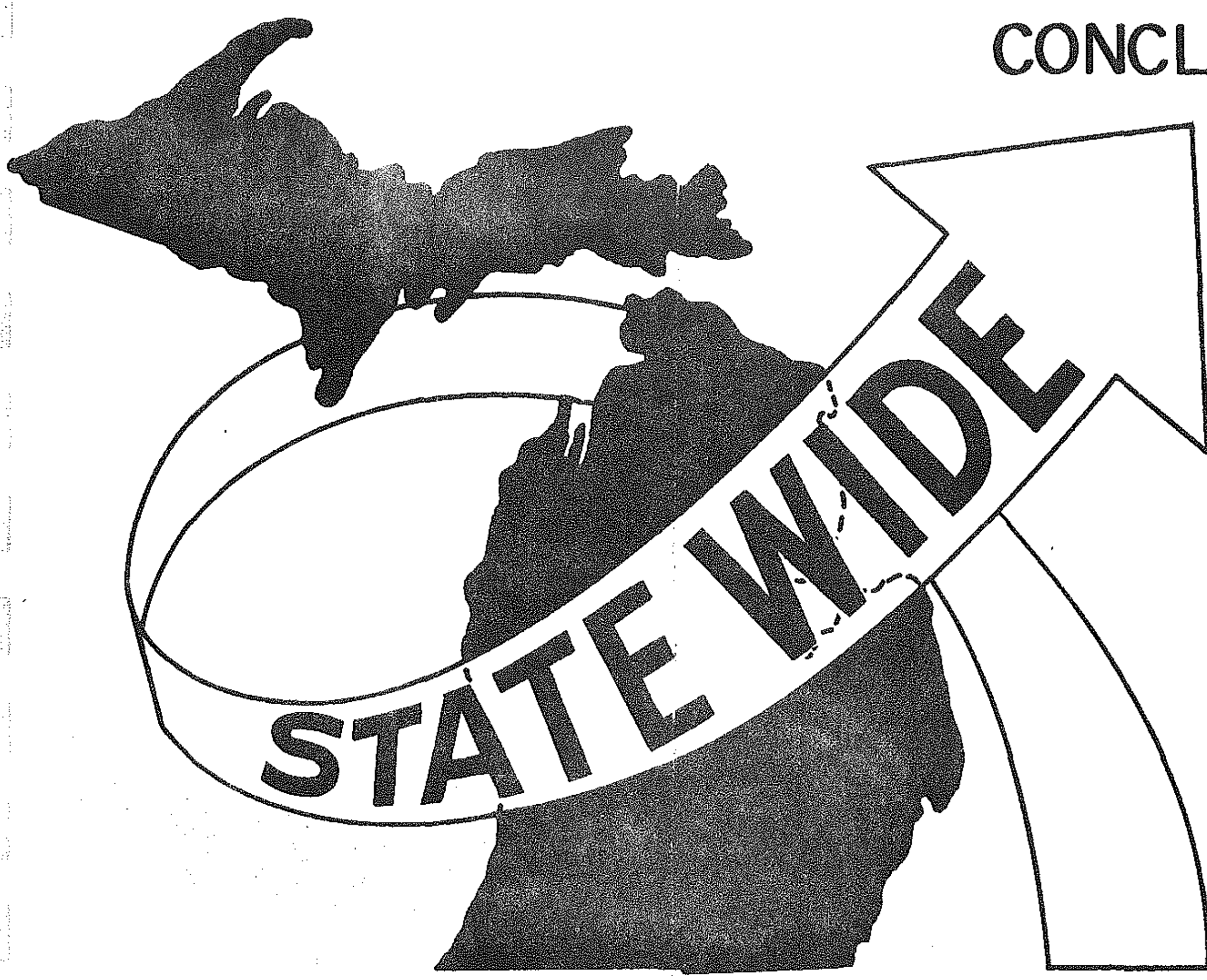
In rural areas the GPD Index can be applied to best advantage in identifying which areas are most likely to benefit from and use mass transit facilities if they are introduced on a competitive basis. (A system that costs either no more or relatively little more than existing transportation modes in both time and money and which provides services frequently enough is competitive.) This is true because, in effect, the index shows the concentrations of people who have either no autos or who have the lowest incomes relative to the population at large, and these people are the most likely candidates for mass transit useage. However, for locating mass transit routes the GPD Index is not a sufficient indicator. It acts only to show where there are more people who have a propensity to walk relative to the total number in the zone under analysis; it does not relate these proportions to actual population numbers. The GPD Index would be sufficient for decision making purposes if all zones in the system had approximately the same number of people. Generally, however, the zones have populations that vary considerably in number. Therefore, in addition to the GPD Index, what is needed for rural analyses is a formula, based upon the reasoning used to derive the GPD Index, which can be used to make estimates of actual numbers of people in each zone who have a propensity to walk or to use mass transit. By using these numbers transportation planners would be able to determine if there were enough people in the indicated areas to support certain types of transit alternatives. Together the GPD Index and the additional formula could greatly aid planners in determining where transit facilities should be located.

In both urban and rural areas, the GPD Index can be used to determine where highways should be located. Those zones that show the highest relative dependency on the auto according to the index and those zones that have the highest number of people dependent upon the auto (this number obtained by using the additional index described above) should be the zones which highways are designed to serve and in which the highways should be located.

The highways should be located in high auto dependency zones for two reasons: First, they will be more accessible to auto users in these zone; and second, when located in high auto dependency areas rather than in high pedestrian dependency areas, their impact on pedestrian traffic will be minimized. Kaplan, Gans and Kahn have indicated that especially in urban areas, the imposition of new highways in high pedestrian dependency areas can create serious disruptions of traditional, and usually quite stable, social patterns. Thus when used in an urban analysis system, one which can be created using the same techniques used to create the Statewide Transportation Modeling System, the GPD Index can be used to indicate those areas in which highways should not be located. The subtleness of the analysis of course, should be related to the needs of the task at hand. Thus for corridor location analysis it may be sufficient to use relatively larger zones when computing the GPD Index. However, for highway alignment decisions it may be necessary to use smaller areal aggregates defined by such criteria as ethnic or economic interaction patterns.

The potential of the GPD index, although limited in isolated use, is substantial when used with other analysis techniques. It can be incorporated with other techniques in to a modeling system such as the Statewide Transportation Modeling System to create a unified and comprehensive system of transportation analysis that encompasses economic, social and environmental considerations.

CONCLUSION



CONCLUSION

This report was written to demonstrate how any state might apply a statewide transportation modeling system such as Michigan's (Figure 5) in the area of social impact analysis. Analysis procedures detailed and tested in this document deal with impact analysis at the statewide and regional levels. The list of social impact measurement techniques identified in Figure 9 is not meant to be complete, rather these techniques were chosen as examples of how impact measurements can be obtained quickly and inexpensively using modeling techniques.

The Statewide Studies Unit will appreciate any comments that the reader may have concerning the report. Hopefully the techniques described here will be incorporated by transportation analysts into their analytical arsenals, and will help to stimulate new ideas that can lead to improved analytical techniques.