

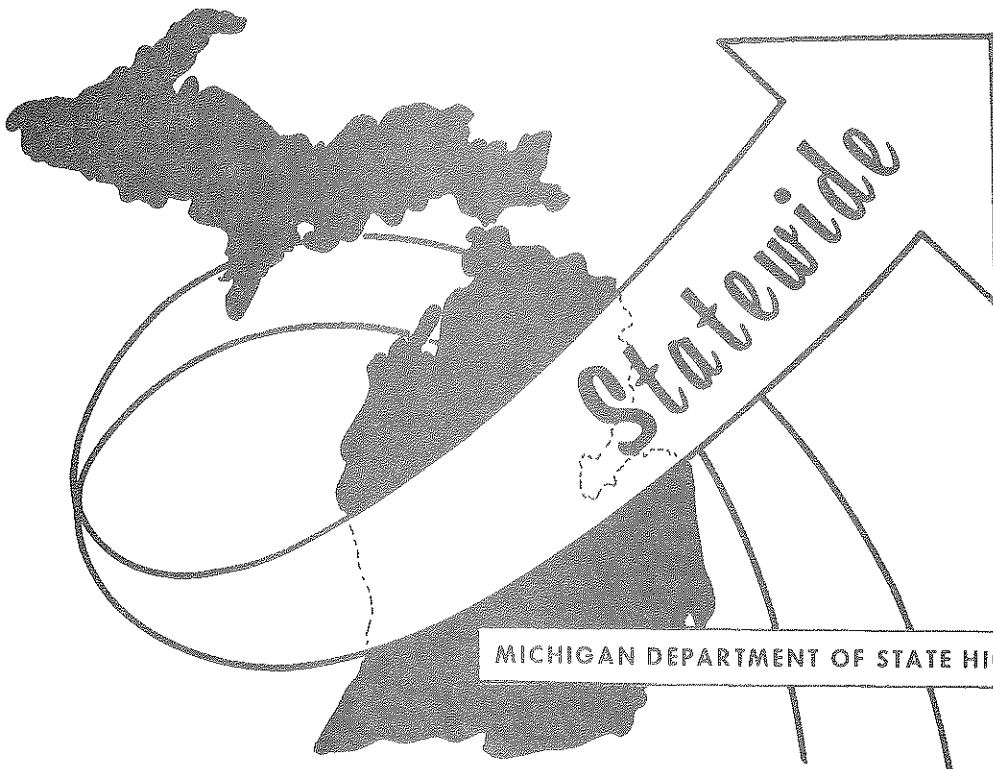
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Statewide Transportation Analysis & Research

STATEWIDE TRANSPORTATION MODEL
MULTIPLE APPLICATIONS:
AMBULANCE
SERVICE-AREA ANALYSIS

Report no. 8

DECEMBER 1973
STATEWIDE STUDIES



MICHIGAN DEPARTMENT

OF

STATE HIGHWAYS AND TRANSPORTATION

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MULTIPLE APPLICATIONS:
AMBULANCE
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JOHN P. WOODFORD, DIRECTOR

January 4, 1974

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

Dear Mr. Cryderman:

The following report was completed in conjunction with inquiries from Mr. Kenneth Malkowski, Health Planning Consultant, Office of Health and Medical Affairs, Executive Office. The decision was reached that elements of the Statewide Transportation Modeling System could supply some valuable information for use in evaluating emergency ambulance services for the state. While initially completed to fulfill this request, the report also demonstrates the reversibility of the Statewide Modeling System by looking at the information from a highway planning perspective. The following pages were completed using a 1965 highway network as a basis, however, the impact of proposed highways on ambulance facilities could easily have been undertaken.

This report was completed by Mr. Alan R. Friend of the Statewide Studies Unit under the supervision of Mr. Richard E. Esch.

Sincerely,

A handwritten signature in cursive script that reads "Keith E. Bushnell".

Keith E. Bushnell
Engineer of Transportation
Survey and Analysis Section



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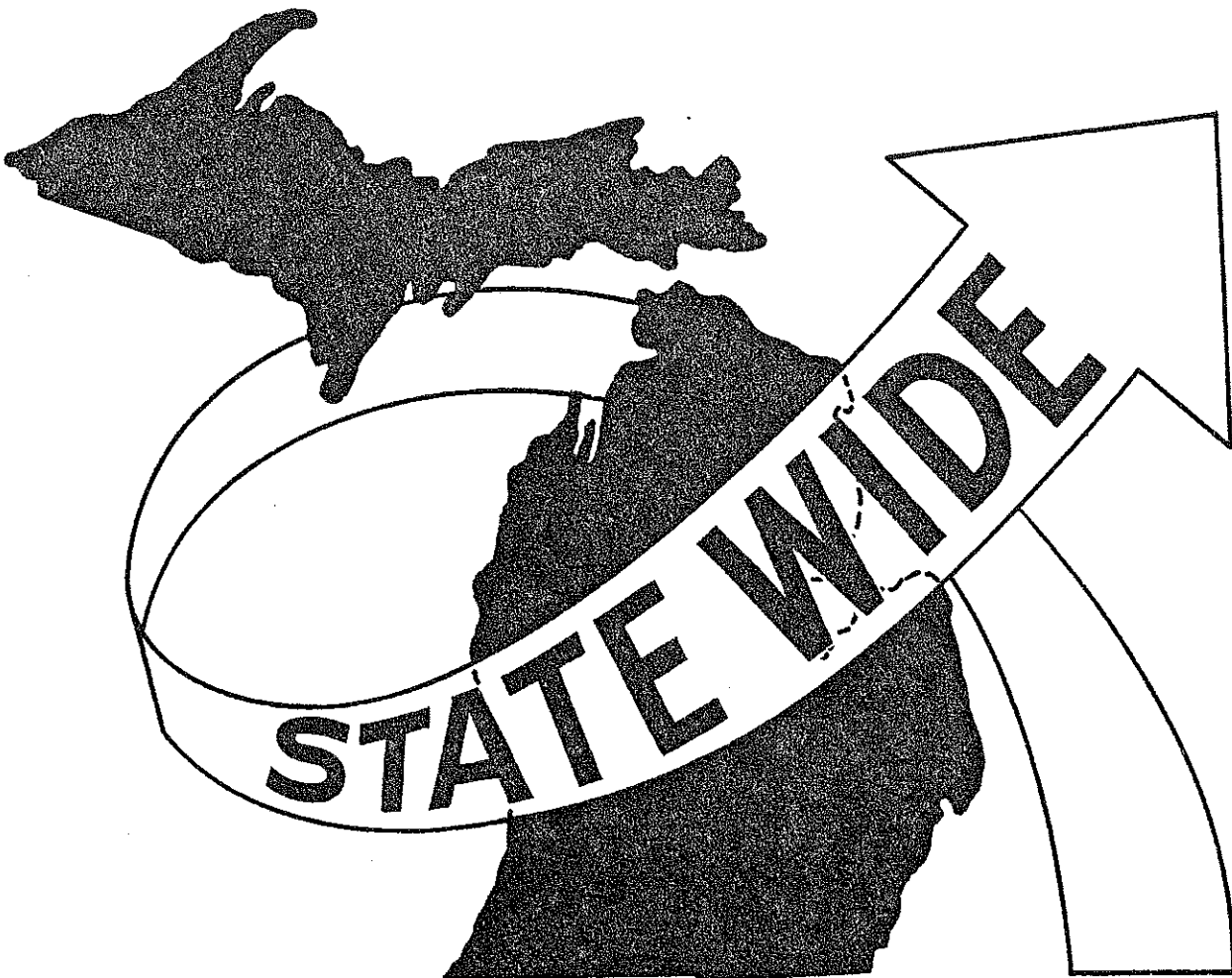
AMBULANCE SERVICE AREA ANALYSIS

BY

ALAN R. FRIEND

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INTRODUCTION



INTRODUCTION

The following report documents another application of the Statewide Transportation Modeling System and was compiled in response to inquiries from the Office of Health and Medical Affairs which is working with the Department of Public Health to evaluate how well the present system of emergency ambulance facilities are serving the state. The report was completed with the cooperation of Mr. Kenneth Malkowski, Health Planning Consultant, Office of Health and Medical Affairs, Executive Office.

Although the Statewide Transportation Modeling System was used as a public health planning tool, the process is equally applicable as a highway planning tool since the techniques which used the present highway system for health planning can be used with proposed highway systems to assist highway planning by observing the impacts of these proposed roads on public health. This approach makes it easier for the highway department to systematically meet its responsibilities related to public involvement in the 1970 federal legislation.

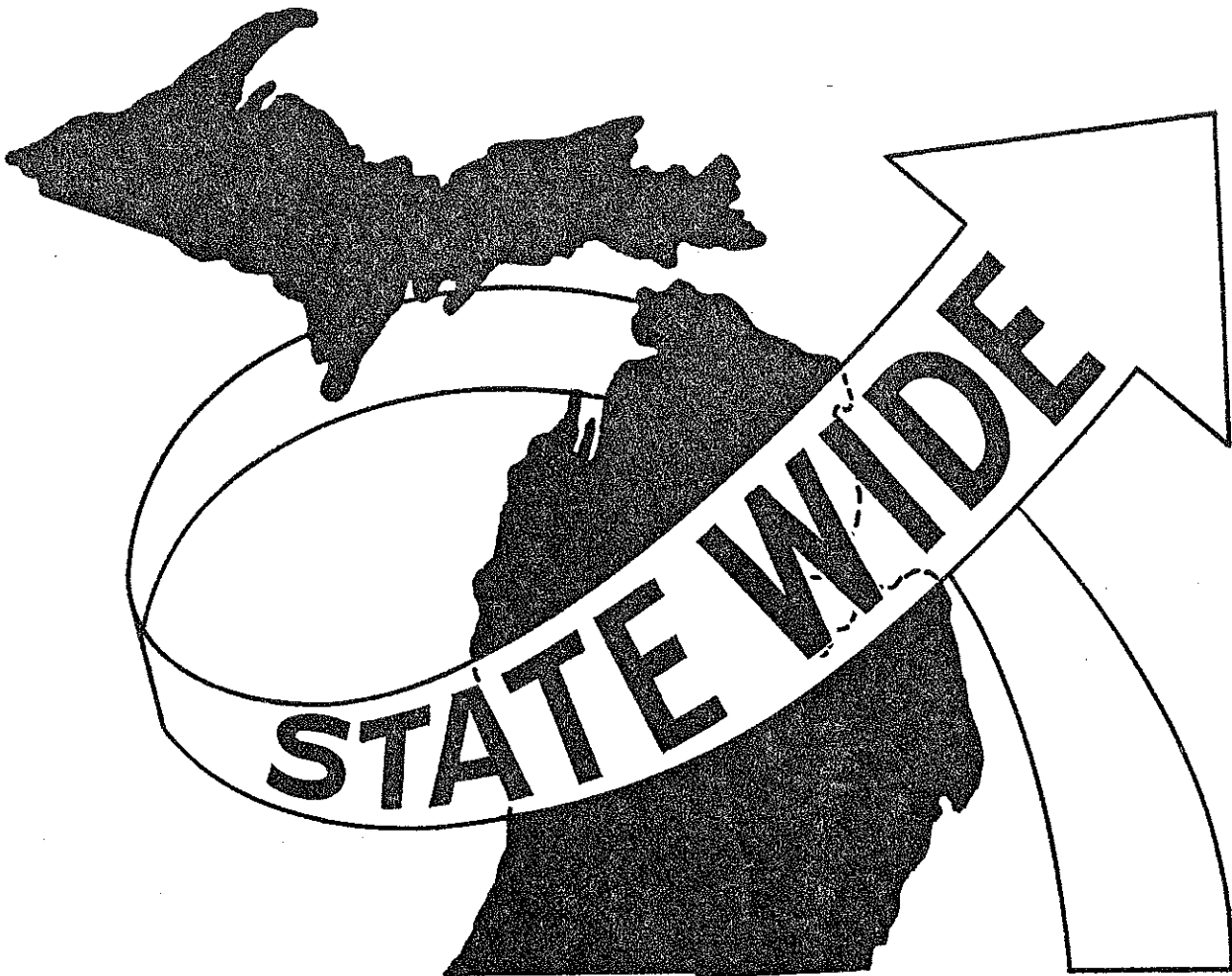
To assist in the evaluation of ambulance facilities the answers to the following questions were sought:

1. What is the relationship of number of people in an area to the number of emergency ambulances?
2. How many automobile injuries occur within 20 minutes of emergency ambulance facilities?
3. What places in the state cannot be reached within 20 minutes and how many injuries are involved for these places?

CONSIDERATIONS

AND

ASSUMPTIONS



CONSIDERATIONS AND ASSUMPTIONS

Techniques and the assumptions which the results are based upon are essentially the same as used in previous work concerning the proximity of automobile injury accidents to hospitals. This study may be reviewed in the publication entitled: Statewide Project Report: Proximity of Automobile Injury Accidents to Hospitals, Part A, June 1973.

The analysis revolves around the 508 areas which the state has been divided into for use in the Statewide Transportation Modeling System. See Figure 1 for these areas, which are referred to as zones. Data about the number of ambulance facilities, the number of vehicles, and the number of injuries were summarized to this zone level. Injury data was for the year 1970.

All proximity information is based on driving between central points called centroids which are located in each zone. All data associated with a zone is assumed to be concentrated at the centroid. Figure 2 shows a sample portion of a highway network in the Muskegon area with driving times to various zones from zone 344. Driving times are based on average speeds on a 1965 highway network. Highways included in the network are state trunklines and some major county roads. To account for trips beginning and ending in the same zone an intra-zonal driving time is used. This contrasts with the previous analysis concerning the proximity of automobile injuries to hospitals where injuries in a particular zone were immediately accessible to hospitals in that same zone. For the ambulance analysis,

FIGURE 1

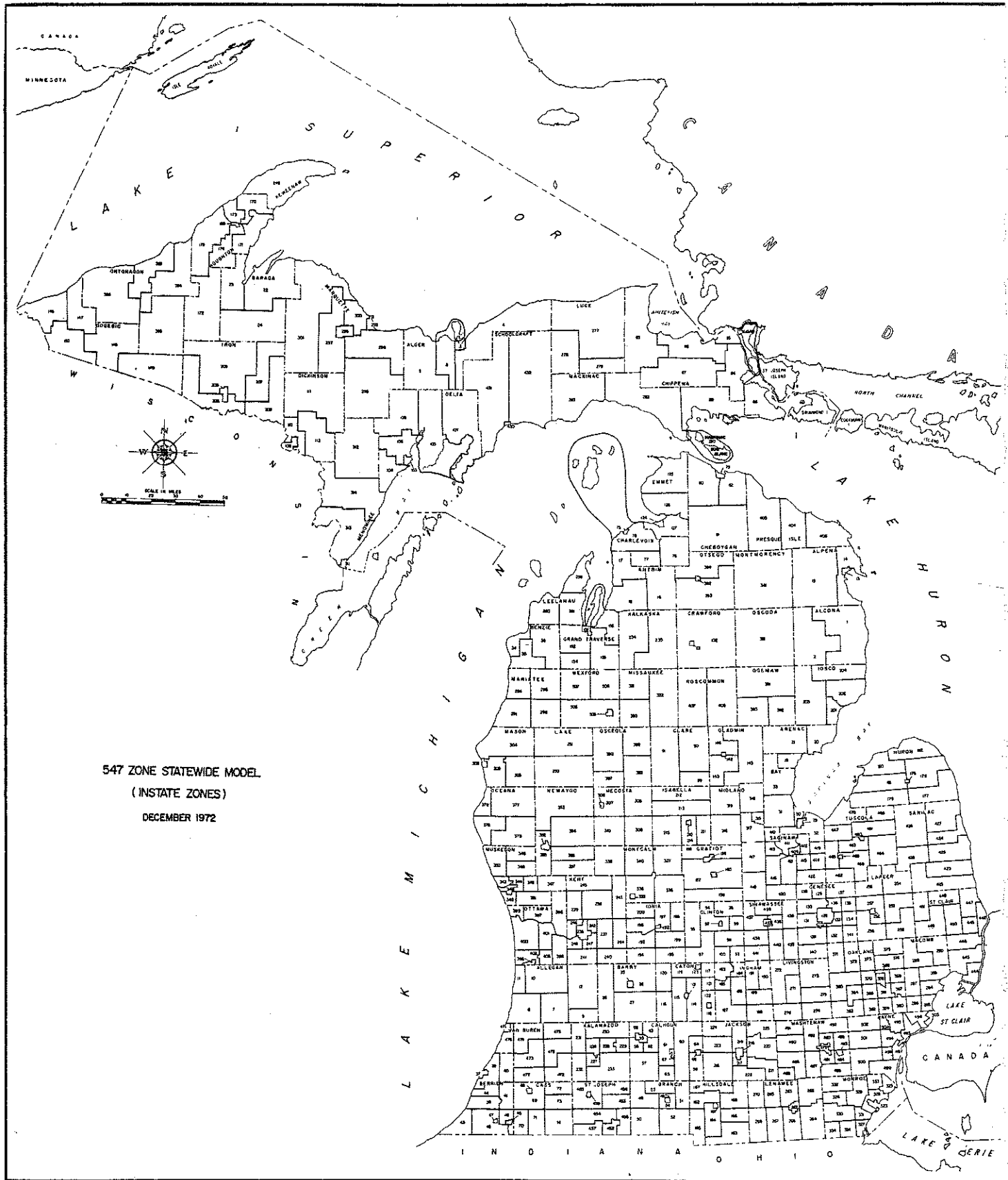
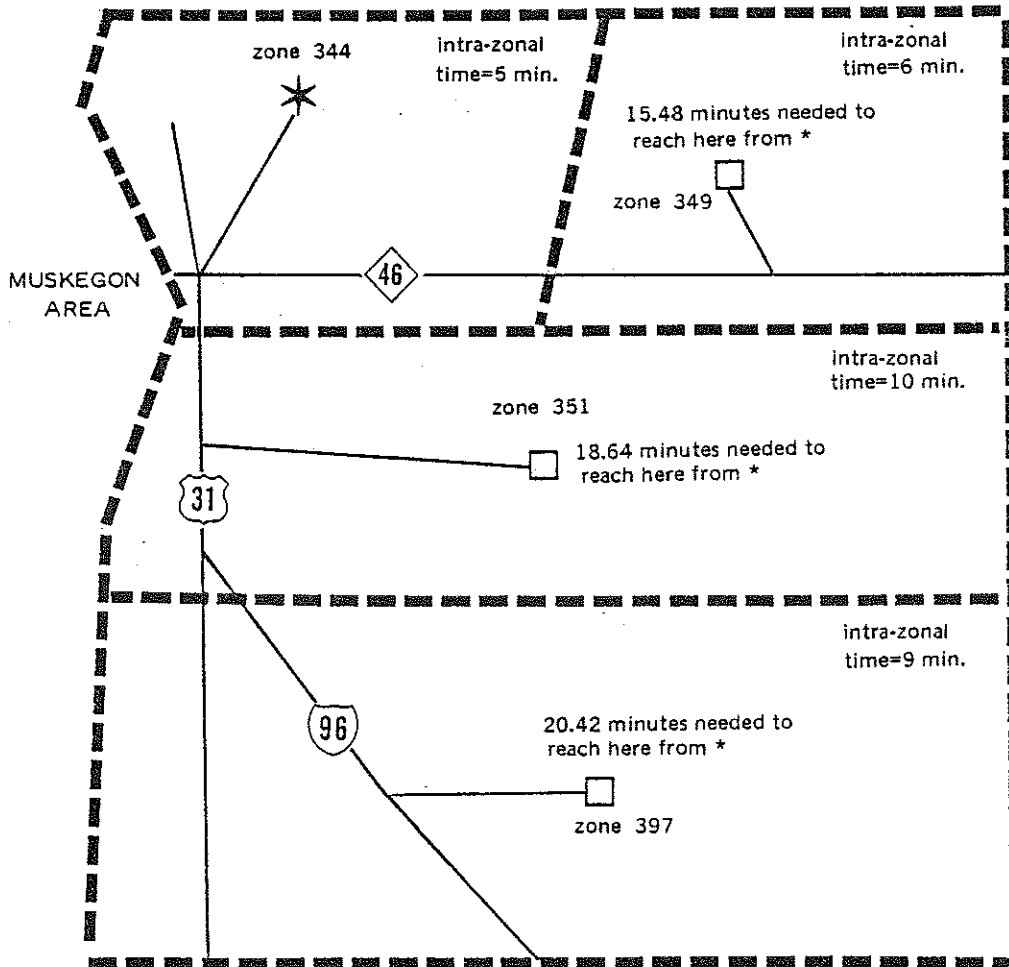





FIGURE 2

PORTION OF NETWORK



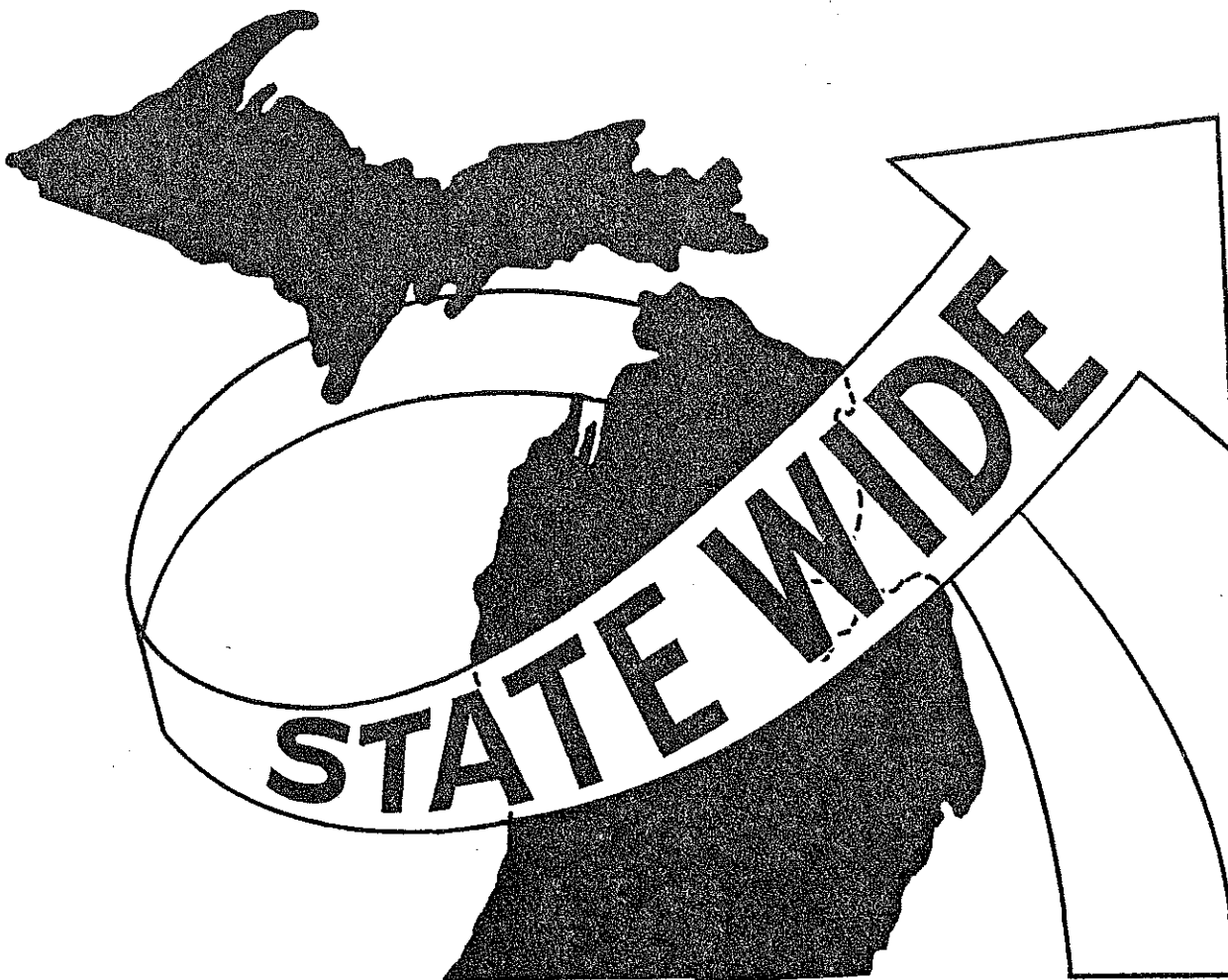
	STATE TRUNKLINE
	ZONE BOUNDARY
	ZONE CENTROID

KEY

injuries are not assumed immediately accessible to ambulance facilities in the same zone but depend upon an intra-zonal driving time. From Figure 2 it can be seen that in zone 397 it would take an average of 9 minutes to get from an ambulance facility (in zone 397) to an injury site still in zone 397. To get from a facility in zone 344 to an injury site in zone 397 it would take slightly more than 20 minutes. For those interested the information concerning the proximity of injuries to hospitals has been rerun using intra-zonal driving times and is available from Kenneth Malkowski of the Office of Health and Medical Affairs.

Three basic files were used to complete the analysis. These files are a zone-to-zone driving-time file, a zonal injury file, and an ambulance facility file. The ambulance facility file was prepared by the Office of Health and Medical Affairs and contains such information as the facility name, number of vehicles, type (emergency or transfer), a facility rating, whether or not the facility operates 24 hours a day, and the zone within which the facility lies. Only emergency type ambulances were used in the analysis.

**RESULTS
AND
PRECAUTIONS**



RESULTS AND PRECAUTIONS

The following will contain examples and summaries of the results. The complete and detailed information has been forwarded to Mr. Malkowski of the Office of Health and Medical Affairs.

To investigate the relationship between people and the number of vehicles in an area a table was made listing for every zone in the state (Figure 1):

1. The number of ambulance facilities
2. The number of vehicles
3. Population
4. Population density
5. Population-to-number-of-vehicles ratio

A sample of this list may be seen in Figure 3. The location of zones by county is indicated by the list in Figure 4.

One of the more interesting items is the ratio of population to number of vehicles. Most zones which have ambulance facilities have a ratio between 1000 and 10,000 persons per vehicle. Those zones with no vehicles were given a ratio of 999999. To better understand the information for each zone on a statewide basis, a shaded map of the State of Michigan was produced (Figure 5). The darker the shading the higher the ratio and the worse the ambulance coverage in comparison to the population. Each point on the map takes the shading level of the nearest zone centroid.

ZONE	# FACILITIES	# VEH	POP	FILE: GAMB / QSTWD POP DENSITY	POP/VEH	
1	1	2	5928.0	408.6	2964.0	1
2	0	0	1185.0	285.5	0.0	2
3	1	2	3677.0	9.6	1838.5	3
4	0	0	2038.0	434.5	0.0	4
5	0	0	2276.0	309.2	0.0	5
6	0	0	577.0	180.9	0.0	6
7	1	3	10961.0	140.7	3653.7	7
8	0	0	8280.0	142.4	0.0	8
9	1	2	14104.0	72.9	7052.0	9
10	1	1	13302.0	209.6	13302.0	10
11	2	2	5264.0	50.0	2632.0	11
12	1	1	14664.0	216.6	14664.0	12
13	2	5	13805.0	8.2	2761.0	13
14	0	0	10625.0	161.5	0.0	14
15	1	1	6278.0	420.3	6278.0	15
16	1	1	3509.0	210.2	3509.0	16
17	0	0	3646.0	133.6	0.0	17
18	2	2	5457.0	176.1	2728.5	18
19	1	1	3515.0	51.1	3515.0	19
20	1	2	3015.0	114.8	1507.5	20
21	0	0	4619.0	203.1	0.0	21
22	0	0	4403.0	384.7	0.0	22
23	1	2	2433.0	185.3	1216.5	23
24	0	0	953.0	355.2	0.0	24
25	0	0	6501.0	5.3	0.0	25
26	3	4	11468.0	208.9	2867.0	26
27	1	1	10901.0	215.4	10901.0	27
28	1	1	9296.0	142.8	9296.0	28
29	1	1	54439.0	12.4	54439.0	29
30	3	5	15896.0	14.5	3179.2	30
31	0	0	2294.0	152.0	0.0	31

EMERGENCY AMBULANCE FACILITIES

FIGURE 3

FIGURE 4

MICHIGAN STATEWIDE FORECASTING MODEL

547 ZONE SYSTEM

INSTATE ZONES

<u>County</u>	<u>Statewide Zones</u>	<u>County</u>	<u>Statewide Zones</u>
1. Alcona	1 - 2	43. Lake	250 - 251
2. Alger	3 - 6	44. Lapeer	252 - 258
3. Allegan	7 - 12	45. Leelanau	259 - 261
4. Alpena	13 - 15	46. Lenawee	262 - 270
5. Antrim	16 - 18	47. Livingston	271 - 276
6. Arenac	19 - 21	48. Luce	277 - 279
7. Baraga	22 - 24	49. Mackinac	280 - 283
8. Barry	25 - 28	50. Macomb	284 - 290
9. Bay	29 - 33	51. Manistee	291 - 294
10. Benzie	34 - 36	52. Marquette	295 - 301
11. Berrien	37 - 47	53. Mason	302 - 305
12. Branch	48 - 54	54. Mecosta	306 - 310
13. Calhoun	55 - 67	55. Menominee	311 - 314
14. Cass	68 - 74	56. Midland	315 - 319
15. Charlevoix	75 - 78	57. Missaukee	320 - 322
16. Cheboygan	79 - 82	58. Monroe	323 - 334
17. Chippewa	83 - 88	59. Montcalm	335 - 340
18. Clare	89 - 91	60. Montmorency	341
19. Clinton	92 - 100	61. Muskegon	342 - 351
20. Crawford	101 - 102	62. Newaygo	352 - 357
21. Delta	103 - 108	63. Oakland	358 - 375
22. Dickinson	109 - 112	64. Oceana	376 - 379
23. Eaton	113 - 123	65. Ogemaw	380 - 382
24. Emmet	124 - 127	66. Ontonagon	383 - 386
25. Genesee	128 - 141	67. Osceola	387 - 390
26. Gladwin	142 - 145	68. Oscoda	391
27. Gogebic	146 - 150	69. Otsego	392 - 394
28. Grand Traverse	151 - 155	70. Ottawa	395 - 403
29. Gratiot	156 - 160	71. Presque Isle	404 - 406
30. Hillsdale	161 - 168	72. Roscommon	407 - 408
31. Houghton	169 - 175	73. Saginaw	409 - 422
32. Huron	176 - 182	74. Sanilac	423 - 429
33. Ingham	183 - 191	75. Schoolcraft	430 - 432
34. Ionia	192 - 200	76. Shiawassee	433 - 441
35. Iosco	201 - 204	77. St. Clair	442 - 451
36. Iron	205 - 209	78. St. Joseph	452 - 459
37. Isabella	210 - 215	79. Tuscola	460 - 470
38. Jackson	216 - 225	80. Van Buren	471 - 478
39. Kalamazoo	226 - 233	81. Washtenaw	479 - 492
40. Kalkaska	234 - 235	82. Wayne	493 - 504
41. Kent	236 - 248	83. Wexford	505 - 508
42. Keweenaw	249		

Location of centroids are indicated by small blank spaces. The darkest shading indicates no vehicles. For example, Figure 5 indicates that an area southwest of Lansing (zone 121) has no facilities. This information is not sufficient to judge the adequacy of ambulance service to an area. In fact it can be very misleading. Although zone 121 has no facilities, it is in fact served by several ambulance facilities because it lies close (via the highway system) to other zones which have many facilities. This brings us to "proximity analysis". Proximity analysis uses a zone-to-zone driving matrix along with ambulance facility information and automobile injury data to illustrate the proximity of ambulance facilities to every zone in the state and to illustrate the proximity of automobile injuries to ambulance facilities.

The proximity of ambulance facilities to zones 121 thru 125 is listed in Figure 6. This table shows the number of service zones (zones with at least one facility), number of ambulance facilities, and number of vehicles within 15 and 20 minutes. As previously noted zone 121 near Lansing has no facilities but Figure 6 shows that within 20 minutes of the zone there are 10 facilities having a total of 20 vehicles. This number represents one of the best served areas in the state with respect to access. If the zone had a very large population it might be possible that 20 vehicles would not be enough. The zone in fact does not have a considerably large population and therefore would probably be considered well served. The ratio of persons to number of vehicles within 20 minutes might be a better measure of service to a zone.

FIGURE 6

PROXIMITY OF AMBULANCE SERVICE

TO ZONE 121-125

<u>ZONE</u>	<u>TIME BAND (MIN.)</u>	<u>NUMBER OF SERVICE ZONES</u>	<u>NUMBER OF FACILITIES</u>	<u>NUMBER OF VEHICLES</u>	<u>INJURIES PER FACILITY</u>	<u>INJURIES PER VEHICLE</u>
121	0 - 15	3	3	5	35.33	21.20
	0 - 20	9	10	20	10.60	5.30
122	0 - 15	2	2	4	3.00	1.50
	0 - 20	4	4	7	1.50	.86
123	0 - 15	3	3	3	6.67	6.67
	0 - 20	3	3	3	6.67	6.67
124	0 - 15	1	1	1	68.00	68.00
	0 - 20	2	2	2	34.00	34.00
125	0 - 15	0	0	0	0.00	0.00
	0 - 20	0	0	0	0.00	0.00

Since most of the service time of ambulances is related to automobile injuries an even better measure might be the number of injuries per facility or per vehicle. These ratios are also available from the table in Figure 6. To better understand statewide coverage a shaded map was produced based on the number of facilities within 20 minutes of each zone. Blank areas indicates no facility within 20 minutes while the darkest shading indicates 10 or more facilities. Figure 7 illustrates how well zone 121 is served relative to the rest of the state.

The two shaded maps together provide a good overall picture of ambulance service for the state. One shows the proximity of facilities to each zone, while the other shows the relationship of facilities in that zone to the population of that zone. A word of caution is in order when comparing maps since there are certain cases of apparent contradiction. Consider zone 1 in Alcona County. The proximity map shows no facilities within 20 minutes, but the population-vehicle map shows that vehicles do exist in zone 1. See Figure 8. The reason these vehicles do not show up in the proximity map is that the intrazonal driving time mentioned earlier is 22 minutes. In other words because the zone is large and there are only two-lane roads, it will take on the average 22 minutes to drive within the zone itself. This type of situation will tend to occur in zones that are large or have few roads.

Proximity analysis also results in a separate list of those zones which are not within 20 minutes of an emergency ambulance facility and a list with the number of automobile injuries which occurred in that zone. A portion of this list can be seen in Figure 9.

FIGURE 7

DENSITY OF FACILITIES WITHIN 20 MINUTES

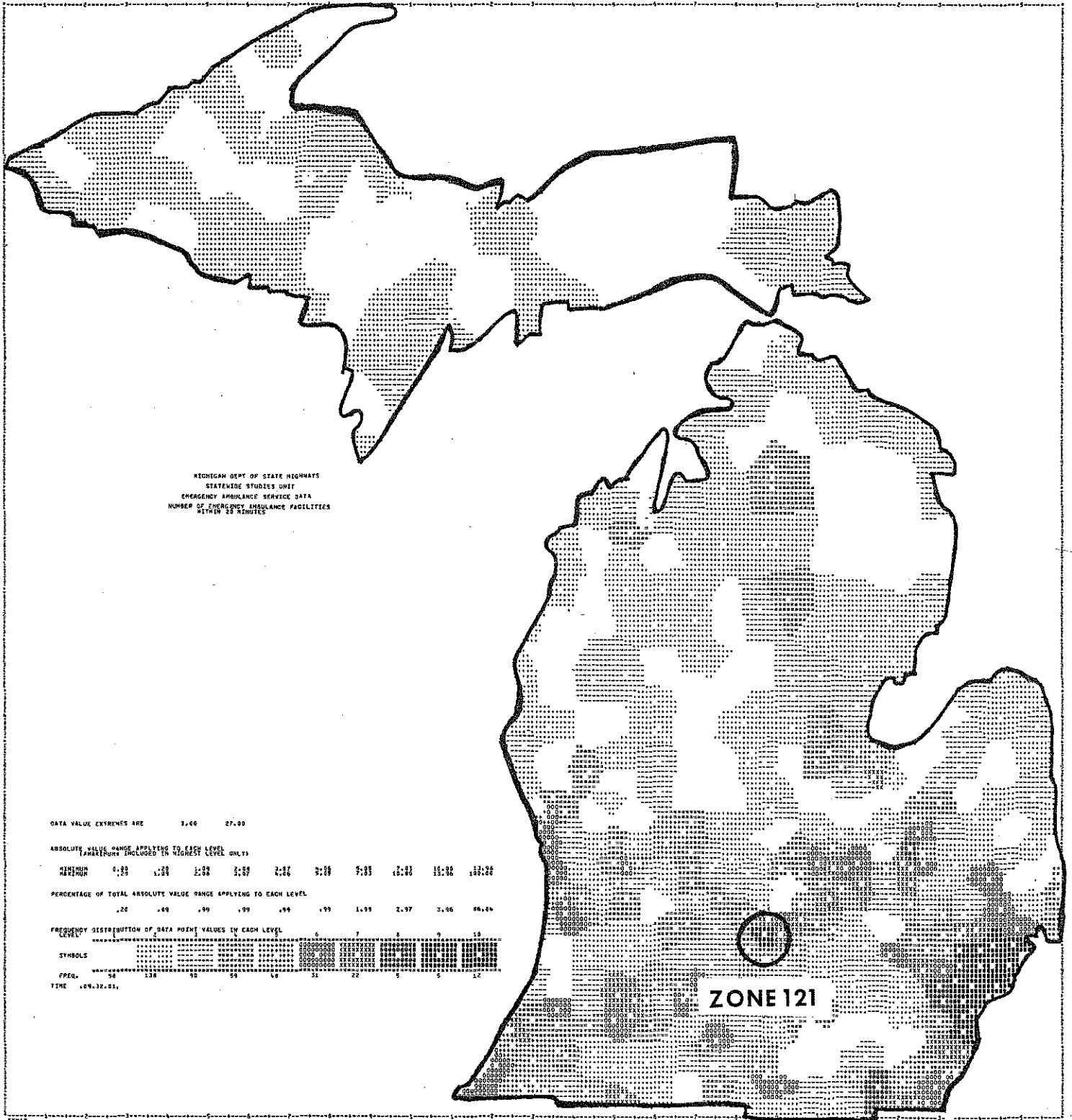


FIGURE 8

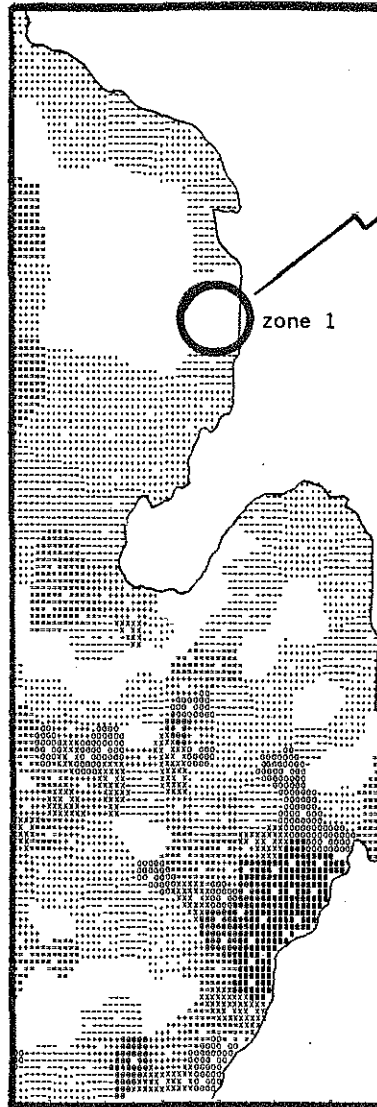
MAP COMPARISON



Population/ number of vehicles

has at least one ambulance

but



Ambulance facilities within 20 minutes

ambulance not counted
due to large intra-zonal
driving time

FIGURE 9

ZONES NOT SERVED

<u>ZONE</u>	<u>INJURIES</u>
1	28
2	18
4	28
5	24
8	50
15	52
.	.
.	.
.	.
470	50
474	32
486	30
487	54
488	26
489	4

TOTAL INJURIES NOT SERVED BY ANY AMBULANCES = 3652

The preceding has been directed toward the proximity of ambulance facilities to all zones in the state. The remaining option has produced information about the proximity of automobile injuries to ambulance facilities. For each zone containing at least one ambulance facility, injuries are accumulated in 15 and 20 minute time bands. For each table the word "ambulances" refers to ambulance facilities not vehicles. The "capacity" refers to the number of vehicles. Figure 10 shows a table produced for zone 9 in Allegan County. Within the zone itself there were 146 injuries and one ambulance facility with two vehicles. Within 15 minutes of zone 9 the injury figures are the same as for the zone itself indicating that no other zone (i.e. zone centroid) can be reached in 15 minutes. The next 5 minutes, however, picks up 52 more injuries bringing the total for 20 minutes from zone 9 to 198 (.398% of total injuries in state). Since there is still only one facility in this 20 minute band, the ratio of injuries to facilities is 198.

A table summarizing the results statewide can be seen in Figure 11. Totaling the 0-15 minute and 15-20 minute band shows there are 46,070 injuries or about 93% of the total injuries in the state that are within 20 minutes of at least one emergency ambulance facility.

As previously noted, the detailed lists for all zones and facilities are available from the Office of Health and Medical Affairs. Those items available regarding emergency ambulance facilities are;

1. Facility information for every zone (Figure 3)
2. Proximity of facilities to all zones (Figure 6)
3. Proximity of auto injuries to all zones having facilities (Figure 10).

PROXIMITY OF INJURIES

DATA FOR ZONE 9
 INJURIES = 146
 NUMBER OF AMBULANCES = 1
 TOTAL CAPACITY = 2

	0- 15	0- 15
INJURIES	146	146
PERCENT OF TOTAL INJURIES	0.294	0.294
AMBULANCES	1	1
INJURIES /AMBULANCES	146.00	146.00
	15- 20	0- 20
INJURIES	52	198
PERCENT OF TOTAL INJURIES	0.105	0.398
AMBULANCES	0	1
INJURIES /AMBULANCES	0.00	198.00

PROXIMITY OF INJURIES TO ZONE 9

FIGURE 10

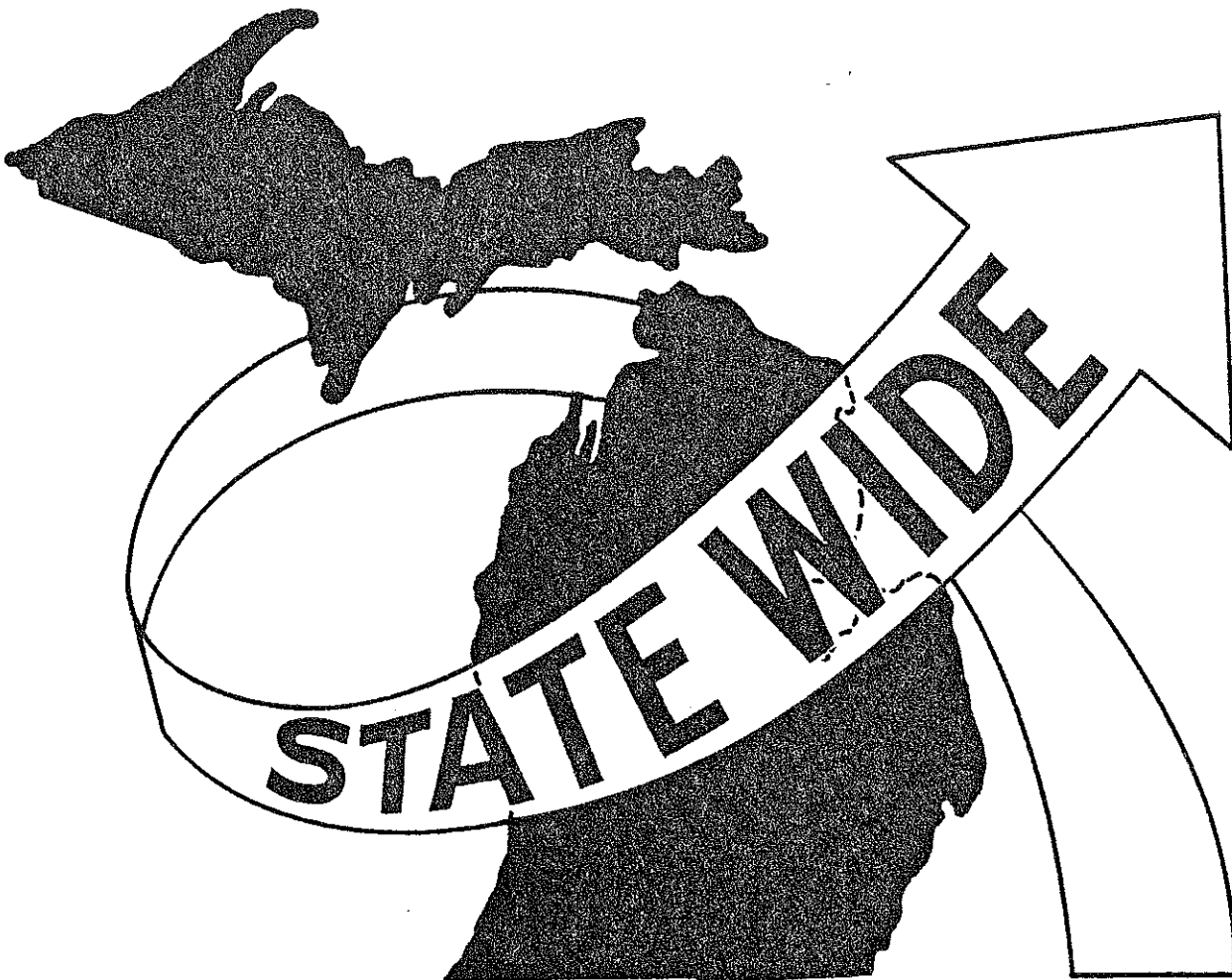
	INJURIES	PROXIMAL TO ANY AMBULANCES
TIME BAND	INJURIES	PERCENT OF TOTAL INJURIES
0- 15	41064	82.587
15- 20	5006	10.068

FIGURE 11

PROXIMITY OF INJURIES TO AMBULANCE FACILITIES

STATEWIDE SUMMARY

CONCLUSIONS



CONCLUSIONS

Since the highway system plays an important role in most any type of planning process, elements of the Statewide Transportation Modeling System can be a valuable tool for obtaining, evaluating, and displaying information. While the original purpose here was to aid in the health planning area, the process can be used for highway planning as well. The ambulance facility analysis was carried out using an existing road system; those in highway planning, however, could make use of the same evaluation but completed with various proposed road systems. This evaluation can facilitate in measuring the impacts which various alternatives have upon public health. The process can even be carried one step further. The building of new roads may alleviate the necessity of creating more ambulance facilities. Thus, a new level of cooperation between those in highway planning and those in health planning is now possible.

The techniques used are not limited to use by any one agency. The system allows information from many different agencies to be used to solve problems. The present statewide facility file could be of use to many different agencies. The files now available are shown in Figure 12. Over 50 categories of socio-economic information are available. A few of these may be seen in Figure 13.

Further questions concerning analysis techniques and ways to display information for regional or statewide planning tasks can be directed to Statewide Studies, Michigan Department of State Highways and Transportation.

FIGURE 12

STATEWIDE FACILITY FILE

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 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

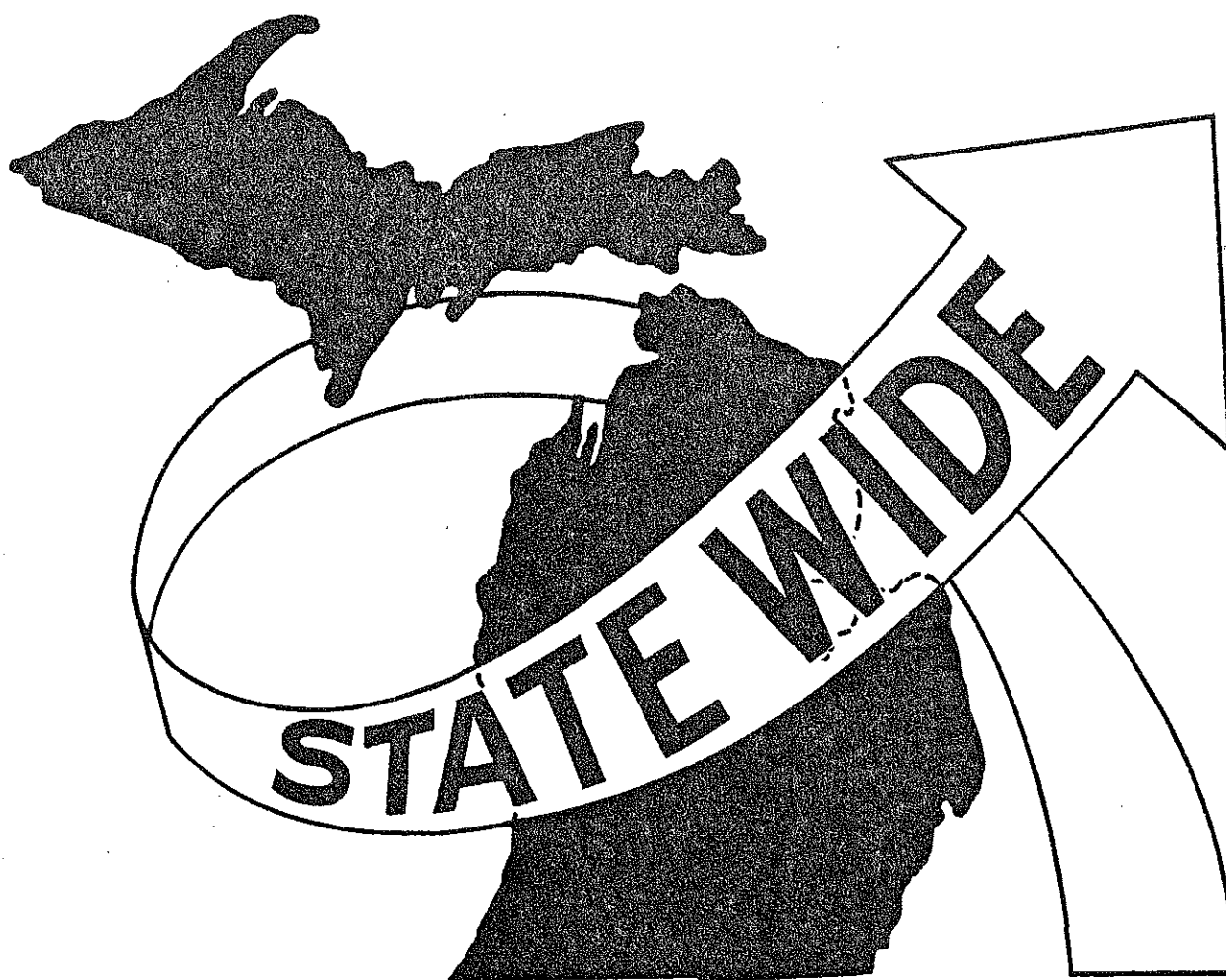
AGE BY SEX
TYPE OF FAMILY
MARITAL STATUS

AREA CHARACTERISTICS

LAKE FRONTAGE
ASSESSED VALUATION
WATER AREA

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

UPDATED ANALYSIS



UPDATED ANALYSIS

During 1976, an updated version of the original analysis was completed in cooperation with Jari Foster of the Office of Health and Medical Affairs Division of Emergency Medical Services (E.M.S.).

The zone-to-zone driving time file was updated using a 1975 road system. The ambulance facility file was updated by E.M.S. with only emergency ambulance facilities being used in the analysis. The zonal injury file remained constant. Some additional work was done with a hospital facility file. A description of information supplied to E.M.S. follows.

Five symaps and two proximity analysis listings were provided. The symaps include a zonal symap of persons per ambulance using the Bureau of the Budget 1975 population figures, a symap showing the ratio of injuries in each zone to the number of ambulance vehicles within 15 minutes and one showing the same ratio for ambulances within 30 minutes, and symaps showing the ratio of injuries in each zone to hospitals within 15 and 30 minutes. The proximity analysis listings show both ambulances and hospitals within 15 and 30 minutes of injury accidents. The ratios in these listings equal zero if there were no injuries in the zone and are starred if there were no facilities accessible within the given time band. These were plotted as zeros and 9999999 respectively on the corresponding symaps.