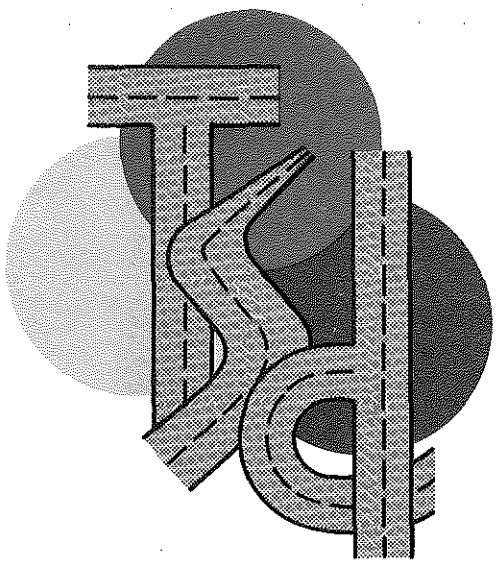
Report TSD-223-73

A TRAFFIC ACCIDENT ANALYSIS OF HIGH ACCIDENT LOCATIONS IN THE CITY OF MARQUETTE



TRAFFIC and SAFETY DIVISION

DEPARTMENT OF STATE HIGHWAYS
STATE OF MICHIGAN

MICHIGAN DEPARTMENT

OF

STATE HIGHWAYS AND TRANSPORTATION

Report TSD-223-73

A TRAFFIC ACCIDENT ANALYSIS OF HIGH ACCIDENT LOCATIONS IN THE CITY OF MARQUETTE

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TRAFFIC ENGINEERING SERVICES

August 1974

PREPARED BY

Traffic Engineering Services
Traffic and Safety Division
Michigan Department of State Highways and Transportation

in cooperation with

The Michigan Office of Highway Safety Planning
and
The U. S. Department of Transportation
Federal Highway Administration

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TABLE OF CONTENTS

LIST OF FIGURES

List of Figures Continued

INTRODUCTION

The Highway Safety Act of 1966 was enacted by the Congress of the United States in order to promote highway safety. Highway safety standards were then developed to assure the orderly implementation of the Act.

Purpose

Highway Safety Standard 4.4.13, Traffic Engineering Services, is one of those standards. The purpose of Standard 4.4.13 is

> "to assure the full and proper application of modern traffic engineering principles and uniform standards for traffic control to reduce the likelihood and severity of traffic accidents.".

This standard includes the identifying of specific locations or sections of streets and highways which have a high accident experience or potential as a basis for establishing priorities for improvement, selective enforcement or other practices that will eliminate or reduce the hazards. It provides an orderly inventory of all traffic control devices, which include those signs, signals, markings and devices placed on, over or adjacent to a street or highway to regulate, warn and guide vehicular and pedestrian traffic.

The State of Michigan carries out a program of this type on the state trunkline system; however, many of the state's city and county agencies lack the financial and technical prerequisites necessary to pursue similar programs with similarly defined objectives. To insure that this additional highway safety standard is met and to improve the overall evaluation of the accident picture in Michigan, the Michigan Department of State Highways and Transportation requested and received through the Office of Highway Safety Planning in the Department of State Police, a federally funded project entitled "Traffic Engineering Services for Cities and Counties".

In cooperation with participating cities and counties, the proposed service, under the direction of Department personnel, will make a traffic engineering evaluation of the factors causing traffic accidents and will recommend corrections to those conditions which may be contributing to accidents; and additionally will recommend the upgrading of traffic control devices where necessary.

Scope

The intent of this program is to improve traffic safety on all Michigan streets and roads by expanding the traffic engineering evaluation of factors causing accidents, and by providing uniform

standards for traffic control to reduce the likelihood and severity of traffic accidents.

Study Procedures

The study procedures for the subject project involve several distinct phases. They may be described as follows: basic data collection, identifying and locating high accident locations, field investigations, an accident analysis of the high accident locations, technical evaluation of previously compiled facts and consequent remedial recommendations.

Since a portion of the data collection phase involves accident reports and records, and since the Michigan Department of State Police is responsible for keeping all accident records in Michigan, the task of identifying and locating high accident locations in the City of Marquette (and providing an inventory of those locations) was designated as State Police responsibility. The high accident locations for the City of Marquette were determined by the 1968 city accident reports. From these reports the 25 highest accident locations were selected. Once the problem locations were identified, additional accident information for the years 1969, 1970 and 1971 was compiled in order to expand the accident base at each location. After compiling this information, the Department of State Police transmitted it to the Department of State Highways and Transportation.

The Department of State Highways and Transportation is then responsible for further data collection utilizing the following basic steps: 1) conducting field investigations; 2) preparing collision diagrams and, if necessary, physical condition diagrams for each selected location; and 3) obtaining traffic counts where necessary.

The accident analysis phase involves the analysis of the summarized facts and field data from the viewpoint of a highway traffic engineer with special attention focused on the effect which the highway environment may have had on the accident. Thus, at each high accident location, individual accident reports were reviewed in detail and the accident factors were tabulated and grouped in various tables. The collision diagrams which were prepared for each location are used to identify accident patterns and to locate the accident in relation to the intersection.

A technical evaluation and engineering analysis of the compiled data is used to recommend corrections to those conditions which may be contributing to accidents.

Funding

The implementation of the proposed recommendations is the

responsibility of the City of Marquette. Financial assistance can be obtained through the Highway Safety Act of 1973 which was established to provide funding for the implementation of safety improvement projects aimed at the elimination or reduction of traffic accidents. Also, funding is available through the Urban Systems Program which is also Federally sponsored. Further information on these two Programs can be obtained by contacting the Local Government Division of the Michigan Department of State Highways and Transportation.

Study Area

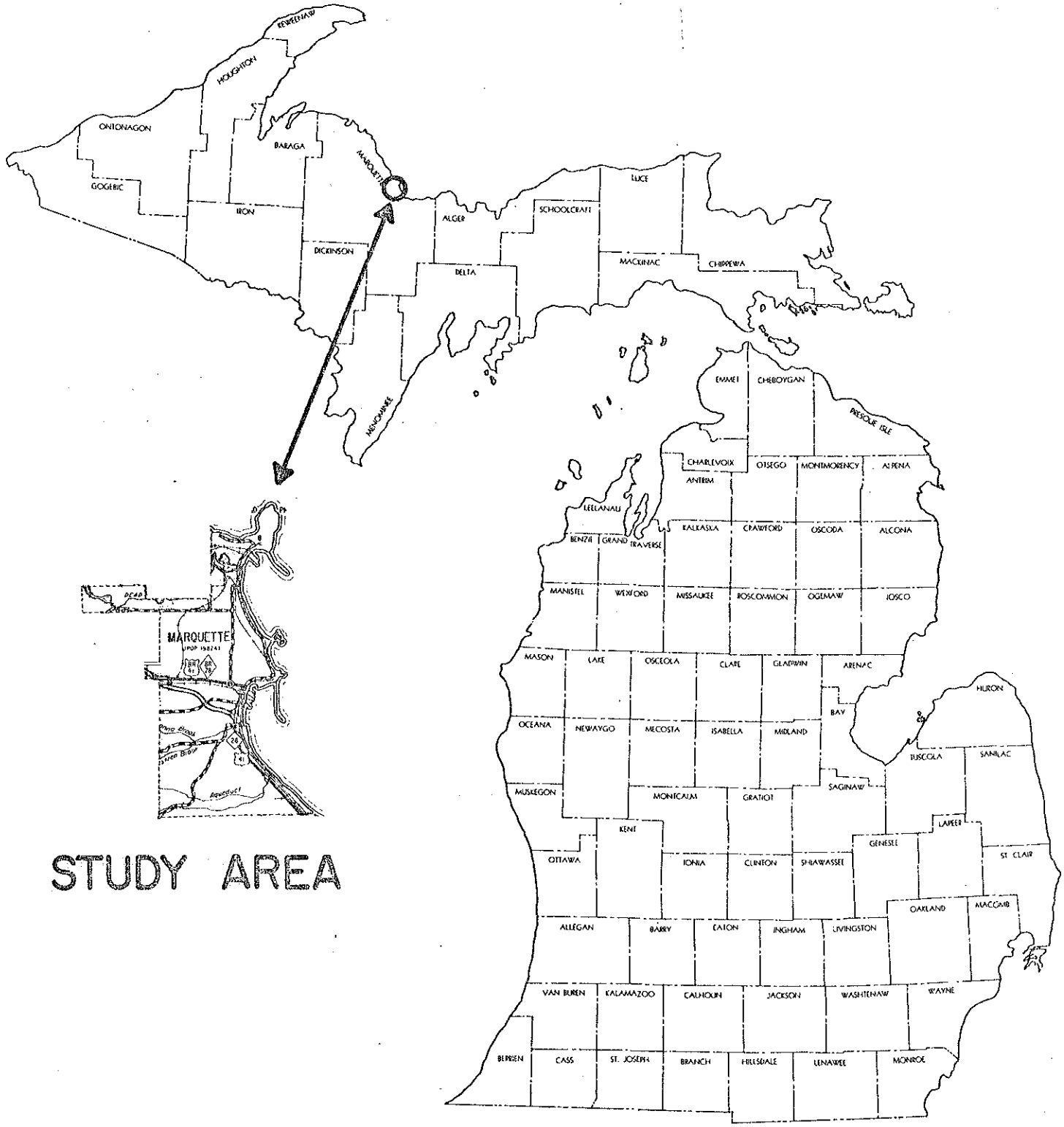
The City of Marquette is located in the mid-west section of the Upper Peninsula on the southern shore of Lake Superior (Figure 1). This shoreline locality makes Marquette one of the Upper Peninsula's largest ports with an annual freight traffic of over 2,000,000 tons.

The origin and development of Marquette is closely related to the production and shipment of iron ore from the Marquette Iron Range, and naturally enough the growth and prosperity of the community parallels the fluctuation of the nation's iron and steel consumption. The City now has grown to a population of 21,967 people. According to the 1970 census this figure is an increase of 10.8 percent over the last decade which indicates that Marquette is a steadily growing community. The population trend of the City can be seen on the graph provided on p. 5 of this report.

Rail service in the City of Marquette is provided by the Soo Line and the Lake Superior and Ishpeming Railroad. The City also has the service of two major highways, US-41 and M-28, which enable the Marquette area to be easily accessible to tourists and people from outlying villages. This not only aids the economy of the city, but also enables thousands of people to view the City's vast tourist attractions every year.

The street system of the City of Marquette is made up of 6.84 miles of state trunkline, 3.66 miles of county roads, 22.46 miles of major city streets and 49.62 miles of local city streets for a total of 82.58 miles of roadway within the city limits. This information is found in the Twenty-First Annual Progress Report, compiled by the Local Government Division of the Michigan Department of State Highways and Transportation. A map of this street system can be found on p. 6 of this report.

FIGURE 1

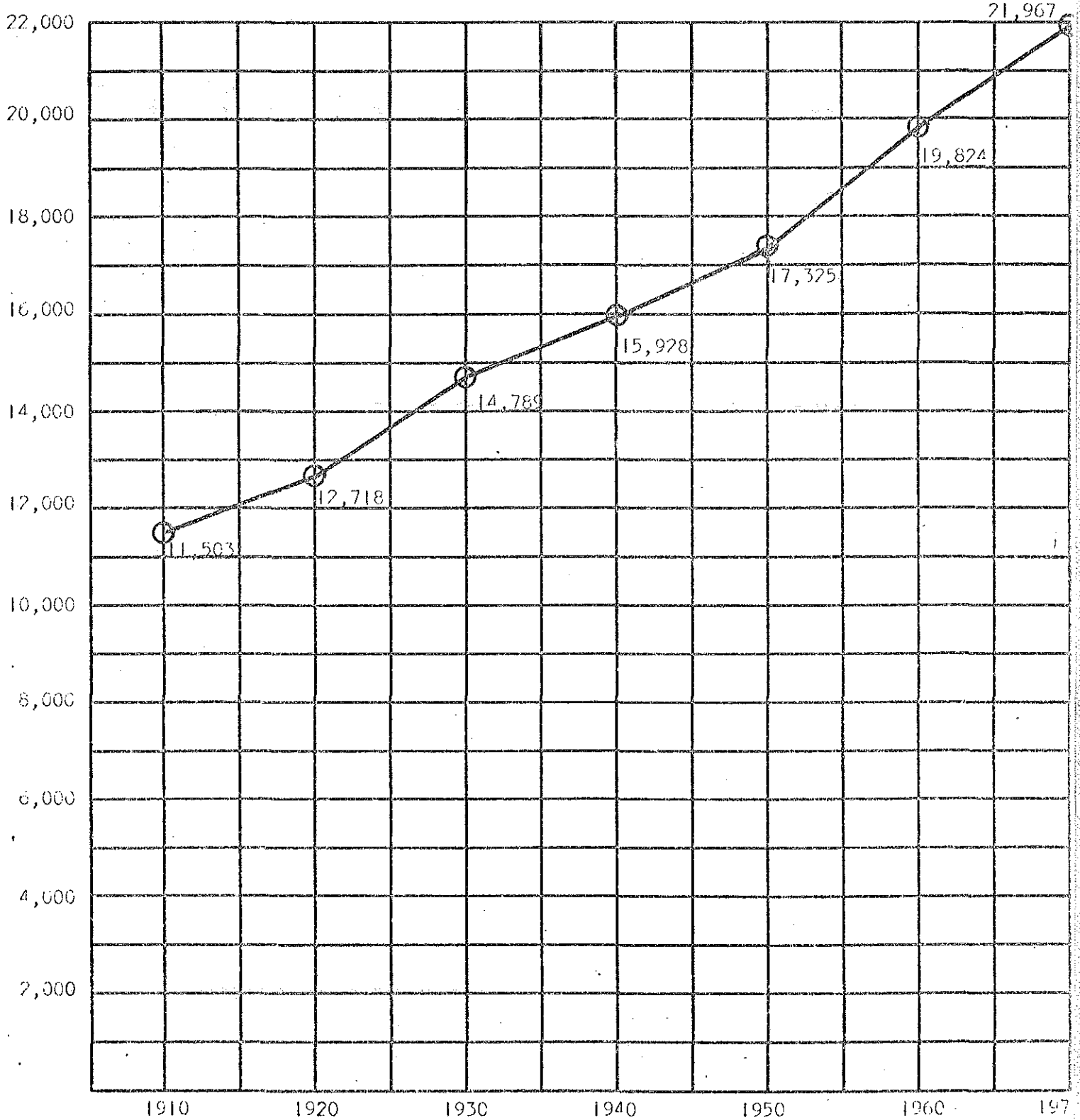


STUDY AREA

FIGURE 7

POPULATION TREND

CITY OF MARQUETTE: 1910 - 1970



Source: U.S. Bureau of Census

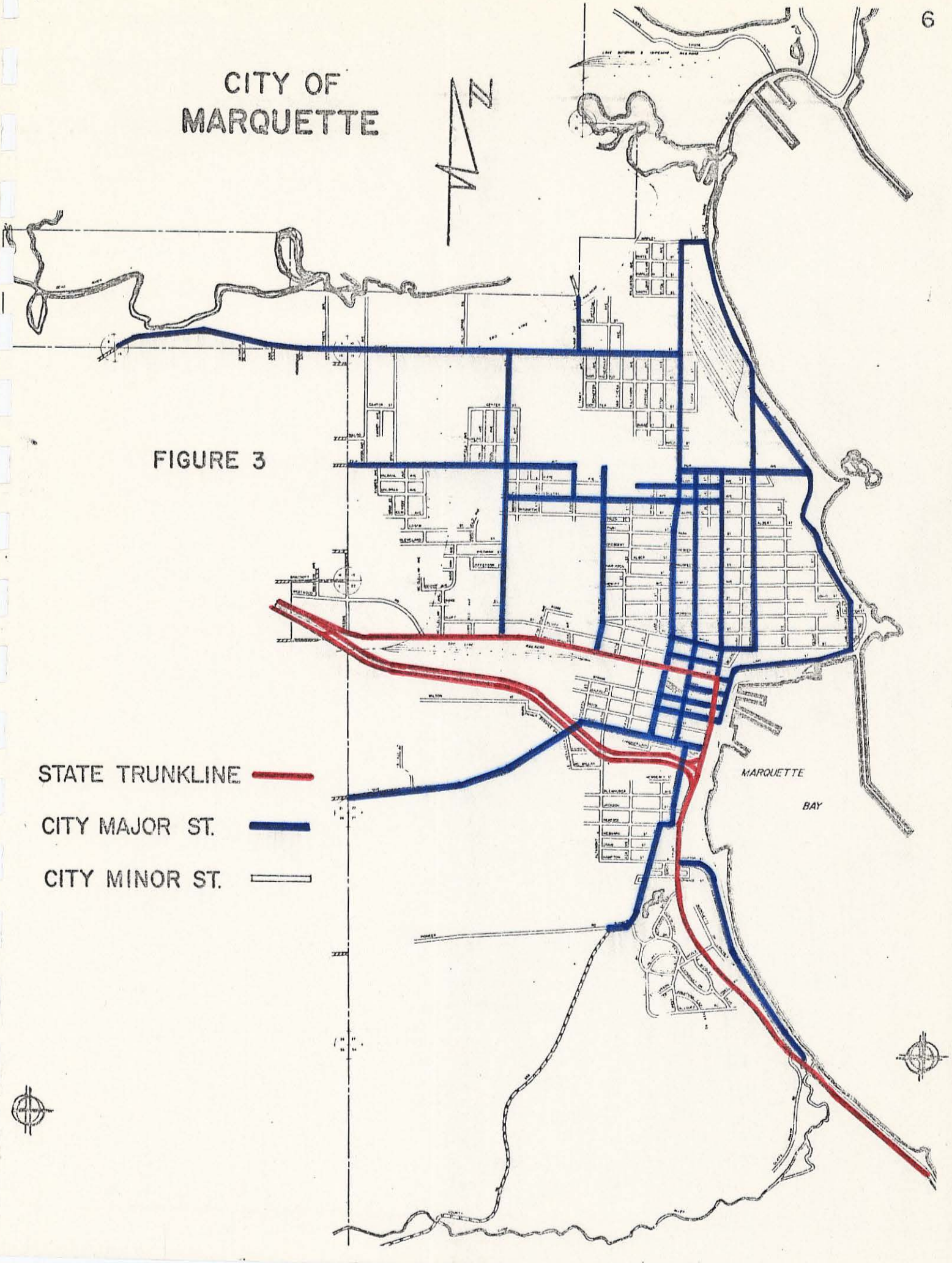

CITY OF
MARQUETTE
N
MARQUETTE
BAY
STATE TRUNKLINE
CITY MAJOR ST.
CITY MINOR ST.

FIGURE 3

TRAFFIC ENGINEERING ANALYSIS

The traffic engineering analysis phase involves evaluating the summarized facts and field data and prescribing the proper remedial treatment. One of the basic tools used in this type of analysis is a graphic representation of accidents, either on a collision diagram or strip map, which is used to determine accident patterns. An accident pattern is the prevalence of one or more types of accident occurrences. This accident pattern gives an indication of the type of corrective action needed at the specific location.

Accident causes, however, are numerous and often difficult to determine. An accident pattern does not always exist. In some cases the collisions may involve a combination of driving hazards such as slippery pavement, snow or fog, drinking drivers, defective equipment, excessive speed and inadequate traffic control. In many cases these hazards may be eliminated or at best alleviated. In some cases, the accident causes may lie in factors outside the jurisdiction of the traffic engineer, such as enforcement. In this instance he can offer specific infomation to the police or other responsible agencies and request their cooperation.

In the City of Marquette the traffic engineering analysis began when the State Police transmitted to the Michigan Department of State Highways and Transportation 25 high accident locations (Spot Map p. 12). After this data was transmitted, additional statistical information was collected on the reported traffic accidents in the City of Marquette and Marquette County. Figure 4, which contains this information, shows that reported traffic accidents in the City of Marquette decreased between 1968 and 1970 only to increase in 1971. There was a total of 3,771 reported accidents on Marquette city streets for an average of almost 943 accidents per year. The 25 high accident locations accounted for 604 accidents or 16 percent. The total accidents on Marquette County roads remained almost constant between 1968 and 1970 and increased almost 32 percent in 1971.

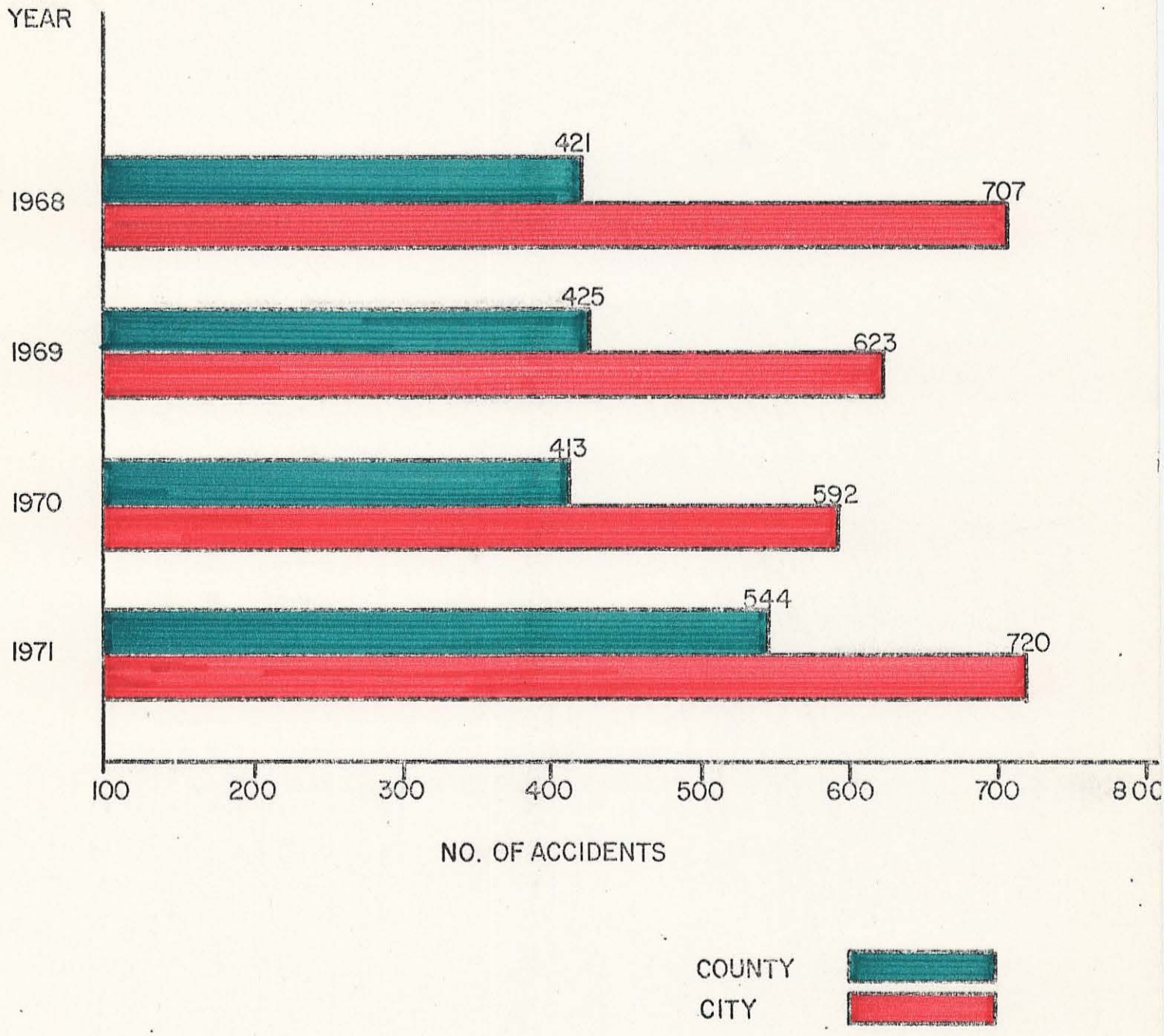
City-Wide Recommendations

Wet Pavement Accidents

After the pertinent data was assembled an accident analysis of the 25 high accident locations was conducted. This analysis indicated that wet pavement accidents were predominant at a few of the locations. At any location where wet pavement accidents are greater than 27 percent of the total accidents and greater than 40 percent of the total accidents minus the snow and ice accidents, skidometer tests are usually warranted. This criteria is used by the Michigan

REPORTED TRAFFIC ACCIDENTS IN MARQUETTE COUNTY & THE CITY OF MARQUETTE

FIGURE 4



Department of State Highways and Transportation in their safety program. All skidometer test values are expressed as 40 mph coefficients of wet sliding friction (wsf). A wsf value of 0.40 is generally considered the dividing point between "satisfactory" and "unsatisfactory" pavement surfaces and it has been arbitrarily defined as the "Departmental Safety Standard". Surfaces with coefficient values of 0.35 to 0.40 are in a transitional or questionable range. Surfaces below 0.35 could be dangerous under wet conditions depending on prevailing speeds, road alignment, and geometrics. Surfaces with wsf's below 0.20 are considered as slippery as packed snow. Pavements that fall within the unsatisfactory range should be resurfaced in the very near future. If a skidometer test is warranted at a particular location, it will be mentioned under the recommendation portion of the discussion.

Signal Modernization

Further analysis indicated that not all the signalized locations in the City of Marquette have two vehicular signal faces per approach. The Michigan Manual of Uniform Traffic Control Devices (hereafter referred to as the Manual) has in the past made this treatment mandatory for all signalized intersections where at least one approach is a State Trunkline, and only recommended it for all other signalized intersections. The 1973 edition of the Michigan Manual, however, makes it mandatory that the approaches at all signalized locations be provided with two vehicular signal faces for the following reasons:

1. Two (or more) properly located overhead signal faces will in almost all cases provide drivers with a signal indication even though trucks or buses may momentarily obscure one signal face.

2. Multiple faces provide a safety factor where the signals must compete with a brilliant background such as advertising signs or the sun.

3. The occasional inevitable lamp failure in one face will not leave an approach without any signal indication.

It was also noted during the field investigation of the high accident locations that some signals and flashers in the City of Marquette were painted green. To obtain the

best possible contrast with the visual background, it is desirable to paint signal head housings highway yellow. The insides of visors (hoods) and the entire surface of louvers, fins, and the front surface of backplates shall have a dull black finish to minimize light reflection to the side of the signals. It is recommended that these paint guidelines be applied to all the signals and flashers in the City of Marquette.

Finally, the cycle lengths for the signalized high accident locations included three second clearance intervals in most cases. It is recommended that all signalized locations within the City of Marquette have a minimum clearance interval of four seconds and a maximum time of 4.5 seconds. An adequate clearance interval will contribute to the prevention of right angle accidents at signalized locations.

Turning Radii

The turning radii at many of the intersections in the City of Marquette are too short. In many instances motor vehicles are forced to encroach beyond the center line of the departure-side street while completing a right turn. Encroachment can also occur on the approach side when vehicles go beyond the center line or lane line (two lane approach) in the process of beginning a right turn. This encroachment increases the probability of sideswipe accidents and is not desirable from a capacity standpoint. It is recommended that the City of Marquette establish a city-wide program to increase the radii at all intersections where the existing radii are inadequate. Appendix I contains a chart which can be used as a guide to the relationship between approach lanes, departure lanes and corner radii. This chart was developed by Paul C. Box and Associates, Skokie, Illinois.

Utility Poles

The utility poles at many of the intersections in the City of Marquette were located either in the curb line or on a portion of the road surface. These poles are a hazard because they can be easily sideswiped by turning vehicles. Thus, it is recommended that the utility company be required to move all utility poles in the city that are located in the curb line or on a portion of any roadway.

Center Line Markings

The center line markings in the City of Marquette are white. The 1973 edition of the Michigan Manual indicates that center line markings should be yellow. The center line markings on two-lane, two-way highways shall be either:

1. A normal broken yellow line where passing is permitted.

2. A double line consisting of a normal broken yellow line and a normal solid yellow line where passing is permitted in one direction.

3. A double line consisting of two normal solid yellow lines where passing is prohibited in both directions.

The center line on a two-way, undivided highway where four or more lanes are always available, is usually a double solid yellow line.

High Accident Locations

After the analysis of the 25 high accident locations was complete, it was apparent that no engineering recommendations would be feasible for 10 of the locations. There were no accident patterns at these 10 locations and no present or potential serious driving hazards that could be eliminated or controlled by traffic engineering. Consequently, this report will discuss in detail only the remaining 15 locations. The collision diagrams and pictures for each of these will be found on the pages following each analysis. A cost estimate for each recommendation is included in the Summary of this report. These estimates are based on Michigan Department of State Highways and Transportation costs for materials and labor.

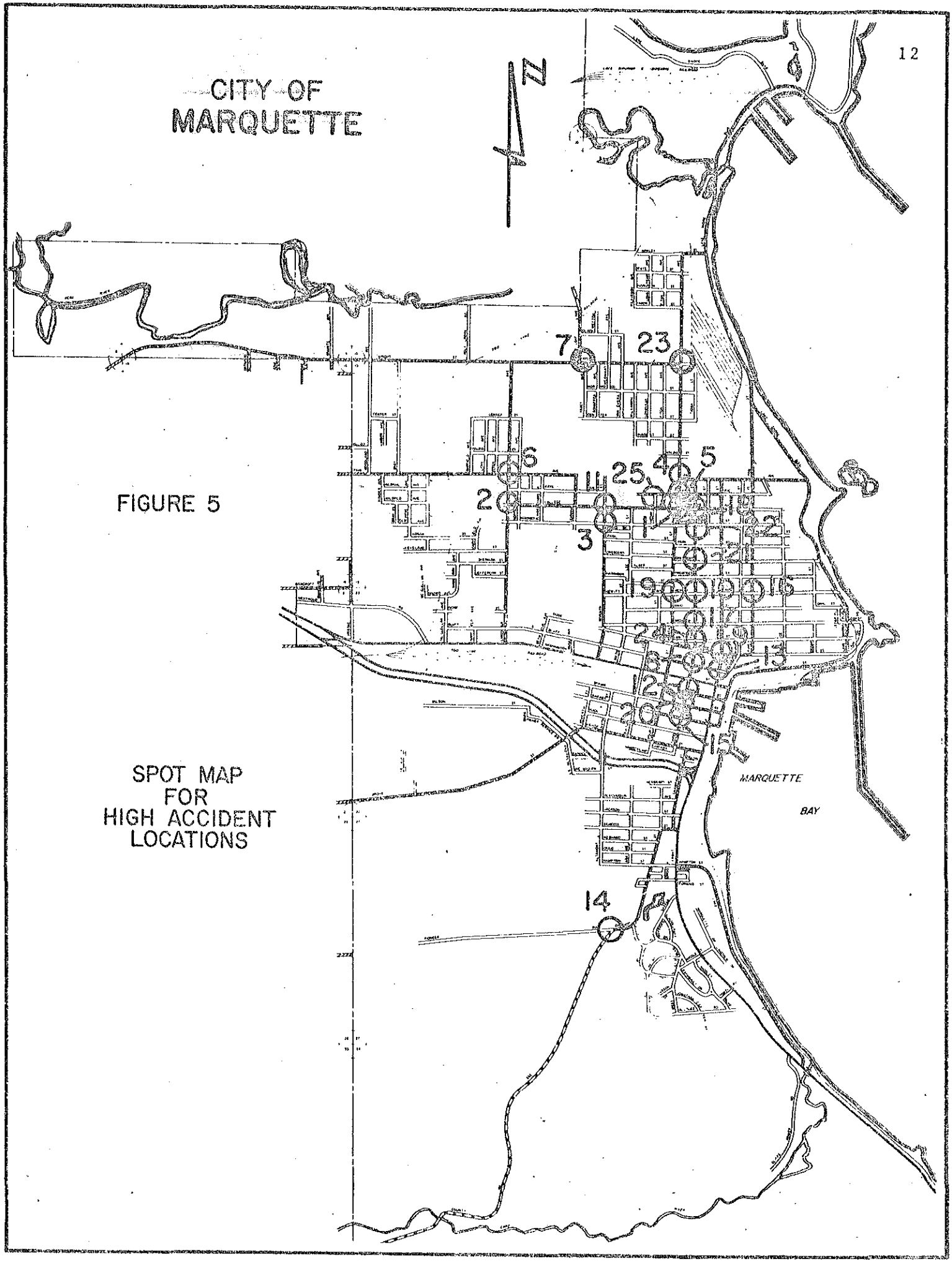


FIGURE 5

SPOT MAP
FOR
HIGH ACCIDENT
LOCATIONS

LOCATION 1 PRESQUE ISLE AVENUE AT COLLEGE AVENUE

Presque Isle Avenue and College Avenue form a right-angle intersection near Northern Michigan University that is under signal control. The existing signal head, which is suspended over the intersection, has a 60 second cycle with a five percent clearance interval.

Presque Isle Avenue has a three lane, 48 ft wide bituminous pavement with the center lane for left turns only. The west leg of College Avenue has a three lane, 40 ft wide bituminous pavement with the outside lane for right turns only and the center lane for both through movements and left turns. The east leg of College Avenue has a two lane, 24 ft wide bituminous pavement.

There were 56 accidents at this location during the four year study period. Fifty-seven percent of these accidents occurred on wet, snowy or icy pavement. Almost 45 percent of the accidents were right-angles which is unusual for a signalized location. Fifteen of the 25 violators disobeyed the red traffic light while almost 42 percent of the violators were 21 years old or younger.

Recommendations

The signals at Presque Isle Avenue and College Avenue should be interconnected with the signals at Lincoln Avenue and College Avenue (Location 2) and the signals at Seventh Street and College Avenue (Location 11). A Time-Space Diagram has been prepared to establish progression through the three intersections (Figure 10, p. 19). At a speed of 27 mph a cycle length of 70 seconds provides College Avenue with the greatest band of green time through the three intersections. Thus, it is recommended that a 70 second cycle with a six percent clearance interval (4.2 seconds) be established at this intersection.

The critical problem at this intersection involves the high incidence of right angle accidents at a signalized intersection. The existence of a single signal head, the short clearance interval and the standard lens size were all contributing factors to the right-angle pattern. It is mandatory in the 1973 edition of the Michigan Manual that at least two signal faces be provided per approach. Therefore, it is recommended that a second signal head be employed at this intersection and furthermore, that each signal should have 12 in. lenses. The problem involving the short clearance interval will be relieved through the adoption of the 70 second cycle and six percent clearance interval already recommended. If right-angle accidents continue in the future, consideration should be given to incorporating an all-red clearance interval into the signals' cycle length.

Many of the operators indicated that they did not see the signal. The fact that the existing signal head was painted green contributed to this problem. To obtain the best possible contrast with the visual background, it is desirable to paint signal head housings highway yellow. The insides of visors (hoods) and the entire surface of louvers, fins and the front surface of backplates shall have a dull black finish to minimize light reflection to the side of the signals. It is recommended that these paint guidelines be applied to the proposed signal heads.

Another accident pattern at this intersection involves the utility pole on the southeast corner. Three of the four ran-off roadway accidents involved this pole. The fact that this utility pole abuts the pavement makes it a target for errant vehicles. Also, because of the sharp turning radius from northbound Presque Isle Avenue to eastbound College Avenue this pole can be easily sideswiped by a turning vehicle. It is recommended that the utility company be contacted to relocate this pole so it is not a target for moving traffic.

The capacity for the west leg of College Avenue is limited because the left turn and through movements are made from the same lane. The lane assignments for the west leg should be changed so that the center lane is for left turns only while the outside lane is for right turns and through movements. The painted arrows on the west leg should be repainted to reflect the change in lane assignments. A 50 ft taper should be constructed on the south side of the east leg of College Avenue to facilitate the movement of College Avenue traffic through the intersection.

The Michigan Manual indicates that symbol arrows indicating a single mandatory movement shall include the word "ONLY". Thus it is recommended that the word "ONLY" be applied under each Left Turn Arrow on Presque Isle Avenue and the west leg of College Avenue.

Roadside Lane-Use Control signs should be erected on the west leg of College Avenue and on the north and south legs of Presque Isle Avenue. These signs should be erected both in advance of the intersection and at the intersection. These Lane-Use Control signs will supplement the existing pavement markings to better inform the vehicle operator which direction he is allowed to travel from any given lane. A detail drawing of the recommendations at this intersection can be found on p. 18 .

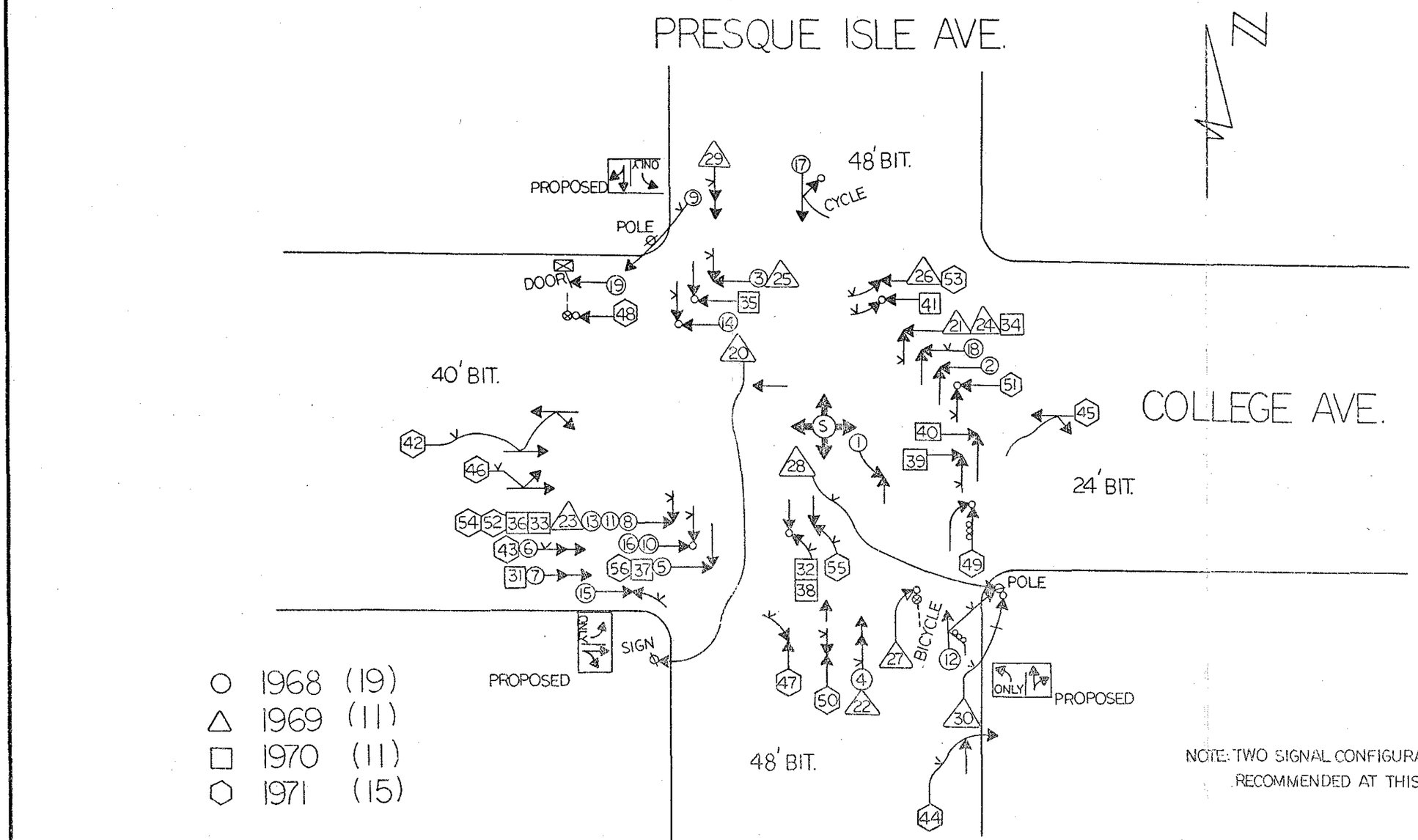


FIGURE 6

LEGEND

Fatal	Out of Control	Pedestrain	Tree
Injury	Driver Intent	Stop & Go Signal	Stop Sign S
Skidding	Deer	Flashing Beacon	Yield Sign Y
Jackknife	Violator		
Overturned	Backing		

Period: 1968 THRU 1971

Accidents – Total 56 P.D. 43

Injury 13 (21) Fatal 0 ( )

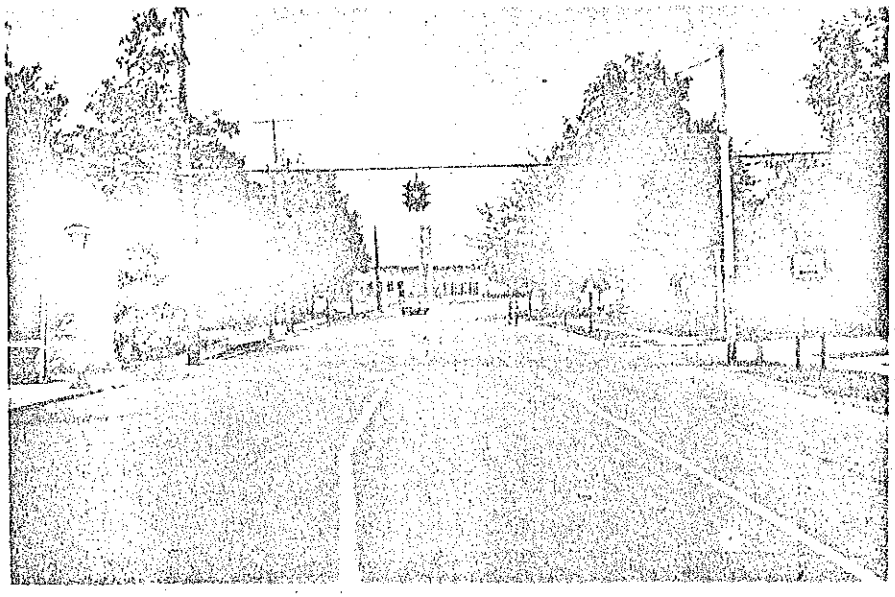
C.S. _____ Miles _____ Drawn DVW

Plan No. LOCATION 1 Date 2-28-73

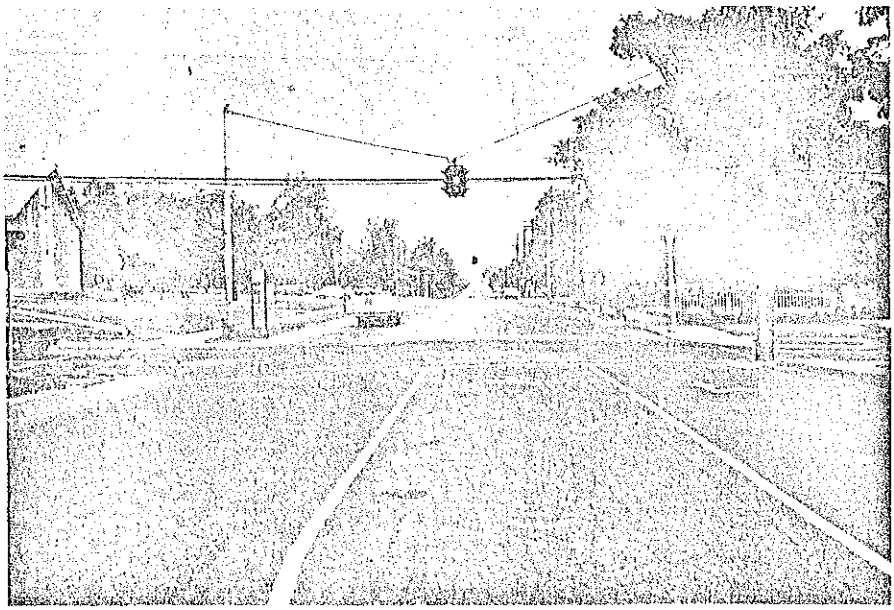
MICHIGAN DEPARTMENT OF STATE HIGHWAYS
TRAFFIC AND SAFETY DIVISION

Location PRESQUE ISLE AVE. at COLLEGE AVE.
CITY OF MARQUETTE
MARQUETTE CO.

FORM NO. 1547 REV. 5-71



SOUTHBOUND PRESQUE ISLE AVENUE



NORTHBOUND PRESQUE ISLE AVENUE

FIGURE 7

EASTBOUND COLLEGE AVENUE

WESTBOUND COLLEGE AVENUE

FIGURE 8

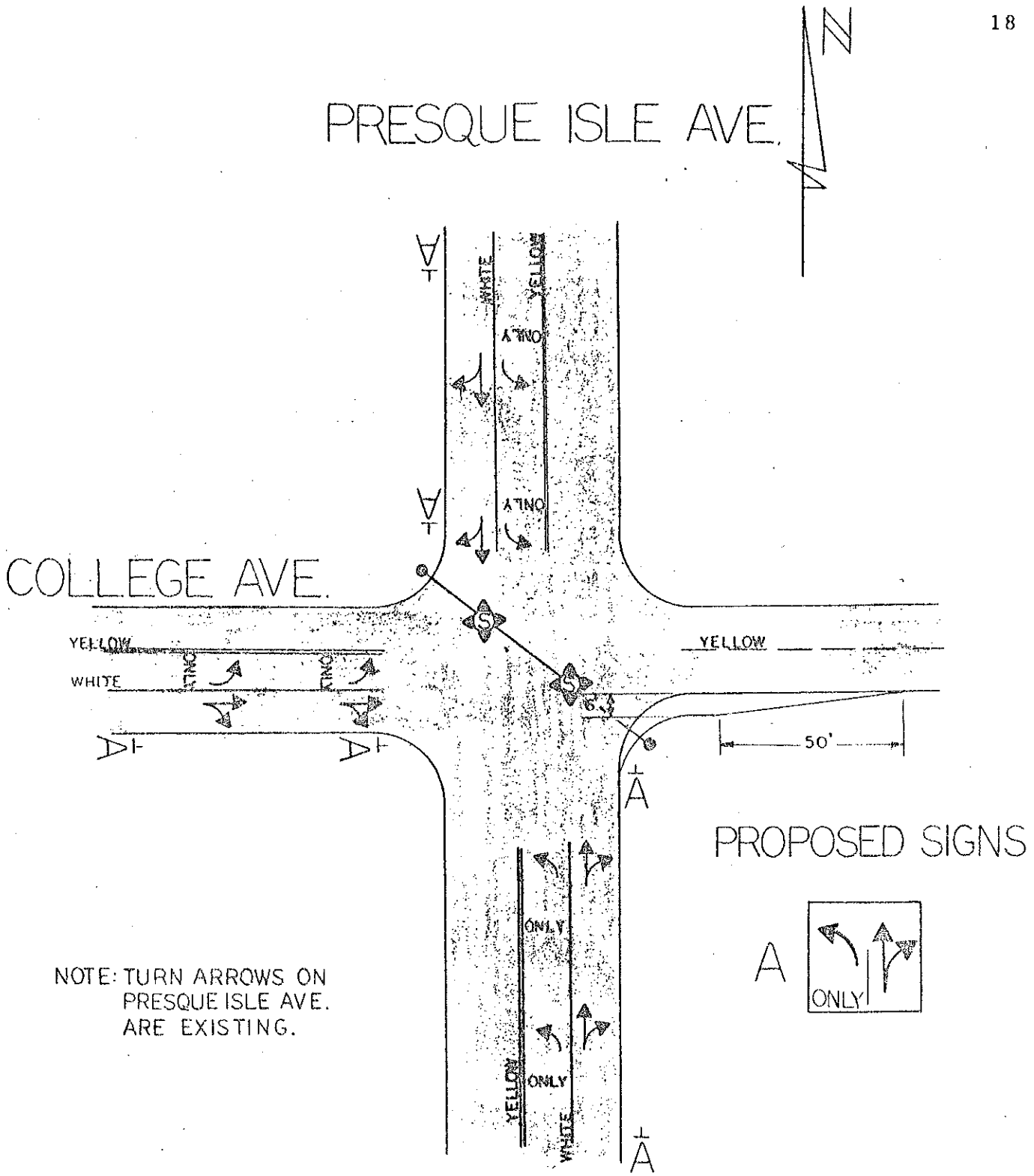
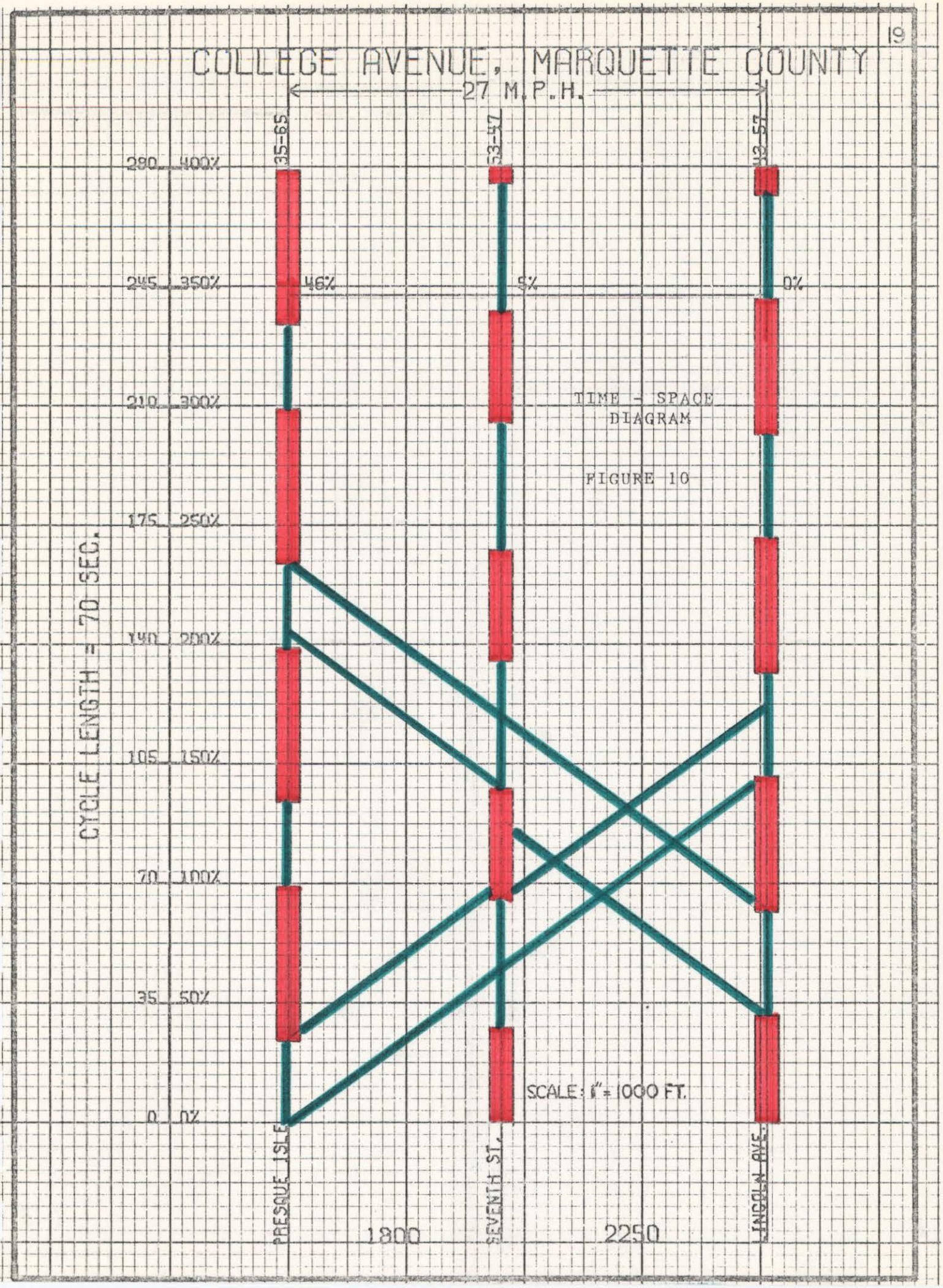


FIGURE 9

STATE OF MICHIGAN DEPARTMENT OF STATE HIGHWAYS TRAFFIC & SAFETY DIVISION	AUTH. NO.	DRAWN DJM	PRESQUE ISLE AVE AT COLLEGE AV CITY OF MARQUETTE MARQUETTE CO.
	CONT. SEC.	DATE	
	REF.	SCALE 1" 40'	
	SHEET OF	PLAN LOCATION 1	


COLLEGE AVENUE, MARQUETTE COUNTY
27 M.P.H.
35-65
33-57
43-57
280 400%
245 350%
210 300%
175 250%
140 200%
105 150%
70 100%
35 50%
0 0%
CYCLE LENGTH = 70 SEC.
46%
5%
0%
TIME - SPACE DIAGRAM
FIGURE 10
SCALE: 1" = 1000 FT.
PRESQUE ISLE
SEVENTH ST.
LINCOLN AVE.
1800
2250

LOCATION 2 LINCOLN AVENUE AT COLLEGE AVENUE

Lincoln Avenue and College Avenue form a signalized intersection near Marquette High School. The existing signal head, which is suspended over the center of the intersection, has a 60-second cycle with a five percent clearance interval.

Lincoln Avenue has a three lane, 32 ft wide bituminous pavement with the center lane for left turns only. The east leg of College Avenue has a three lane, 40 ft wide bituminous pavement with the center lane for left turns only. The west leg of College Avenue has a two lane, 30 ft wide bituminous pavement that provides access to Marquette High School.

There were 36 accidents at this location during the four-year study period. Twenty-four of these accidents or almost 67 percent occurred on wet, snowy or icy pavement. There were nine rear end accidents at this location with seven of them occurring on wet or slippery pavement. There were seven accidents involving the driveways at the southeast and southwest corners. All four of the right-angle accidents occurred on wet or slippery pavement.

Recommendations

The signals at Lincoln Avenue and College Avenue should be interconnected with the signals at Seventh Street and College Avenue (Location 11) and the signals at Presque Isle Avenue and College Avenue (Location 1). A Time-Space Diagram has been prepared to establish progression through the three intersections (Figure 10, p. 19). At a speed of 27 mph a cycle length of 70 seconds provides College Avenue with the greatest band of green time using the existing cycle split. Thus, it is recommended that a 70-second cycle with a six percent clearance interval (4.2 seconds) be established at this intersection.

It is required in the 1973 edition of the Michigan Manual that a minimum of two vehicular signal faces be provided per approach. It is recommended that the requirements of the Manual be complied with at this intersection by erecting a second signal head.

The left turn lanes on Lincoln Avenue are offset in relation to each other which creates a sight distance problem for opposing left turning vehicles. The operators of these vehicles cannot see approaching through traffic. To alleviate this situation it is recommended that the left turn lanes be aligned directly across from each other. This can be accomplished by restriping Lincoln Avenue for two 11 ft through lanes and a 10 ft center lane for left turns (Figure 13, p. 24). Realigning the left turn lanes will make it necessary to increase the radius in the northeast and southwest quadrants to 40 ft to accommodate right turns from east and westbound College Avenue.

When Lincoln Avenue is restriped the painted arrows indicating lane assignments will also have to be repainted. The left turn arrows for both Lincoln Avenue and the east leg of College Avenue refer to a mandatory movement and should be accompanied by the word "Only". The east leg of College Avenue should be restriped so there will be

a double yellow center line. The pavement markings for both Lincoln Avenue and College Avenue should be applied according to the drawing on p. 24 .

To accompany the pavement markings at this intersection it is recommended that Lane-Use Control signs be erected at the intersection and in advance of the intersection for both legs of Lincoln Avenue and for the east leg of College Avenue. These signs will supplement the pavement markings by better defining the lanes available to the vehicle operators.

The grocery store located in the southwest quadrant has neither curbing nor driveways to control vehicles entering or exiting the parking area. It is recommended that curbing and driveways be constructed in this quadrant along the west leg of College Avenue and the south leg of Lincoln Avenue.

Almost 28 percent of the accidents at this location occurred on wet pavement, while altogether 67 percent of the accidents occurred on wet, snowy or icy pavement. These figures indicate that the pavement at this intersection becomes slippery when wet. Thus, it is recommended that skidometer tests be conducted.

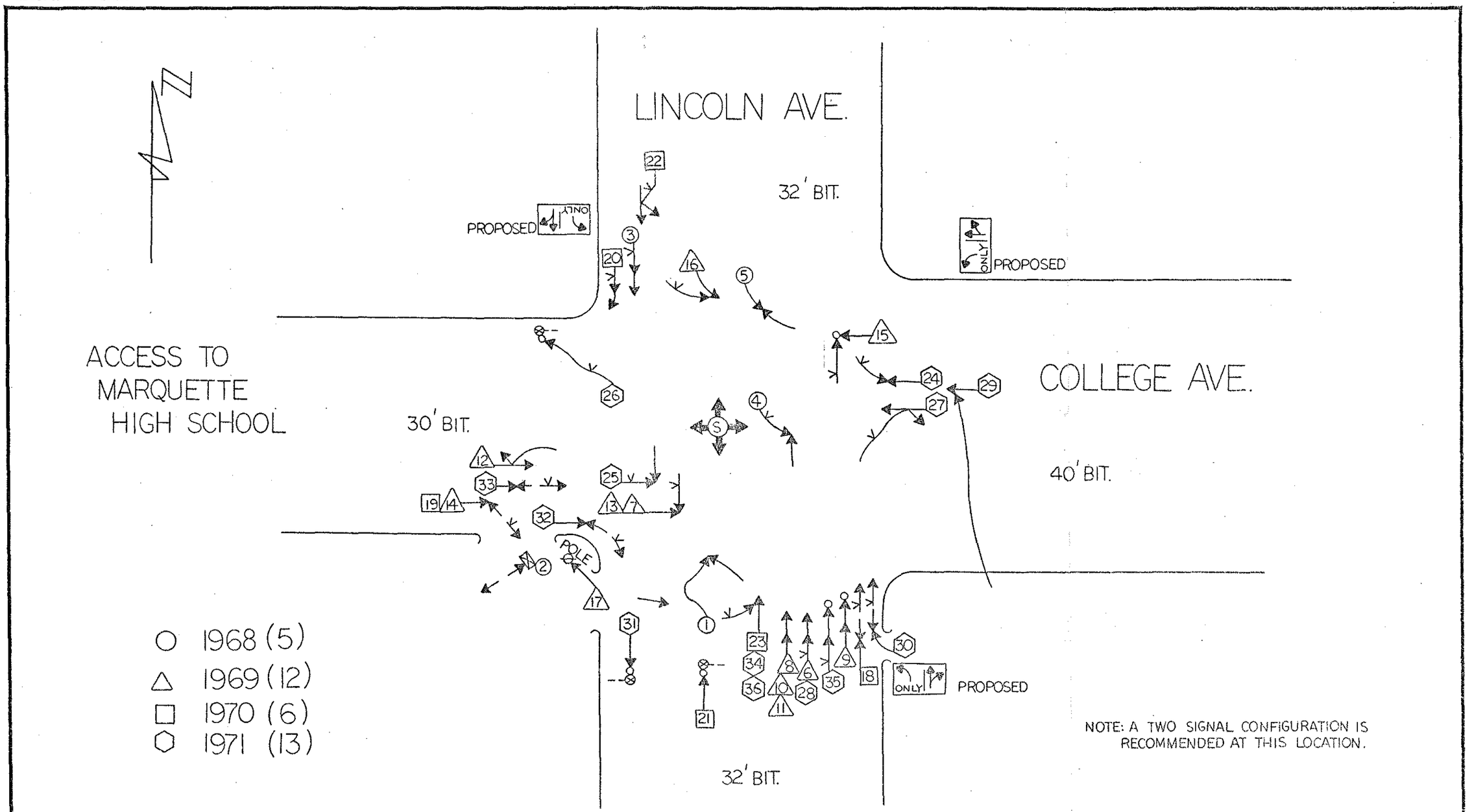


FIGURE 11

LEGEND

Fatal	Out of Control	Pedestrain	Tree
Injury	Driver Intent		
Skidding	Deer	Stop & Go Signal	Stop Sign S
Jackknife	Violator		
Overturned	Backing	Flashing Beacon	Yield Sign Y

Period: 1968 THRU 1971

Accidents – Total 36 P.D. 30

Injury 6 (8) Fatal 0 ( )

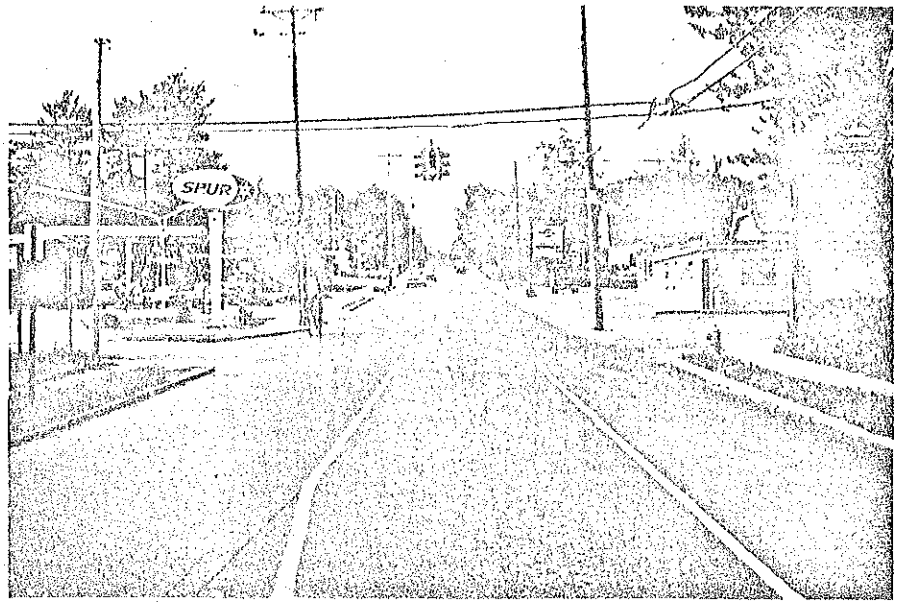
C.S. _____ Miles _____ Drawn DVW

Plan No. LOCATION 2 Date 2-28-73

MICHIGAN DEPARTMENT OF STATE HIGHWAYS
TRAFFIC AND SAFETY DIVISION

Location LINCOLN AVE. at COLLEGE AVE.
CITY OF MARQUETTE
MARQUETTE CO.

FORM NO. 1847 REV. 5-71

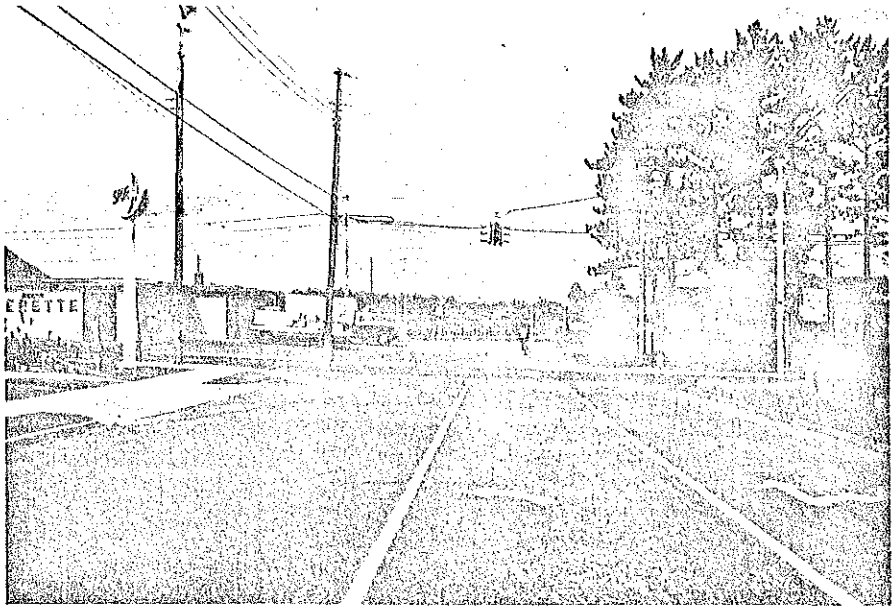


SOUTHBOUND

LINCOLN AVENUE

WESTBOUND

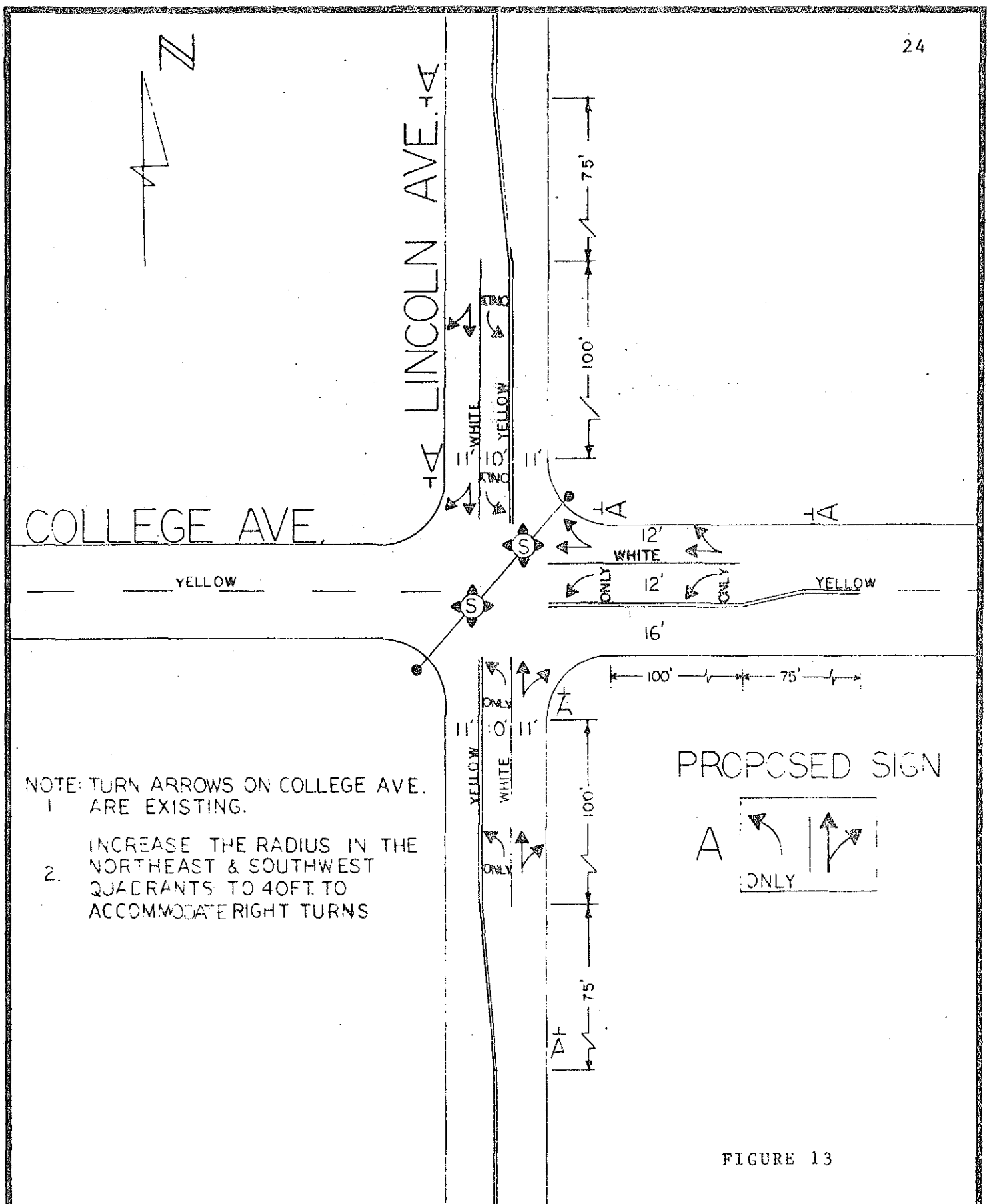
COLLEGE AVENUE



NORTHBOUND

LINCOLN AVENUE

FIGURE 12



NOTE: TURN ARROWS ON COLLEGE AVE.
1. ARE EXISTING.
2. INCREASE THE RADIUS IN THE NORTHEAST & SOUTHWEST QUADRANTS TO 40FT. TO ACCOMMODATE RIGHT TURNS

PROPOSED SIGN

FIGURE 13

STATE OF MICHIGAN DEPARTMENT OF STATE HIGHWAYS — TRAFFIC & SAFETY DIVISION	AUTH. NO.	DRAWN DJM
	CONT. SEC.	DATE
	RDF.	SCALE 1"= 40'
	SHEET OF	PLAN LOCATION 2

LINCOLN AVE. AT COLLEGE AVE.
CITY OF MARQUETTE
MARQUETTE CO.

LOCATION 3 SEVENTH STREET AT MAGNETIC STREET

Seventh Street and Magnetic Street form a four legged intersection with Seventh Street having the right-of-way. Seventh Street has a two lane, 30 ft wide bituminous pavement and Magnetic Street has a two lane, 34 ft wide bituminous pavement. Parking is not allowed in the immediate intersection area. The only existing traffic controls consist of center line markings for all four legs and a 24 in. "Stop" sign for each leg of Magnetic Street.

There were 34 accidents at this location during the four year study period. Of this total 26.5 percent occurred on wet pavement, 47.1 percent occurred on snowy or icy pavement and the remaining 26.4 percent occurred on dry pavement. There were 25 right angle collisions which accounted for 73.5 percent of the total accidents. Seven of these accidents occurred on wet pavement and 11 others occurred on snowy or icy pavement. The remaining accidents at this location exhibited no specific pattern.

Recommendations

The critical problem at this intersection is the occurrence of right-angle accidents. Of the 25 right-angle accidents 12 operators stopped at the "Stop" signs on Magnetic Street and then failed to yield to Seventh Street traffic. Six of these operators indicated that their vision was obstructed by high snow banks while one other operator indicated that a pine tree in the southeast corner obstructed his vision. The remaining 13 right-angle accidents involved operators who ran through the "Stop" signs. It appears from the high number of "Stop" sign violations that a more pronounced warning is needed to inform Magnetic Street traffic of the impending stop at Seventh Street. The minimum accident warrant for a flashing beacon, according to the Michigan Manual, is satisfied when six or more accidents which are susceptible to correction by the cautioning or stopping of traffic occur over a two year period. The highest two-year period occurred between 1968 and 1969 when there were 16 right-angle accidents. The smallest two-year period occurred between 1970 and 1971 when there were nine right-angle accidents. Due to the high number of right-angle accidents at this location it is recommended that a flashing beacon be installed. Furthermore, the flashing beacon should be accompanied by 36 in. "Stop" signs for Magnetic Street.

Almost 27 percent of the accidents at this location occurred on wet pavement. Altogether 73.5 percent of the accidents occurred on wet, snowy or icy pavement. These figures indicate that the pavement at this intersection becomes slippery when wet. For this reason it is recommended that skidometer tests be conducted.

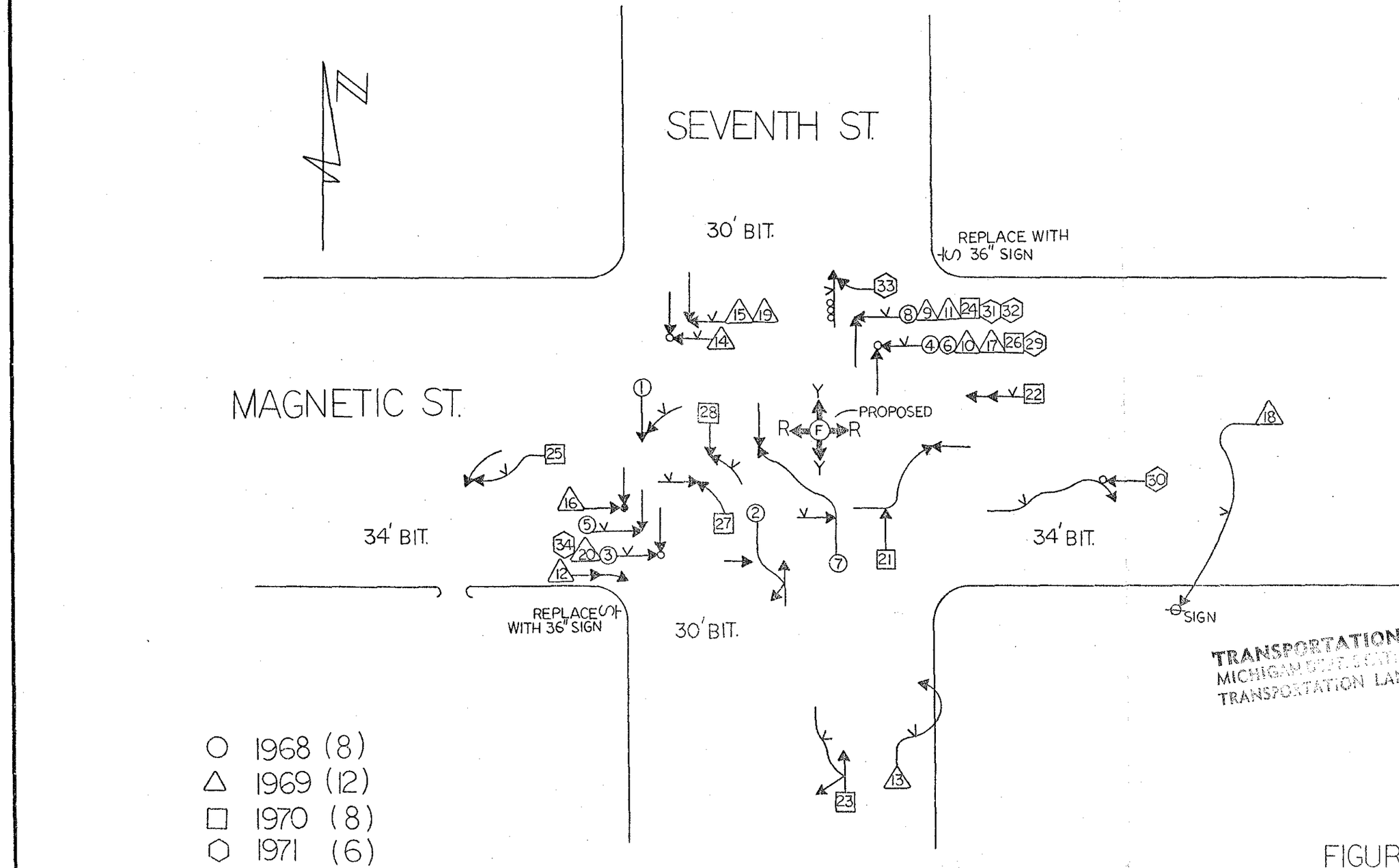


FIGURE 14

LEGEND

Fatal	Out of Control	Pedestrain	Tree
Injury	Driver Intent	Stop & Go Signal	Stop Sign S
Skidding	Deer	Flashing Beacon	Yield Sign Y
Jackknife	Violator		
Overturned	Backing		

Period: 1968 THRU 1971

Accidents -- Total 34 P.D. 22

Injury 11 (17) Fatal 1 (1)

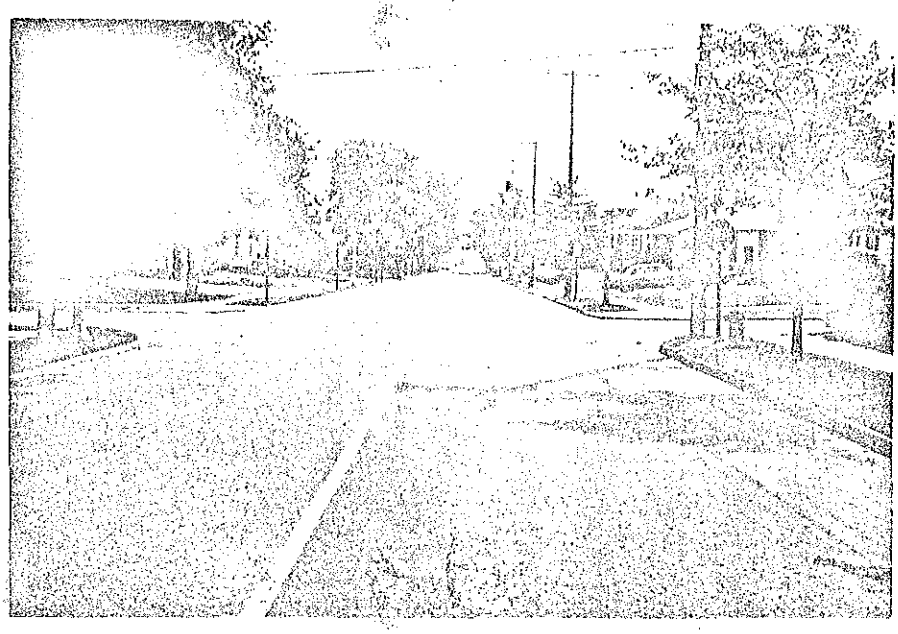
C.S. ____ Miles ____ Drawn DVW

Plan No. LOCATION 3 Date 2-28-73

MICHIGAN DEPARTMENT OF STATE HIGHWAYS
TRAFFIC AND SAFETY DIVISION

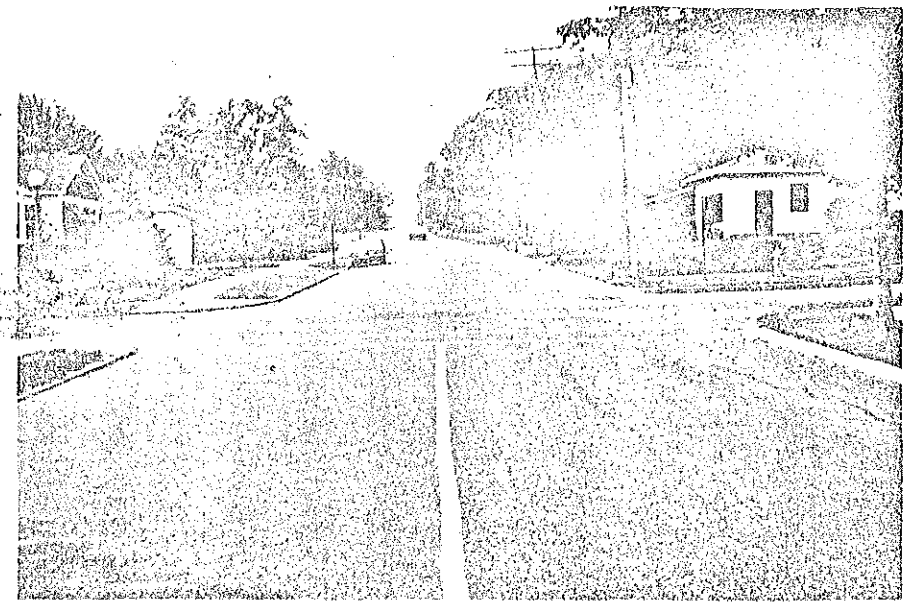
Location SEVENTH ST. at MAGNETIC ST.
CITY OF MARQUETTE
MARQUETTE CO.

FORM NO. 1547 REV. 5-71



EASTBOUND

MAGNETIC STREET



SOUTHBOUND

SEVENTH STREET

WESTBOUND

MAGNETIC STREET

FIGURE 15

LOCATION 4 PRESQUE ISLE AVENUE AT FAIR AVENUE

Presque Isle Avenue and Fair Avenue form a "T" intersection. Presque Isle Avenue has a 48 ft wide bituminous pavement and Fair Avenue has a 35 ft wide bituminous pavement. Presque Isle Avenue has enough available width to accommodate four lanes of traffic. The north leg of Presque Isle has painted left turn arrows for the inside lane and painted through arrows for the outside lane. Fair Avenue has a 24 in. "Stop" sign for westbound traffic.

There were 32 accidents at this location during the four year study period. Of this total 34.3 percent occurred on wet pavement and 16.5 percent occurred on snowy or icy pavement. There were eight head-on left-turn accidents and seven rear end accidents. Four of the head-on left-turn accidents occurred during adverse weather conditions and four of the rear end accidents were reportedly caused by driver carelessness. The remaining accidents at this location did not exhibit any distinct pattern.

Recommendations

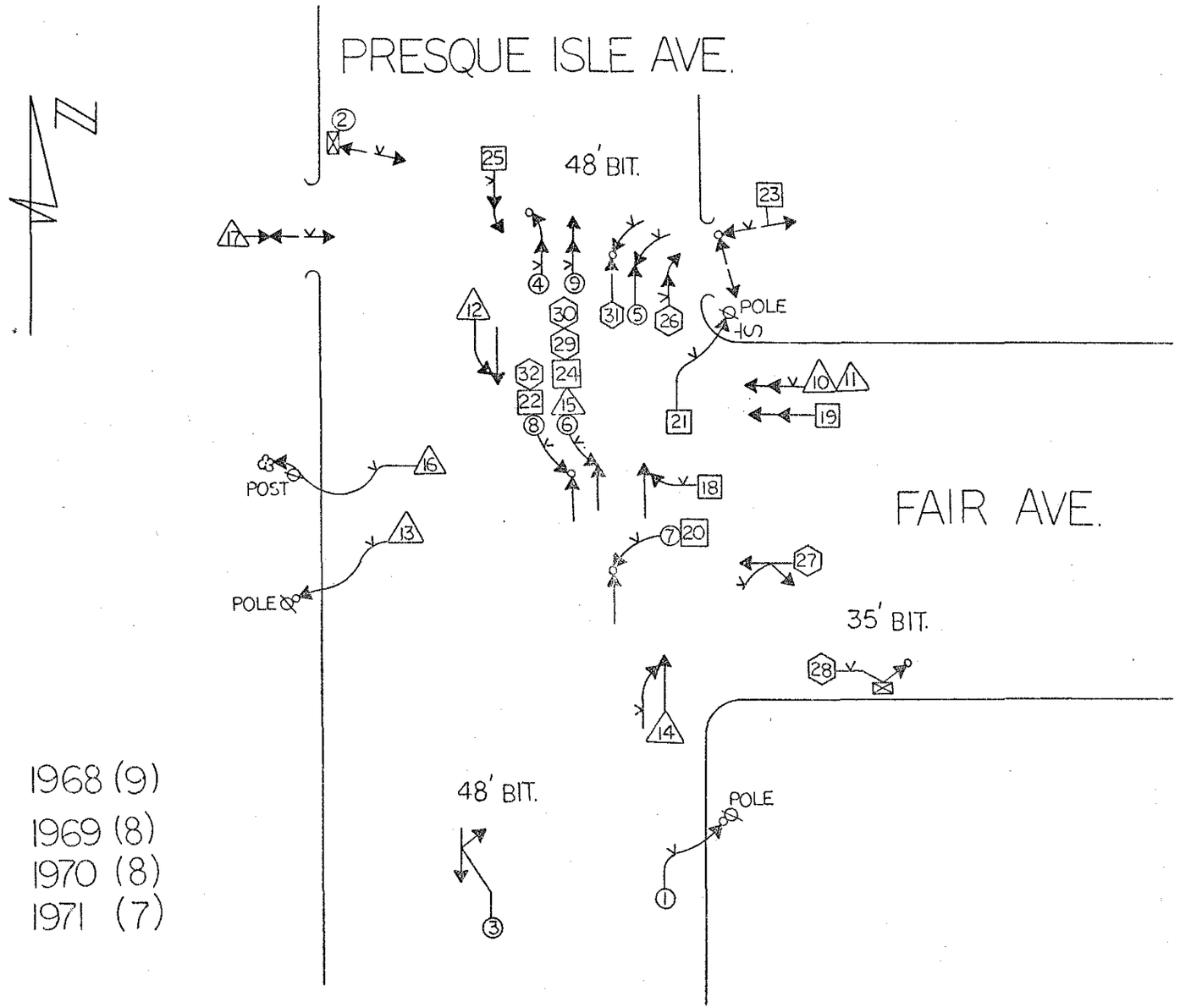
Thirty-four percent of the accidents at this location occurred on wet pavement. Taken as a percentage of the dry and wet pavement accidents only, 40.7 percent of the accidents occurred on wet pavement. These figures indicate that the pavement at this intersection becomes slippery when wet. For this reason it is recommended that skidometer tests be conducted.

There were eight head-on left-turn accidents involving southbound Presque Isle Avenue traffic. The Michigan Manual makes it mandatory to include the word "Only" with symbol arrows that indicate a single mandatory movement. Thus it is recommended that the word "Only" accompany the left turn and through arrows located on the north leg of Presque Isle Avenue. Also Lane-Use Control signs located at the intersection and in advance of the intersection should be erected for northbound Presque Isle Avenue traffic (Figure 18).

The Michigan Manual indicates that lane lines should be applied on all multi-lane highways. Thus it is recommended that lane lines be applied to Presque Isle Avenue to create four 12 ft lanes. Also the center line for Presque Isle Avenue, which should be a double yellow line, should be applied throughout the entire length of the pavement. The center line for Fair Avenue should be painted yellow and also applied throughout the entire length of the pavement (Figure 18).

Two of the ran-off roadway accidents involved westbound Fair Avenue vehicles that ran off the roadway after crossing Presque Isle Avenue. Even though the occurrence of this type of accident was

minimal, it is felt that the change in alignment should be called to the attention of westbound Fair Avenue traffic. Thus it is recommended that a 24 in. x 48 in. Bi-Directional Target Arrow be erected in target position at the end of Fair Avenue and that a 36 in. "Stop" sign replace the existing 24 in. sign.



○ 1968 (9)
△ 1969 (8)
□ 1970 (8)
⬡ 1971 (7)

FIGURE 16

LEGEND

Fatal	Out of Control	Pedestrain	Tree
Injury	Driver Intent		
Skidding	Deer	Stop & Go Signal	Stop Sign S
Jackknife	Violator		
Overturned	Backing	Flashing Beacon	Yield Sign Y

Period: 1968 THRU 1971

Accidents – Total 32 P.D. 21

Injury 11 (12) Fatal 0 ( )

C.S. ____ Miles ____ Drawn DVW

Plan No. LOCATION 4 Date 2-28-73

MICHIGAN DEPARTMENT OF STATE HIGHWAYS
TRAFFIC AND SAFETY DIVISION

Location PRESQUE ISLE AVE. at FAIR AVE.
CITY OF MARQUETTE
MARQUETTE CO.

SOUTHBOUND

PRESQUE ISLE AVENUE

WESTBOUND

FAIR AVENUE

NORTHBOUND

PRESQUE ISLE AVENUE

FIGURE 17

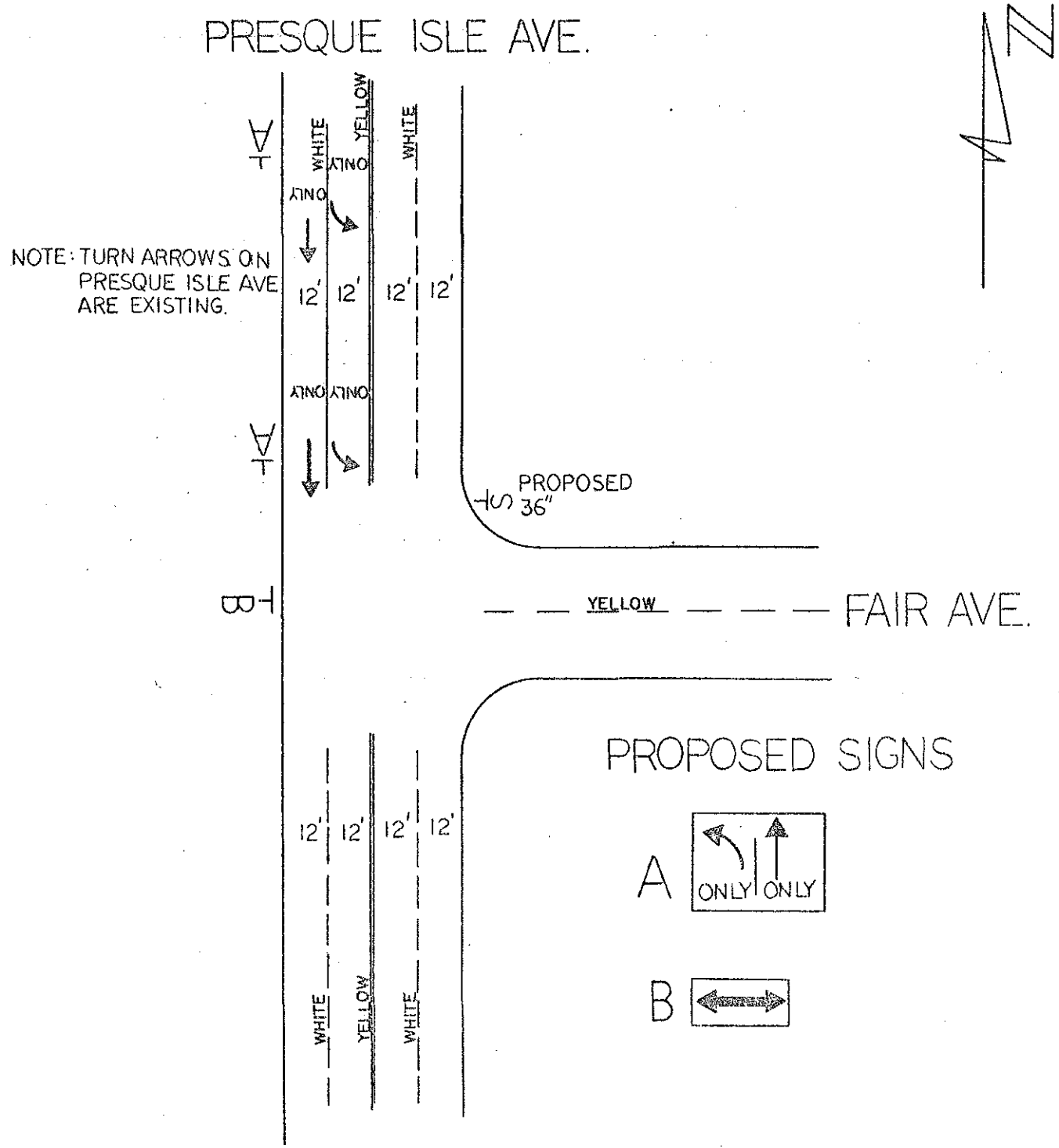


FIGURE 18

STATE OF MICHIGAN DEPARTMENT OF STATE HIGHWAYS TRAFFIC & SAFETY DIVISION	AUTH. NO.	DRAWN DVW	PRESQUE ISLE AVE. at FAIR AVE.
	CONT. SEC.	DATE	CITY OF MARQUETTE
	REF.	SCALE 1" = 40'	
	SHEET OF PLAN LOCATION 4		MARQUETTE CO.

LOCATION 5 PRESQUE ISLE AVENUE AT KAYE AVENUE

Presque Isle Avenue and Kaye Avenue form a signalized intersection adjacent to Northern Michigan University. The existing signal head, which is suspended over the intersection, has a 60 second cycle with a five percent clearance interval.

Presque Isle Avenue has a three lane, 48 ft wide bituminous pavement with the center lane for left turns only. The west leg of Kaye Avenue has a three lane, 55 ft wide bituminous pavement with the center lane for left turns and through movements, while the outside lane is for right turns only. The east leg of Kaye Avenue has a two lane, 24 ft wide bituminous pavement. Both roadways have lane lines and painted arrows to indicate lane assignments.

There were 30 accidents at this location during the four year study period. Fifty-three percent of these accidents occurred on snowy or icy pavement. Twenty of the 30 accidents involved right-angle and rear end collisions. Five of the 12 right-angle collisions involved operators who disregarded the red signal indication and five other right-angle accidents occurred during the signal's flasher operation. Five of the eight rear end accidents occurred on slippery pavement.

Recommendations

The most critical aspect at this location is the high incidence of right-angle accidents at a signalized intersection. Forty percent of the accidents at this intersection involved right-angle collisions. Five of these operators reportedly did not realize they had a red signal indication. To increase the probability that the signal indications will be seen, it is recommended that a second signal head be erected to provide two signal faces per approach. Furthermore, to obtain the best possible contrast with the visual background it is desirable to paint signal head housings highway yellow while the visors, fins, the entire surface of louvers and the front surface of backplates should be painted a dull black finish. It is recommended that these paint guidelines be applied to both the existing signal and the proposed signal.

The Presque Isle Avenue-Kaye Avenue intersection is only 300 ft from the Presque Isle Avenue-College Avenue intersection. The cycle length at Presque Isle Avenue and College Avenue was increased to 70 seconds to establish progression along College Avenue. Presque Isle Avenue at Kaye Avenue and Presque Isle Avenue at College Avenue should have the same cycle length because of the short distance between the intersections. Thus, it is recommended that a 70 second cycle with a six percent clearance interval (4.2 seconds) be established at Presque Isle Avenue and Kaye Avenue.

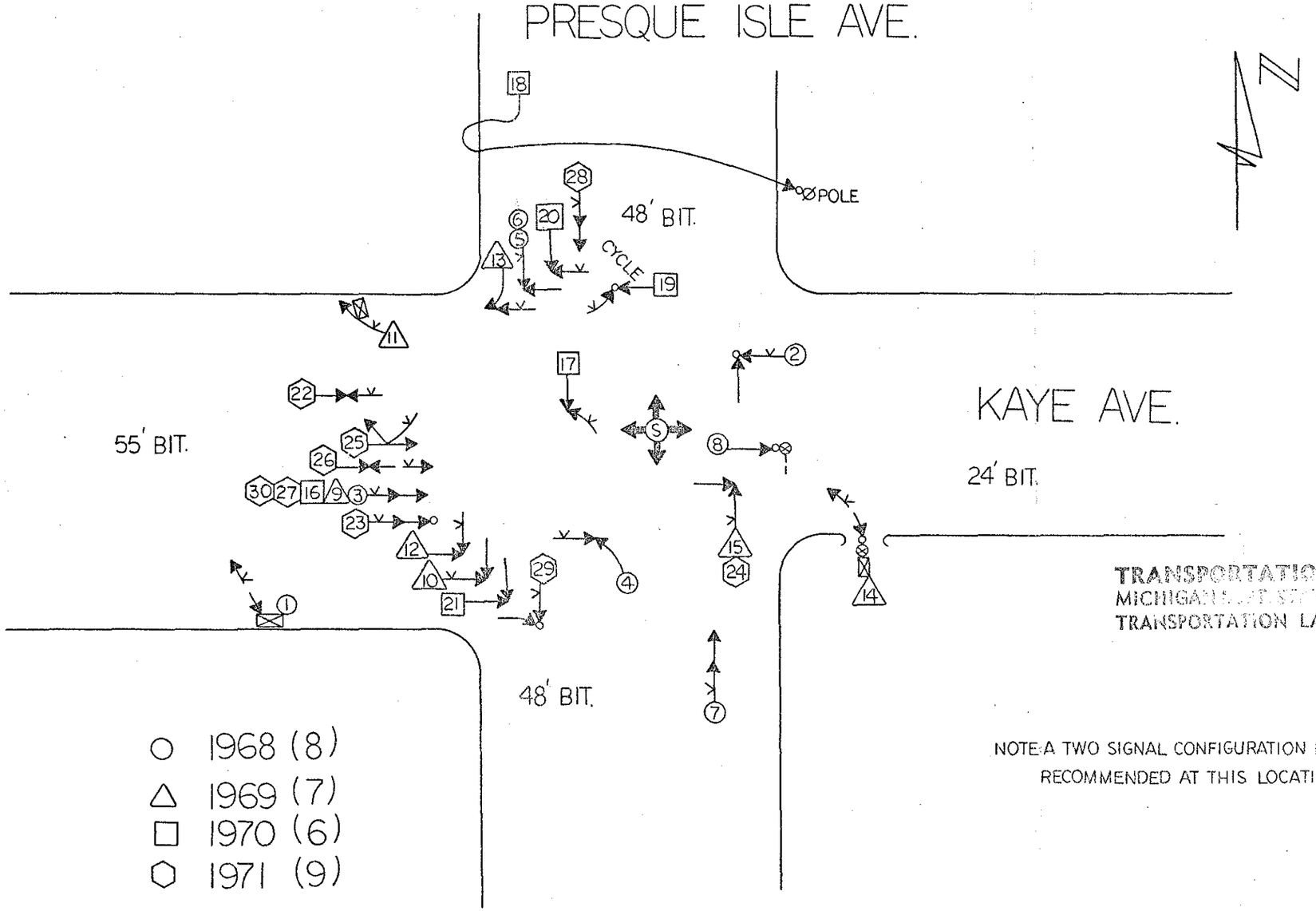
There were five right-angle collisions during the signal's flasher operation. Four of these accidents occurred between 9:50 and 10:50 p.m. It is recommended that the feasibility of increasing the stop and go operation to 11:00 p.m. be investigated.

There were no accidents during the study period that were directly related to improper lane usage. However, because of the difference in width between the east and west legs of Kaye Avenue it is necessary to change the lane assignments on the west leg of Kaye Avenue to reduce conflicts and improve capacity. It is recommended that the west leg of Kaye Avenue be divided into one westbound lane and three eastbound lanes. The three eastbound lanes should be divided into a lane for left turns only, a lane for through movements only and a lane for right turns only. The angle parking located on the north side of the west leg of Kaye Avenue should be removed while parallel parking can be added to the south side. A 50 ft taper should be constructed on the south side of the east leg of Kaye Avenue to accommodate through traffic. Painted arrows accompanied by the word "Only" should be applied to the approach lanes for the west leg of Kaye Avenue. Also, overhead Lane-Use Control signs should be erected for eastbound Kaye Avenue approximately 100 ft from the center of the intersection.

The establishment of a 12 ft departure lane for the west leg of Kaye Avenue will make the right turn from the north leg of Presque Isle Avenue difficult because of the short turn radius. It is recommended that the radius for the northwest corner be increased to 40 ft.

The lane assignments for Presque Isle should be brought to the motorists' attention by the use of roadside signs. Lane-Use Control signs should be erected at the intersection and in advance of the intersection for both legs of Presque Isle Avenue. Also, the word "Only" should be used in conjunction with the left turn arrows for the center lane of Presque Isle Avenue.

A detail drawing of the recommendations formulated for this intersection can be found on p. 38.



NOTE: A TWO SIGNAL CONFIGURATION IS RECOMMENDED AT THIS LOCATION.

FIGURE 19

LEGEND

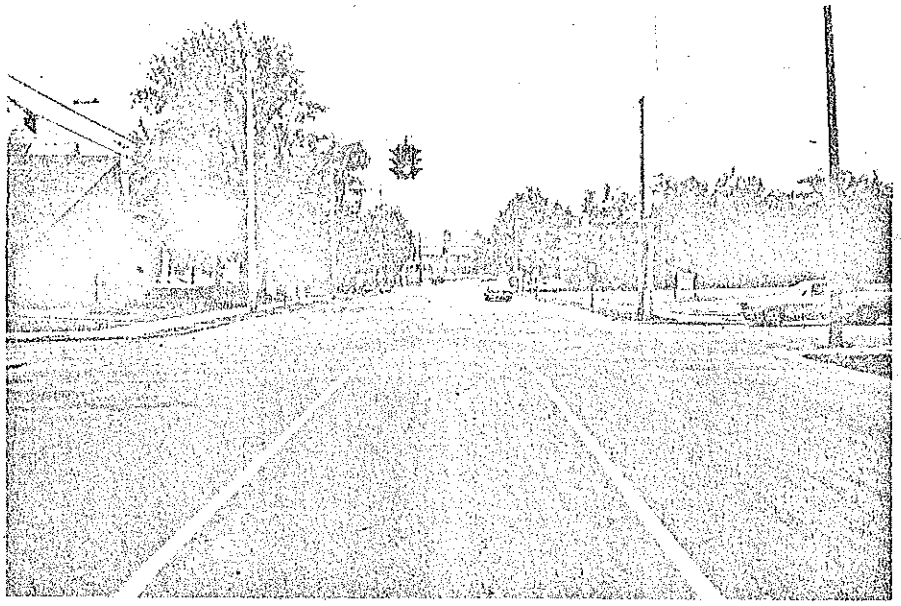
Fatal
Injury
Skidding
Jackknife
Overturned
Out of Control
Driver Intent
Deer
Violator
Backing
Pedestrain
Stop & Go Signal
Flashing Beacon
Tree
Stop Sign S
Yield Sign Y

Period: 1968 THRU 1971
Accidents -- Total 30 P.D. 23
Injury 7 (10) Fatal 0 ( )
C.S. ____ Miles ____ Drawn DVW
Plan No. LOCATION 5 Date 2-28-73

MICHIGAN DEPARTMENT OF STATE HIGHWAYS
TRAFFIC AND SAFETY DIVISION

Location PRESQUE ISLE AVE. at KAYE AVE.
CITY OF MARQUETTE
MARQUETTE CO.

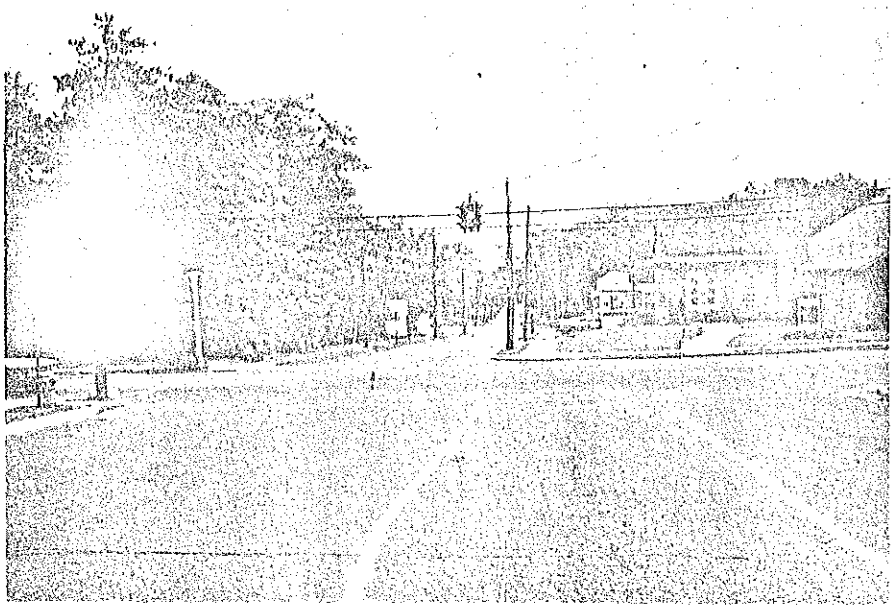
FORM NO. 1547 REV. 5-71



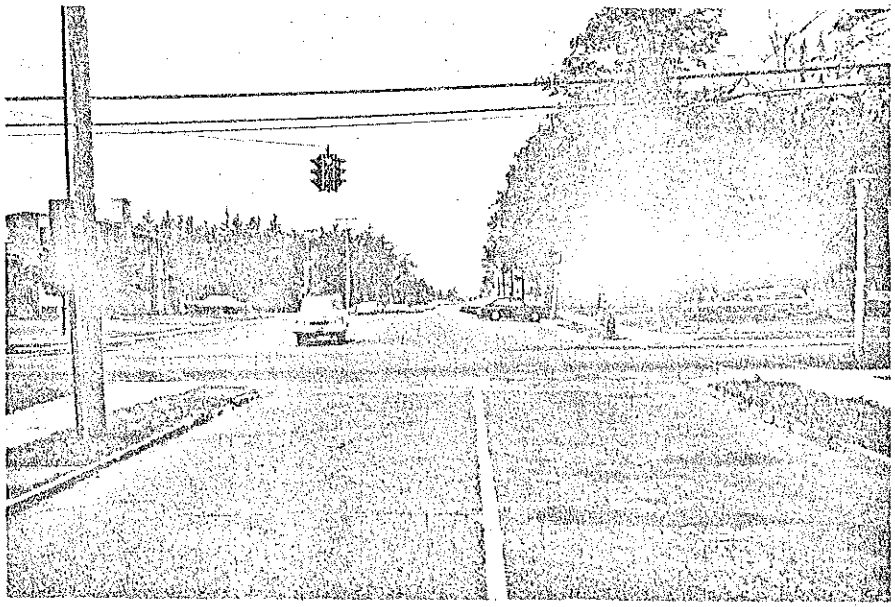
SOUTHBOUND PRESQUE ISLE AVENUE

NORTHBOUND PRESQUE ISLE AVENUE

FIGURE 20

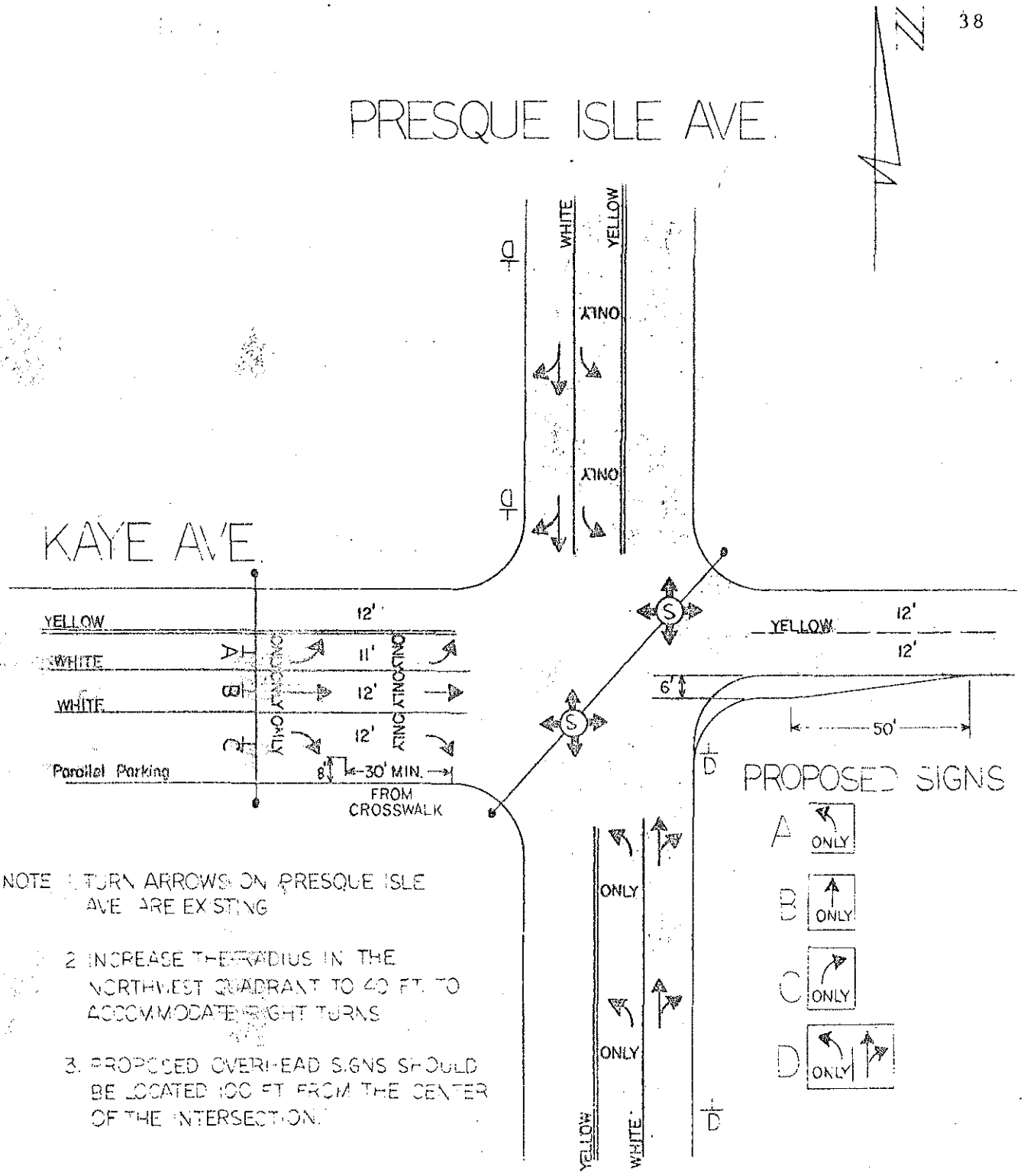


EASTBOUND KAYE AVENUE



WESTBOUND KAYE AVENUE

FIGURE 21



NOTE: 1. TURN ARROWS ON PRESQUE ISLE AVE ARE EXISTING

2. INCREASE THE RADIUS IN THE NORTHWEST QUADRANT TO 40 FT. TO ACCOMMODATE RIGHT TURNS

3. PROPOSED OVERHEAD SIGNS SHOULD BE LOCATED 100 FT FROM THE CENTER OF THE INTERSECTION.

FIGURE 22

STATE OF MICHIGAN DEPARTMENT OF STATE HIGHWAYS TRAFFIC & SAFETY DIVISION	AUTH. NO.	DRAWN DVW	PRESQUE ISLE AVE. at KAYE AVE. CITY OF MARQUETTE MARQUETTE CO.
	CONT. SEC.	DATE	
	REF.	SCALE 1"=40'	
	SHEET OF	PLAN LOCATION 5	

LOCATION 6 LINCOLN AVENUE AT WEST FAIR AVENUE

Lincoln Avenue and West Fair Avenue form a four legged intersection with Lincoln Avenue having the right-of-way. The north leg of Lincoln Avenue has a 30 ft wide bituminous pavement and the south leg has a 32 ft wide bituminous pavement. The west leg of West Fair Avenue has a three lane, 40 ft wide bituminous pavement with the center lane for left turns only. The east leg of West Fair Avenue has a two lane, 32 ft wide bituminous pavement that provides access to Northern Michigan University.

There were 29 accidents at this location during the four year study period. Almost 70 percent of these accidents occurred during adverse weather conditions with 13 of the accidents happening on snowy or icy pavement. There were 15 right-angle collisions which is almost 52 percent of the total accidents. Seven of these operators failed to stop at the intersection while the remaining eight operators stopped and then failed to yield to Lincoln Avenue traffic. There were seven rear end accidents, four of which occurred on snowy or icy pavement. The remaining accidents at this location did not indicate any distinct pattern.

Recommendations

The critical problem at this location involves the occurrence of right-angle accidents. Six of the operators who did stop at the "Stop" signs indicated that they did not see approaching traffic on Lincoln Avenue. Thus it is recommended that clear vision corners be established at all four quadrants using a minimum sight distance of 270 ft measured from the intersection along Lincoln Avenue (major highway). A motorist stopped at the "Stop" sign on West Fair Avenue should be able to see clearly to a point on Lincoln Avenue 270 ft from the intersection. This distance was computed using the information on pages 392-400 of a publication by the American Association of State Highway Officials entitled, "A Policy on Geometric Design of Rural Highways", 1965 edition (Appendix 1, pp. 85 - 94).

There were also seven right angle accidents where the operators failed to stop for the "Stop" signs. It is recommended that 36 in. "Stop" signs be erected to increase the operator's awareness of the impending stop.

The east leg of West Fair Avenue is a two lane roadway while the west leg is a three lane roadway. It is recommended that the east leg of West Fair Avenue be painted for three lanes to coordinate with the three lanes on the west leg. The lane lines for the west leg of West Fair Avenue are not painted the proper color. Both legs of West Fair Avenue should be marked in accordance with the drawing on p. 43 .

Painted arrows to indicate lane assignments should be applied to the east leg of West Fair Avenue. The word "Only" should accompany the left turn arrows for both legs of West Fair Avenue. Roadside Lane-Use Control signs should be erected in advance of the intersection for both legs of West Fair Avenue.

The partial centerline for the south leg of Lincoln Avenue should be a broken yellow line instead of a solid white line and it should be applied throughout the entire length of the pavement. It is also recommended that a broken yellow centerline be applied throughout the entire length of the north leg of Lincoln Avenue.

Right turns can be made from three of the four approaches without any difficulty. However, the right turn from the northbound approach on Lincoln Avenue has to be made into an 11 ft lane on West Fair Avenue. The existing radius is not large enough to accommodate this turn. Thus, it is recommended that the radius in the southeast quadrant be increased to 40 ft.

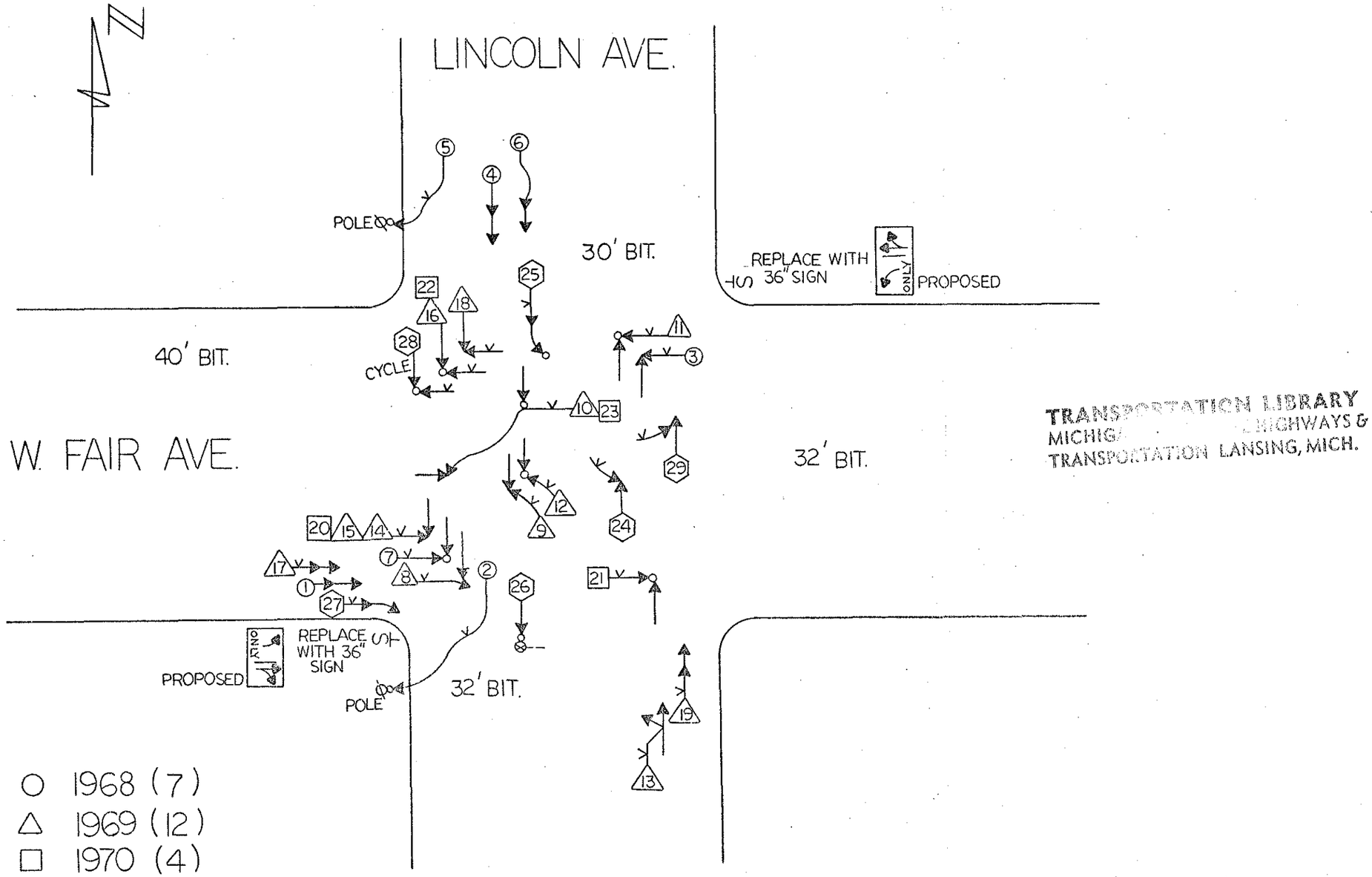


FIGURE 23

LEGEND

Fatal
Injury
Skidding
Jackknife
Overturned
Out of Control
Driver Intent
Deer
Violator
Backing
Pedestrain
Stop & Go Signal
Flashing Beacon
Tree
Stop Sign S
Yield Sign Y

Period: 1968 THRU 1971
Accidents – Total 29 P.D. 16
Injury 13 (23) Fatal 0 ( )
C.S. Miles Drawn DVW
Plan No. LOCATION 6 Date 2-28-73

MICHIGAN DEPARTMENT OF STATE HIGHWAYS
TRAFFIC AND SAFETY DIVISION

Location LINCOLN AVE. at W. FAIR AVE.
CITY OF MARQUETTE
MARQUETTE CO.

FORM NO. 1547 REV. 5-71

EASTBOUND

W. FAIR AVENUE

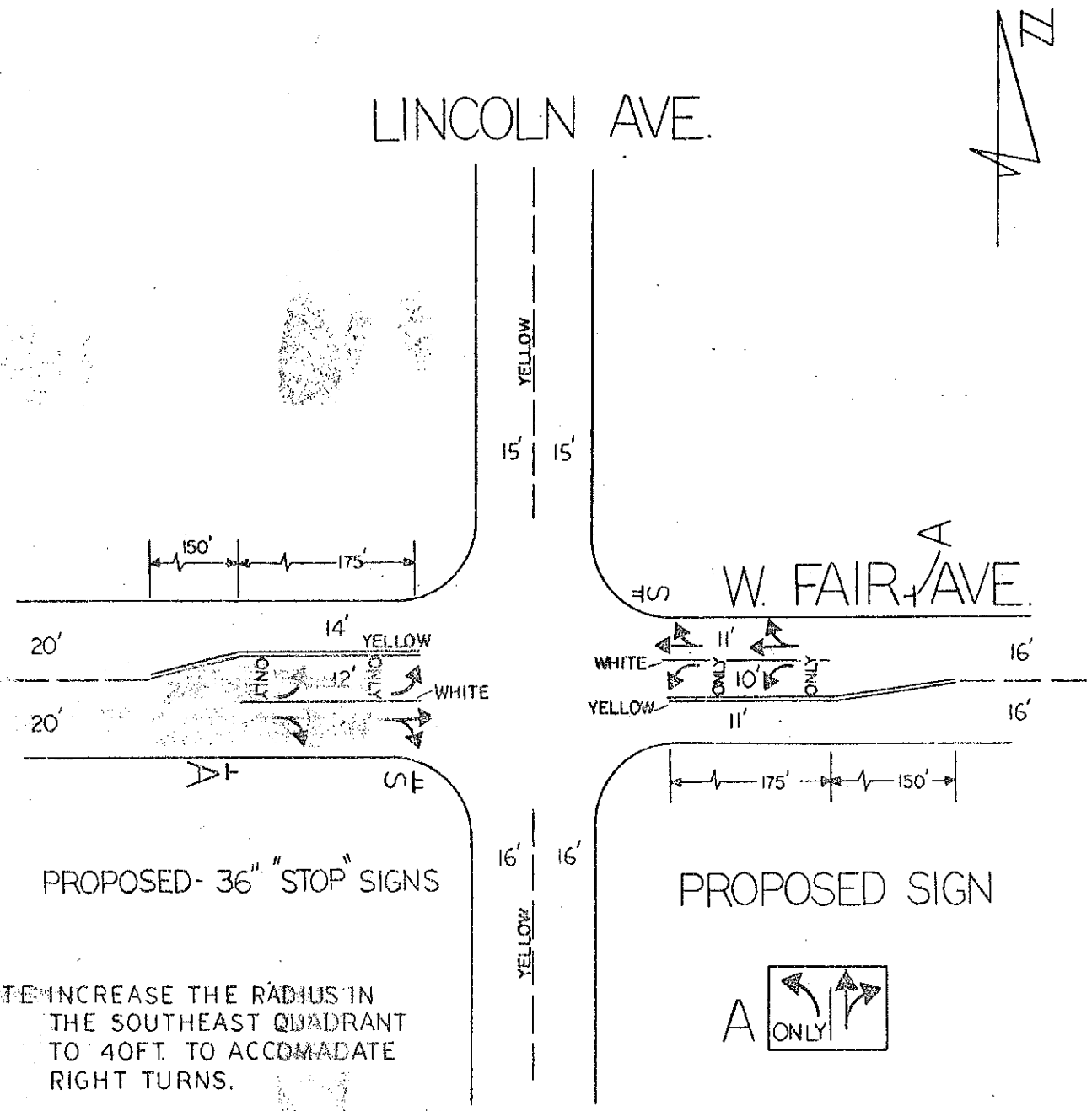
SOUTHBOUND

LINCOLN AVENUE

NORTHBOUND

LINCOLN AVENUE

FIGURE 24



NOTE: INCREASE THE RADIUS IN THE SOUTHEAST QUADRANT TO 40FT. TO ACCOMADATE RIGHT TURNS.

FIGURE 25

STATE OF MICHIGAN DEPARTMENT OF STATE HIGHWAYS TRAFFIC & SAFETY DIVISION	AUTH. NO.	DRAWN D.V.W.	LINCOLN AVE AT W. FAIR AVE. CITY OF MARQUETTE MARQUETTE CO.
	CONT. SEC.	DATE	
	REF.	SCALE 1 40	
	SHEET OF	PLAN LOCATION 6	

LOCATION 7 WRIGHT STREET FROM COUNTY ROAD 550 EAST TO TRACY AVENUE

Total	Property Damage	Injury	Fatal
29	25	4	0

LOCATION 8 THIRD STREET AT BLUFF STREET

Total	Property Damage	Injury	Fatal
28	23	5	0

LOCATION 9 FRONT STREET AT RIDGE STREET

Front Street and Ridge Street form a four-legged intersection with Front Street providing one-way travel northerly. The north leg of Front Street has a 34 ft wide bituminous pavement and the south leg has a 40 ft wide bituminous pavement. Ridge Street, which has a 34 ft wide bituminous pavement, has 24 in. "Stop" signs on the northeast and southwest corners.

There were 28 accidents at this location during the four year study period. Parking, ran-off roadway and turning accidents accounted for 75 percent of the total. Driver carelessness was reportedly involved in a majority of these accidents.

Recommendations

Improper lane usage was involved in six of the accidents at this location. Thus, it is recommended that a broken white lane line be applied on Front Street through the intersection area. This lane line should be carried through the intersection because of the positive gradient that crests at Ridge Street.

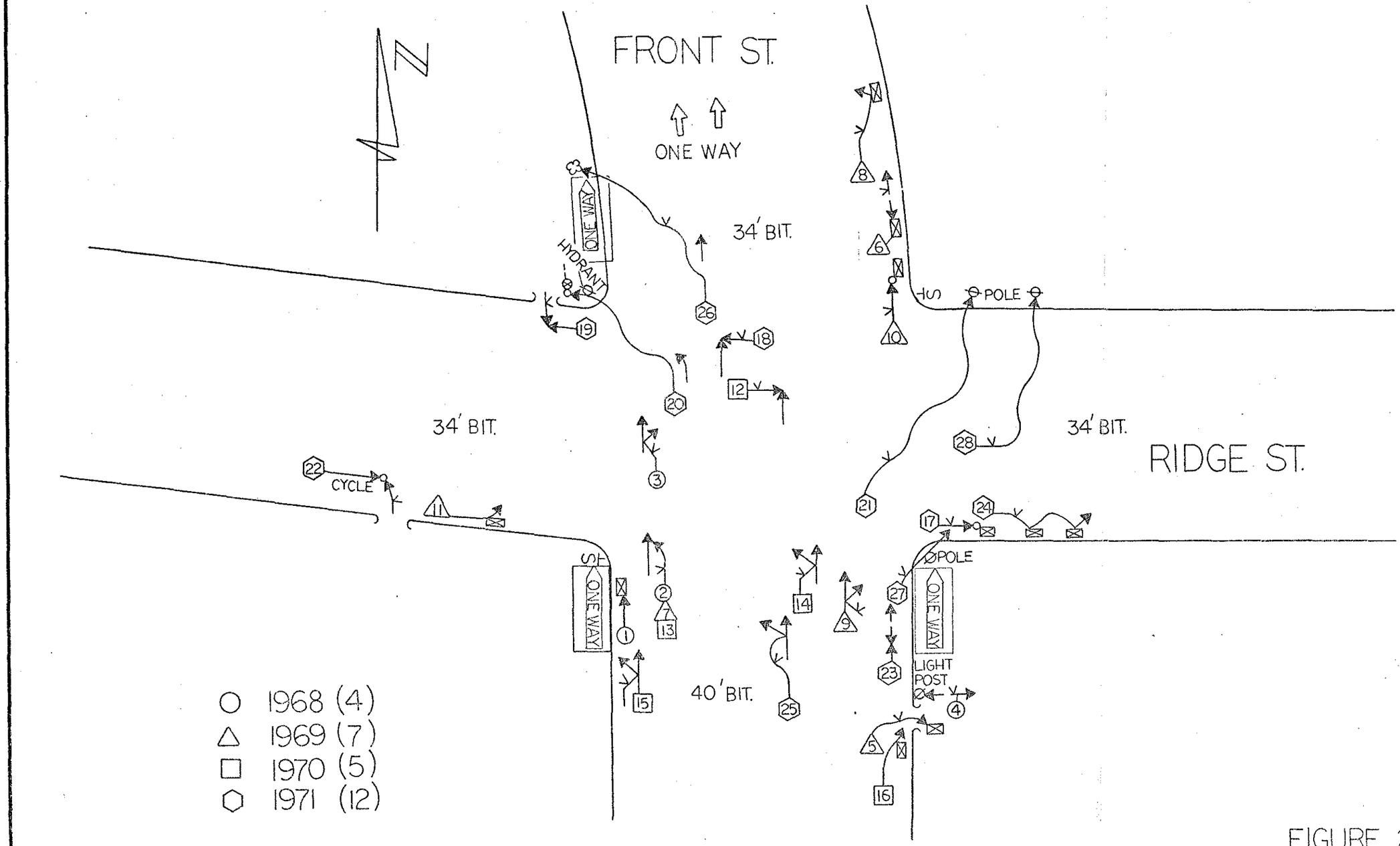


FIGURE 26

LEGEND

Fatal	Out of Control	Pedestrain	Tree
Injury	Driver Intent	Stop & Go Signal	Stop Sign S
Skidding	Deer	Flashing Beacon	Yield Sign Y
Jackknife	Violator		
Overturned	Backing		

Period: 1968 THRU 1971

Accidents – Total 28 P.D. 24

Injury 4 (5) Fatal 0 ( )

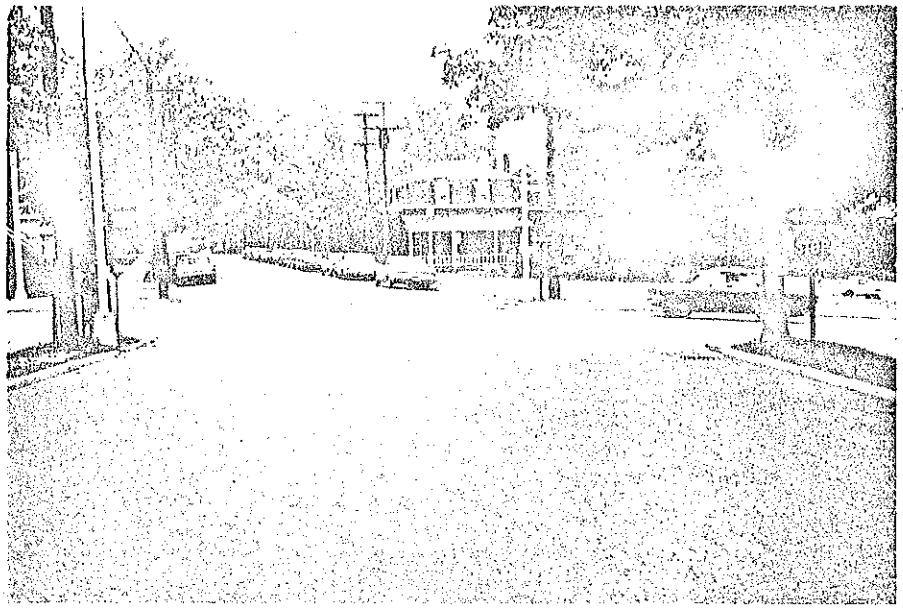
C.S. _____ Miles _____ Drawn DVW

Plan No. LOCATION 9 Date 2-28-73

MICHIGAN DEPARTMENT OF STATE HIGHWAYS
TRAFFIC AND SAFETY DIVISION

Location FRONT ST. at RIDGE ST.
CITY OF MARQUETTE
MARQUETTE CO.

FORM NO. 1547 REV. 5-71

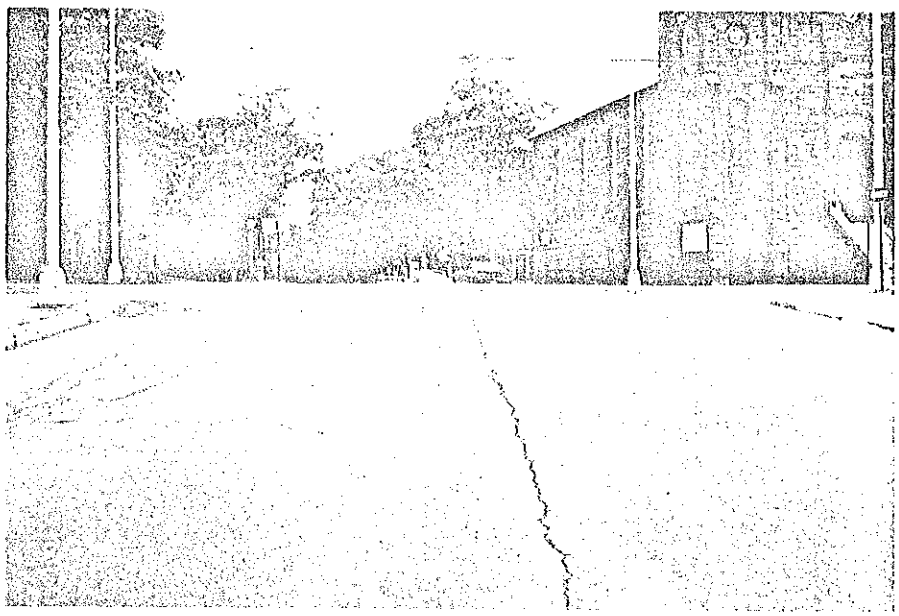


EASTBOUND

RIDGE STREET

NORTHBOUND

FRONT STREET



WESTBOUND

RIDGE STREET

FIGURE 27

LOCATION 10 THIRD STREET AT HEWITT AVENUE

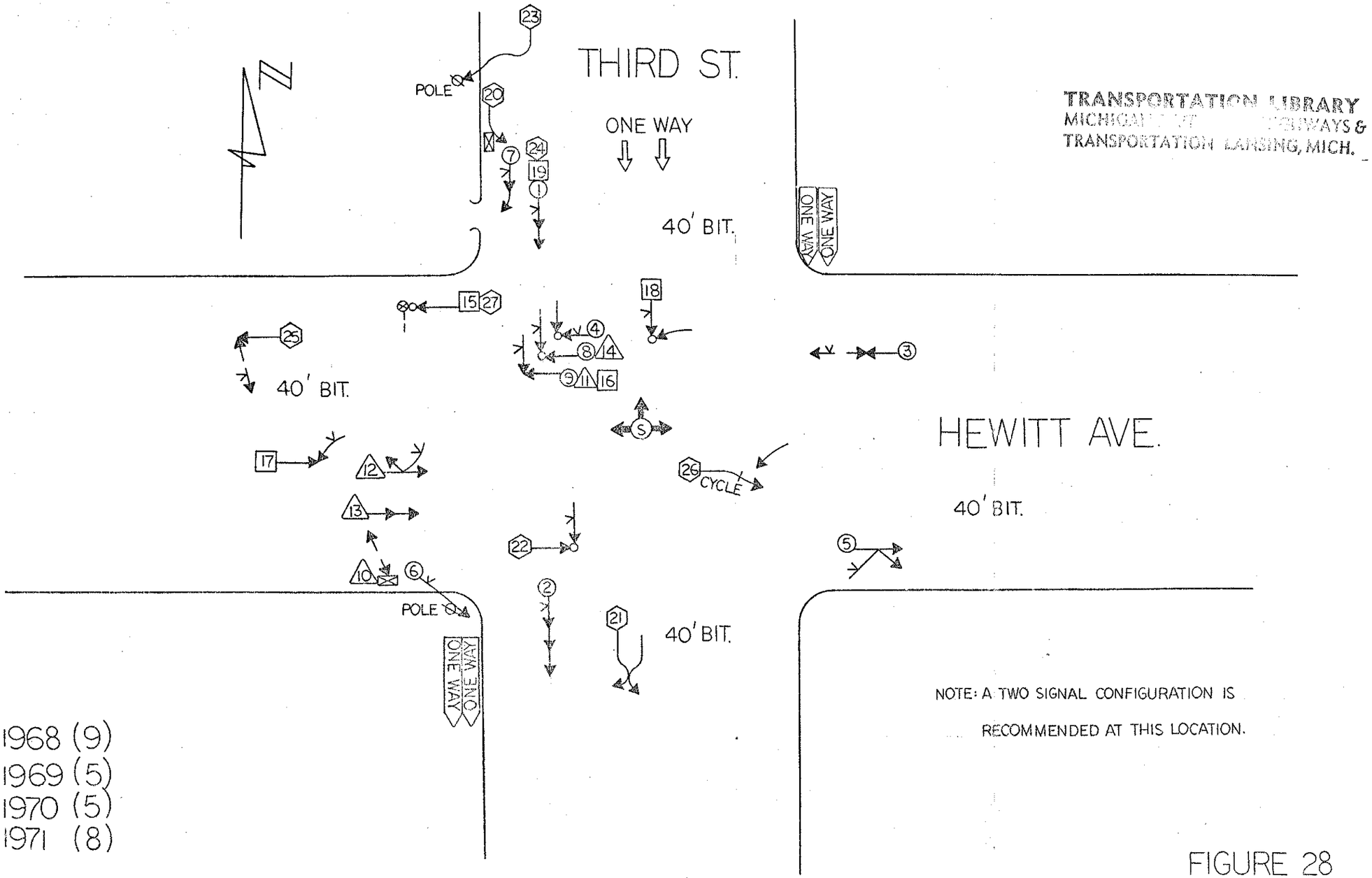
Third Street and Hewitt Avenue form a right angle intersection that is under signal control. The existing signal head, which is suspended over the southeast portion of the intersection, has a 60 second cycle and a five second clearance interval. Third Street, which has a 40 ft wide bituminous pavement, provides one way travel in a southerly direction. Hewitt Avenue, which provides two way travel, has a 40 ft wide bituminous pavement. Parking is permitted except in the immediate intersection area.

There were 27 accidents at this intersection during the four year study period. Right-angle and rear end collisions accounted for 52 percent of the accidents. One of the right-angle accidents occurred when Third Street had the right-of-way and Hewitt Avenue was under stop control. The seven remaining right-angle accidents occurred after the installation of the traffic signal. In all seven of these accidents the violator approached the intersection from the north leg of Third Street. The remaining accidents at this location did not form any distinct pattern.

Recommendations

All seven of the violators involved in the right-angle accidents that occurred after the signal installation indicated that they did not see the signal. The problem involves the unnatural location of the signal over the southeast portion of the intersection instead of the center. To increase the probability that the signal will be seen, it is recommended that a second signal be erected so that it is suspended over the northwest portion of the intersection. The same type of support that is used for the existing signal can be employed to support the proposed signal head. The addition of an extra signal head will provide two signal faces per approach for both roadways.

The existing clearance interval is too long to be very effective. Since the clearance interval should not be longer than 4.5 seconds, it is recommended that a seven percent (4.2 seconds) clearance interval be established.



NOTE: A TWO SIGNAL CONFIGURATION IS RECOMMENDED AT THIS LOCATION.

FIGURE 28

LEGEND

Fatal
Injury
Skidding
Jackknife
Overturned
Out of Control
Driver Intent
Deer
Violator
Backing
Pedestrain
Stop & Go Signal
Flashing Beacon
Tree
Stop Sign S
Yield Sign Y

Period: 1968 THRU 1971
Accidents – Total 27 P.D. 20
Injury 7 (13) Fatal 0 ( )
C.S. Miles Drawn DVW
Plan No. LOCATION 10 Date 2-28-73

MICHIGAN DEPARTMENT OF STATE HIGHWAYS
TRAFFIC AND SAFETY DIVISION

Location THIRD ST. at HEWITT AVE.
CITY OF MARQUETTE
MARQUETTE CO.

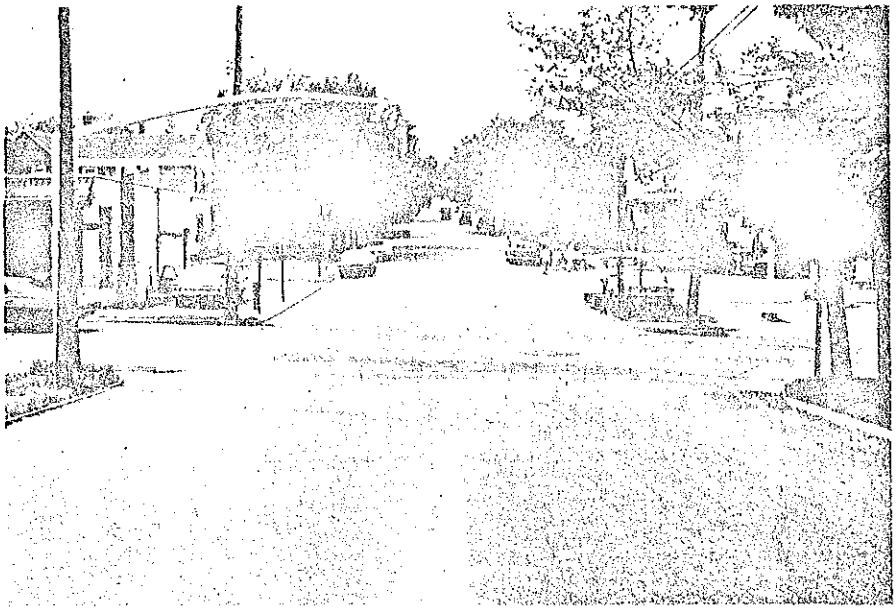
FORM NO. 1547 REV. 5-71

SOUTHBOUND

THIRD STREET

WESTBOUND

HEWITT STREET



EASTBOUND

HEWITT STREET

FIGURE 29

LOCATION 11 COLLEGE AVENUE AT SEVENTH STREET

College Avenue and Seventh Street form a right-angle intersection in a residential area that is under signal control. The existing signal head, which is suspended over the center of the intersection, has a 60 second cycle with a five percent clearance interval.

College Avenue has a 40 ft wide bituminous pavement. The north leg of Seventh Street has a 36 ft wide bituminous pavement while the south leg has a 30 ft wide bituminous pavement. Both roadways have crosswalk markings and parking is not allowed on either street in the immediate intersection area.

There were 26 accidents at this intersection during the four year study period. Almost 57 percent of these accidents occurred on wet, snowy or icy pavement. Right-angle and rear end collisions accounted for 76.9 percent of the accidents. Eleven of the 12 right-angle accidents involved operators who did not stop for either the red signal indication or the red flasher. These operators indicated that they did not see the traffic signal. Five of the eight rear end accidents occurred on snowy or icy pavement. The remaining accidents at this location did not form any distinct pattern.

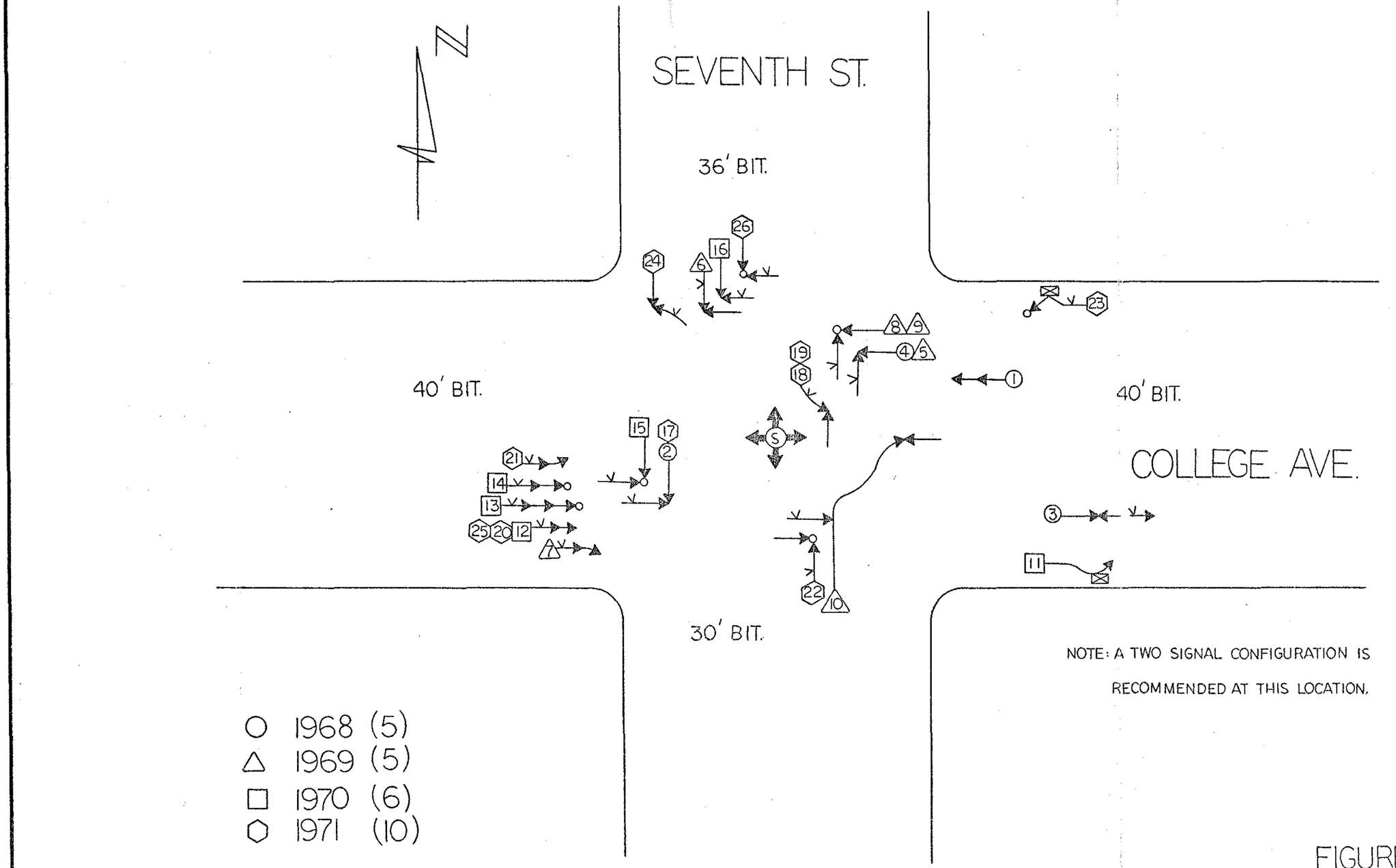
Recommendations

The signals at Seventh Street and College Avenue should be interconnected with the signals at Lincoln Avenue and College Avenue (Location 2) and the signals at Presque Isle Avenue and College Avenue (Location 1). A Time-Space Diagram has been prepared to establish progression through the three intersections (Figure 10, p. 19). At a speed of 27 mph a cycle length of 70 seconds provides College Avenue with the greatest band of green time using the existing cycle split. Thus, it is recommended that a 70 second cycle with a six percent clearance interval (4.2 seconds) be established at this intersection.

The critical problem at this location involves the high number of right-angle accidents. Eleven of the 12 violators involved in the right-angle accidents indicated that they did not see the traffic signal. Thus, it is recommended that a second signal head be installed so that each approach will be provided with two vehicular signal faces.

It is also recommended that College Avenue be divided into three lanes with the center lane for left turns only to provide two lanes for each approach. The center lane should be 12 ft wide and the two outside lanes should each be 14 ft wide. Left turn arrows accompanied by the word "Only" should be applied to the center lane and right turn-through arrows should be applied to the outside

approach lanes. Lane-Use Control signs should be erected at the intersection and in advance of the intersection for both legs of College Avenue. These signs will supplement the pavement markings by better defining the lanes available to the vehicle operators. A detail drawing of these recommendations can be found on p. 54.



○ 1968 (5)
△ 1969 (5)
□ 1970 (6)
⬡ 1971 (10)

NOTE: A TWO SIGNAL CONFIGURATION IS RECOMMENDED AT THIS LOCATION.

FIGURE 30

LEGEND

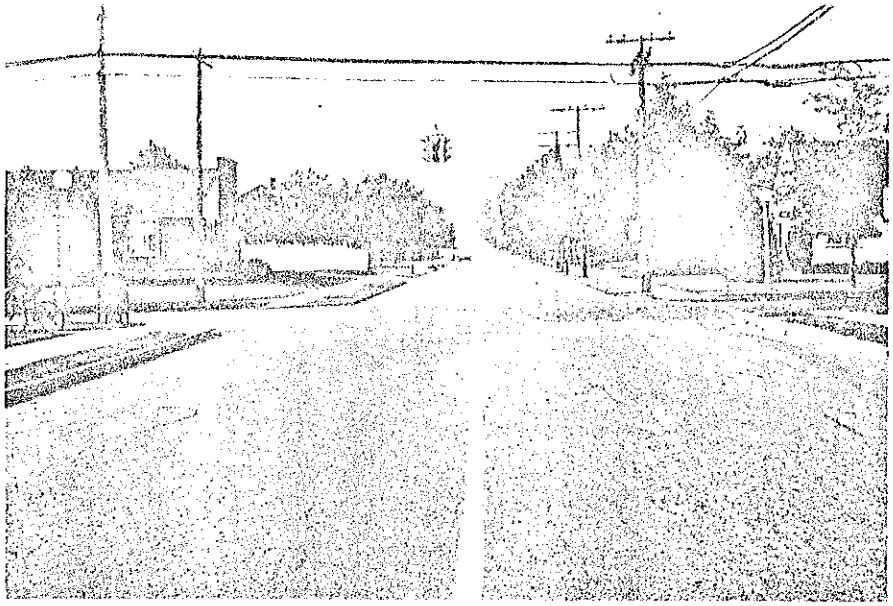
Fatal	Out of Control	Pedestrain	Tree
Injury	Driver Intent	Stop & Go Signal	Stop Sign S
Skidding	Deer	Flashing Beacon	Yield Sign Y
Jackknife	Violator		
Overturned	Backing		

Period: 1968 THRU 1971
Accidents – Total 26 P.D. 18
Injury 8 (12) Fatal 0 ( )
C.S. ____ Miles ____ Drawn DVW
Plan No. LOCATION II Date 2-28-73

MICHIGAN DEPARTMENT OF STATE HIGHWAYS
TRAFFIC AND SAFETY DIVISION

Location COLLEGE AVE. at SEVENTH ST.
CITY OF MARQUETTE
MARQUETTE CO.

FORM NO. 1547 REV. 5-71

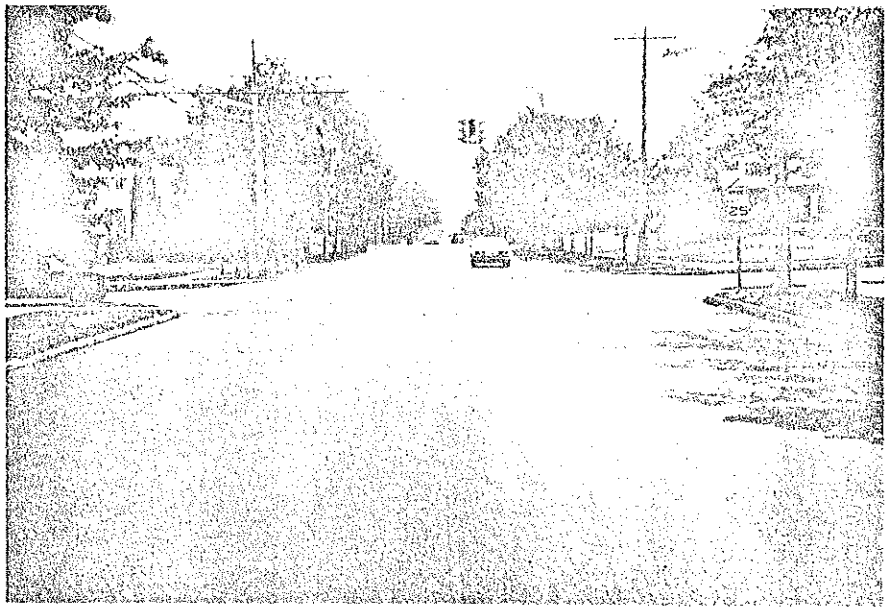


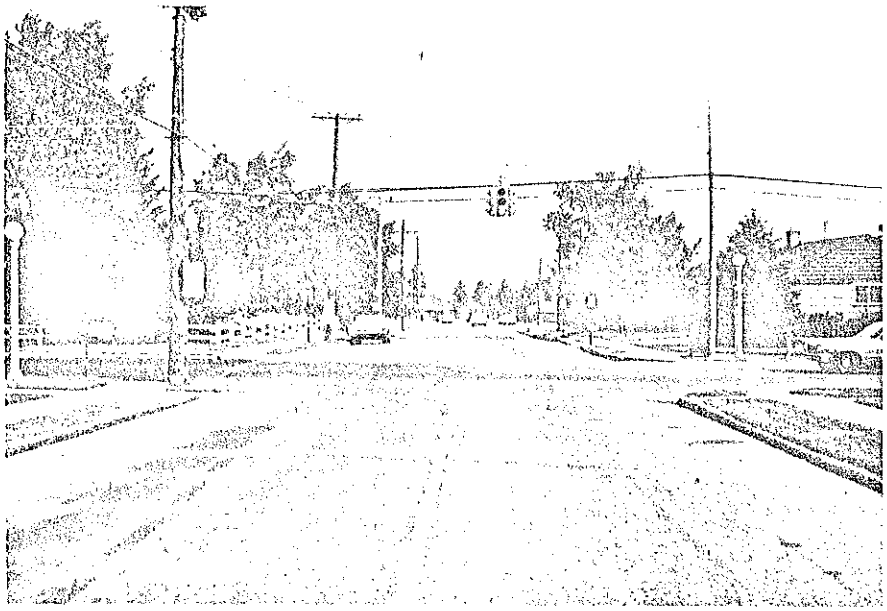
SOUTHBOUND

SEVENTH STREET

EASTBOUND

COLLEGE AVENUE





NORTHBOUND

SEVENTH STREET

FIGURE 31

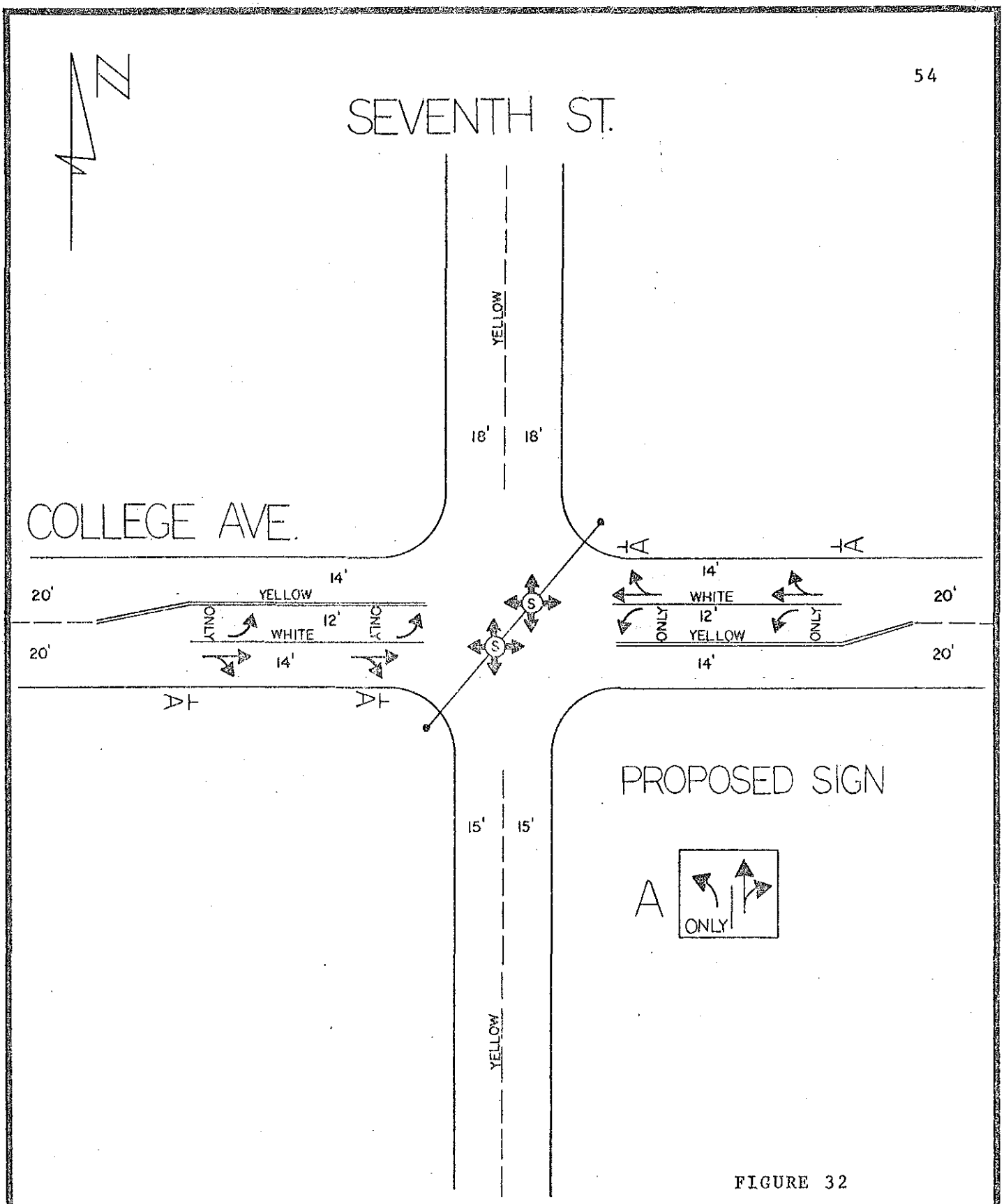


FIGURE 32

STATE OF MICHIGAN DEPARTMENT OF STATE HIGHWAYS TRAFFIC & SAFETY DIVISION	AUTH. NO.	DRAWN DVW	COLLEGE AVE. at SEVENTH ST.
	CONT. SEC.	DATE 7-12-74	
	REF.	SCALE 1"=40'	CITY OF MARQUETTE
	SHEET OF	PLAN LOCATION 11	MARQUETTE CO.

LOCATION 12 MAIN STREET AT THIRD STREET

Main Street and Third Street form a "T" intersection in the Central Business District. Third Street traffic has the right-of-way while Main Street traffic is controlled by a 24 in. "Stop" sign.

Third Street, which is a one-way street in the southerly direction, has a 44 ft wide bituminous pavement. Main Street has a 90 ft wide bituminous pavement with a narrow median separating east and westbound traffic. On westbound Main Street the north side has parallel parking and the median side has 45 degree angle parking. On eastbound Main Street the south side has 90 degree angle parking and the median side has parallel parking.

There were 26 accidents at this location during the four year study period. Fifty percent of these accidents occurred on wet, snowy or icy pavement. The largest accident type involved parking accidents. Seven of the 15 parking accidents occurred on the north half of Main Street and eight occurred on the south half.

Recommendations

The south side of eastbound Main Street has 90 degree angle parking. Vehicles leaving these parking stalls are striking the parallel parked vehicles located along the north side of eastbound Main Street. To alleviate this problem it is recommended that the 90 degree angle parking be changed to 45 degree angle parking. Reduction of the parking angle will provide greater maneuverability for vehicles leaving the parking area. If the parallel parked vehicles continue to be hit in the future it is recommended that the parallel parking be removed.

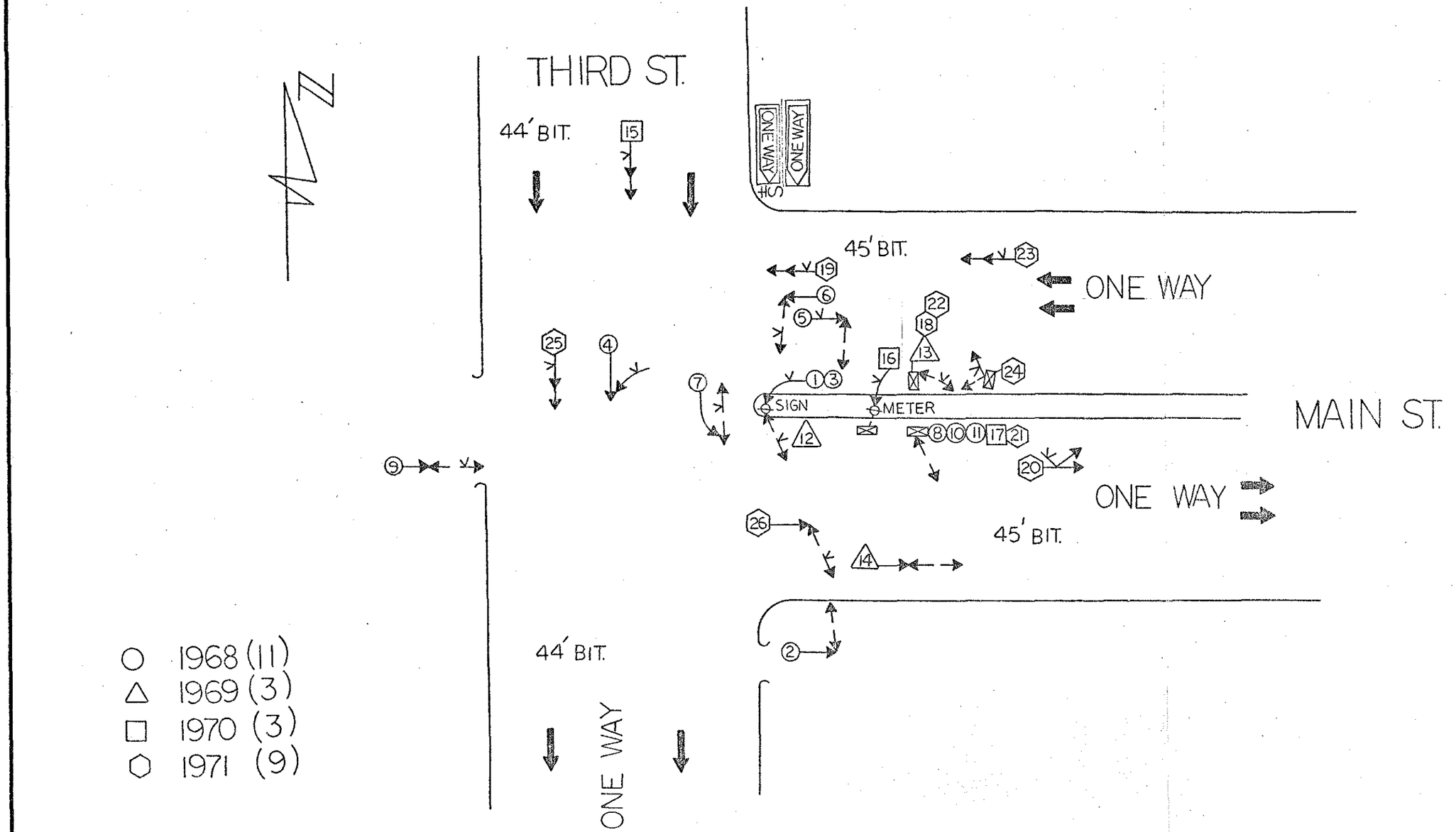


FIGURE 33

LEGEND

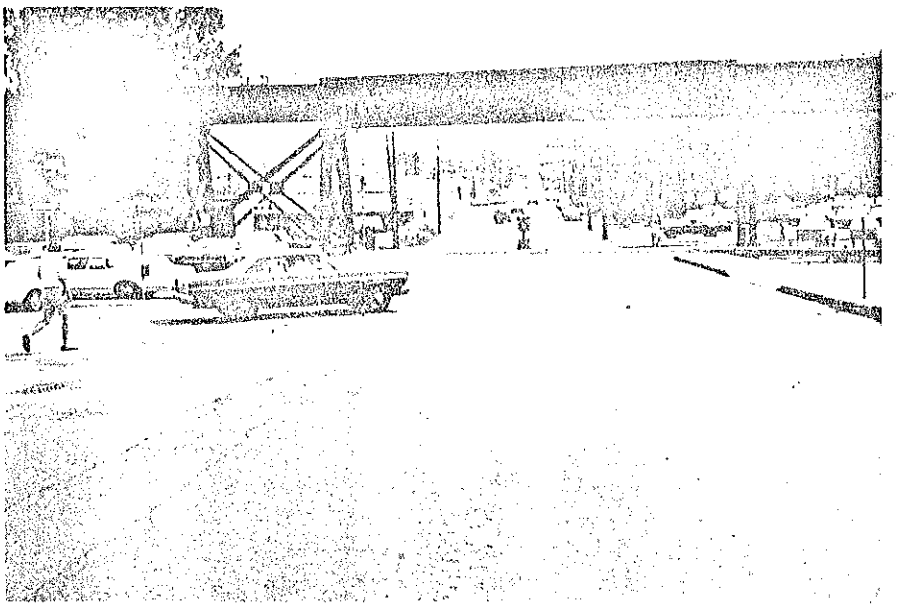
Fatal
Injury
Skidding
Jackknife
Overturned
Out of Control
Driver Intent
Deer
Violator
Backing
Pedestrain
Stop & Go Signal
Flashing Beacon
Tree
Stop Sign S
Yield Sign Y

Period: 1968 THRU 1971
Accidents – Total 26 P.D. 26
Injury 0 ( ) Fatal 0 ( )
C.S. ____ Miles ____ Drawn DVW
Plan No. LOCATION 12 Date 2-28-73

MICHIGAN DEPARTMENT OF STATE HIGHWAYS
TRAFFIC AND SAFETY DIVISION

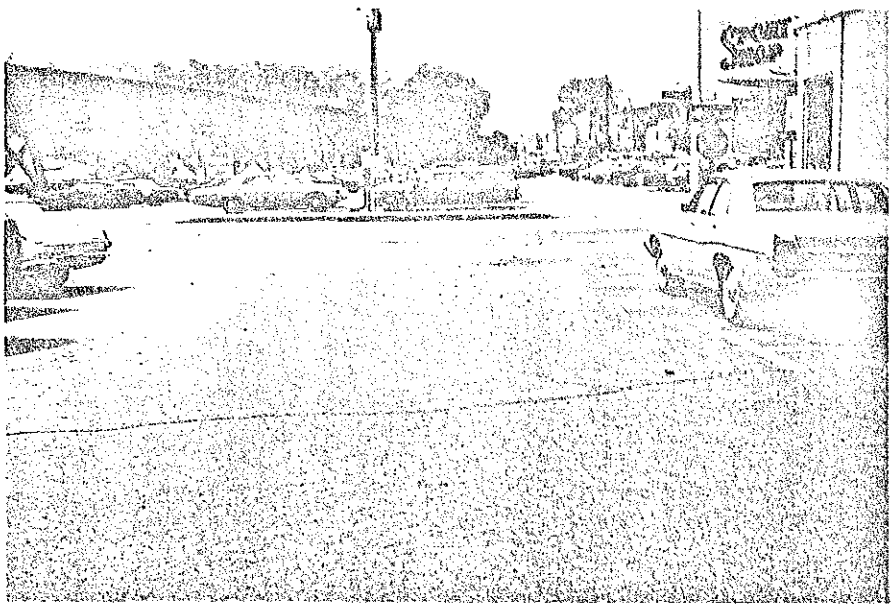
Location MAIN ST. at THIRD ST.
CITY OF MARQUETTE
MARQUETTE CO.

FORM NO. 1547 REV. 5-71



SOUTHBOUND

THIRD STREET



WESTBOUND

MAIN STREET

(ONE WAY WEST)

EASTBOUND

MAIN STREET

FACING WEST

FIGURE 34

LOCATION 13 NORTH FRONT STREET AT BLUFF STREET

Total	Property Damage	Injury	Fatal
24	20	4	0

LOCATION 14 COUNTY ROAD 553 (F.A.S. 323) AT PIONEER ROAD AND DIVISION STREET

County Road 553 forms a "Y" intersection with Pioneer Road and Division Street. County Road 553 joins the other two roadways at a skew. Northbound County Road 553 has a 36 in. "Stop" sign and eastbound Pioneer Road has a 24 in. "Stop" sign. County Road 553 and Division Street have two lane, 22 ft wide bituminous pavements while Pioneer Road has a two lane, 20 ft wide bituminous pavement.

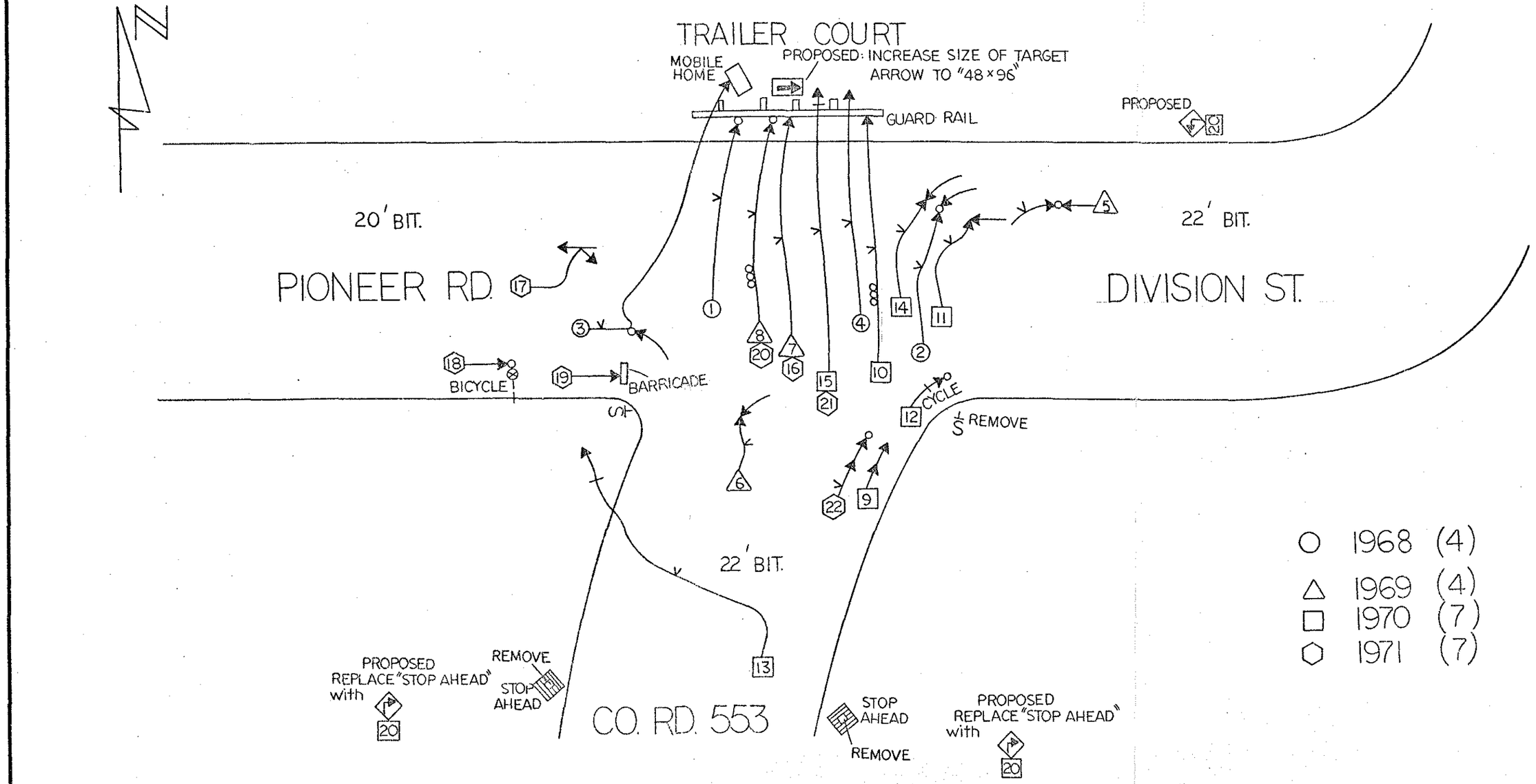
There were 22 accidents at this location during the four year study period. Fifty percent of these accidents occurred on icy pavement. There were 10 ran-off roadway and five right-angle accidents at this intersection. Five of the 10 ran-off roadway accidents and four of the five right-angle accidents occurred on icy pavement.

Recommendations

Nine of the 10 ran-off roadway accidents involved vehicles that ran through the "Stop" sign on County Road 553, striking the guardrail located on the north side of the intersection. All five right-angle accidents involved vehicles that skidded by the "Stop" sign on County Road 553, striking a westbound Division Street vehicle. In 11 of these 15 accidents excessive speed was reportedly a major factor. It is apparent that the transition from a speed of 65 mph to a stop condition has been difficult for these operators to negotiate. Since the major movement of traffic is from County Road 553 to Division Street and vice versa it is recommended that the "Stop" sign on County Road 553 be removed. It is also recommended that 36 in. Turn signs with accompanying 20 mph advisory speed panels be erected for both sides of northbound County Road 553 and the north side of westbound Division Street. The 20 mph advisory speed was selected on the basis of Devil Level readings taken at this intersection. The Turn signs and speed panels for County Road 553 should be erected on the existing lattice background in place of the "Stop Ahead" signs. The existing 24 in. x 48 in. target arrow located at the end of County Road 553 should be replaced by a 48 in. x 96 in. target arrow.

The removal of the "Stop" sign and the addition of Turn signs and advisory speed panels should reduce the ran-off roadway accidents.

However, if these accidents continue in the future, the radius for the curve would have to be increased to enable motor vehicles to travel at a higher speed. The radius could be increased by moving County Road 553 so that it intersects Division Street east of the present intersection. A larger radius would enable the advisory speed to be increased so that there is less of a transition from the posted speed limit to the safe speed for the curve.



○ 1968 (4)
△ 1969 (4)
□ 1970 (7)
⬡ 1971 (7)

FIGURE 35

LEGEND

Fatal	Out of Control	Pedestrain	Tree
Injury	Driver Intent	Stop & Go Signal	Stop Sign S
Skidding	Deer	Flashing Beacon	Yield Sign Y
Jackknife	Violator		
Overturned	Backing		

Period: 1968 THRU 1971

Accidents – Total 22 P.D. 13

Injury 9 (16) Fatal 0 ( )

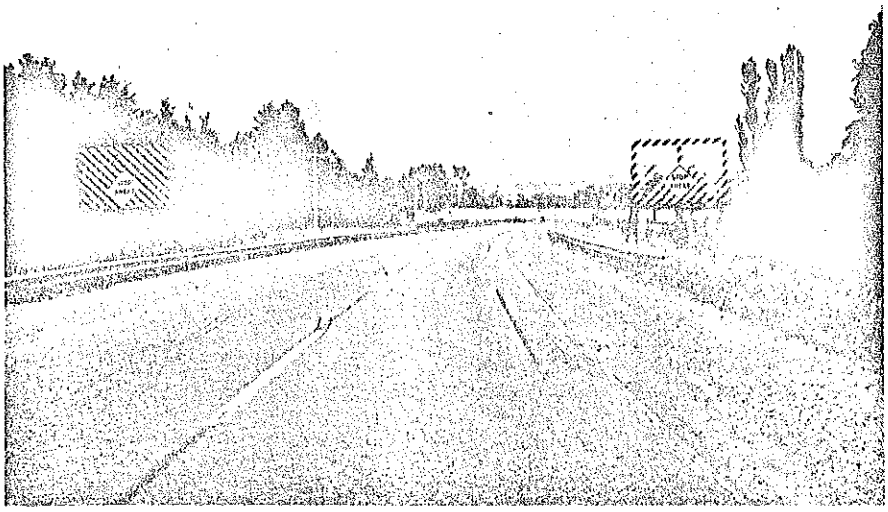
C.S. _____ Miles _____ Drawn DVW

Plan No. LOCATION 14 Date 2-28-73

MICHIGAN DEPARTMENT OF STATE HIGHWAYS
TRAFFIC AND SAFETY DIVISION

Location
CO. RD. 553 at PIONEER RD., DIVISION ST.
CITY OF MARQUETTE
MARQUETTE CO.

FORM NO. 1547 REV. 5-71

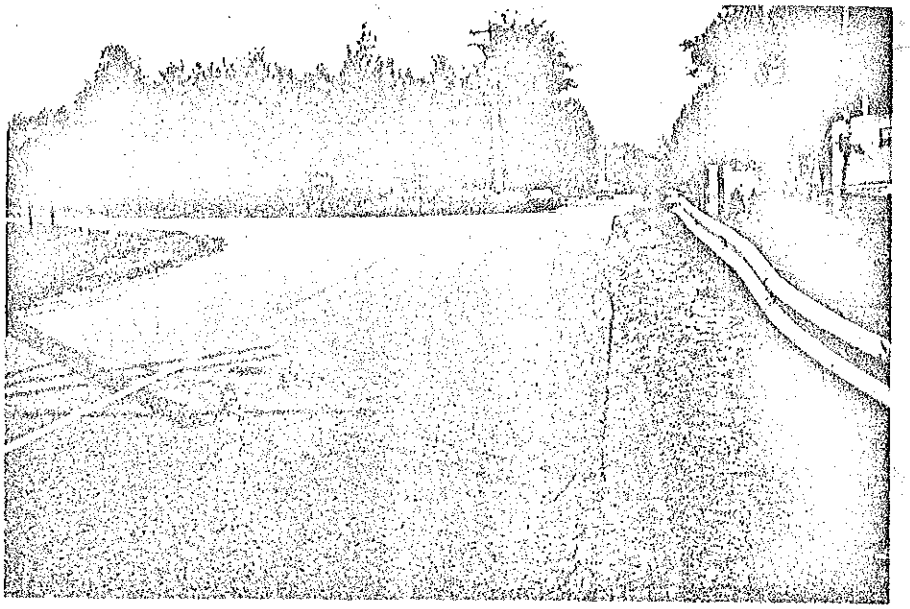


NORTHBOUND CO. RD. 553

APPROACHING THE INTERSECTION

NORTHBOUND CO. RD. 553

FIGURE 36



WESTBOUND

DIVISION STREET

EASTBOUND

PIONEER ROAD

FIGURE 37

LOCATION 15 THIRD STREET AT BARAGA AVENUE

Third Street and Baraga Avenue form a four legged intersection with Third Street having the right-of-way. Baraga Avenue has 24 in. "Stop" signs controlling east and westbound traffic.

Third Street, which provides one way travel in a southerly direction, has a 45 ft wide bituminous pavement. The east leg of Baraga Avenue has a 76 ft wide bituminous pavement while the west leg has a 60 ft wide bituminous pavement.

There were 21 accidents at this location during the four year study period. Almost 67 percent of these accidents occurred on wet or icy pavement. Right-angle collisions accounted for 71.4 percent of the accidents. The remaining accidents at this location did not form any distinct pattern.

Recommendations

The critical problem at this location involves the occurrence of right-angle collisions. There were 15 right-angle accidents during the four year study period from 1968-1971 and 31 right-angle accidents during the six year period from 1966-1971. Eleven of the 15 right-angle accidents during the study period involved operators who reportedly did not see the stop signs. Thus, it is recommended that the existing 24 in. "Stop" signs be replaced by 36 in. signs. Furthermore, it is recommended that a flasher with a 12 in. lens be erected over the center of the intersection to give greater emphasis to the required stop at Third Street. An illuminated case sign reading "Stop" for Baraga Avenue should be suspended from the flasher.

The Manual indicates that only one additional sign shall be displayed with a "Stop" sign and it shall be either a Street Name sign, a One-Way sign or a sign that restricts a turning movement. Thus, it is recommended that the existing "No Right Turn" sign be excluded from the proposed 36 in. "Stop" sign on the northeast corner. Only the existing "One-Way" arrows can be retained on the proposed 36 in. "Stop" signs.

Third Street has a partial solid white lane line on the north leg. The Michigan Manual indicates that lane lines should be a broken white line. Thus, it is recommended that a broken white lane line be applied throughout the entire length of Third Street. Also, yellow center line markings should be applied on Baraga Avenue to give each operator an indication of the available pavement width for his direction of travel.

Thirty-eight percent of the accidents at this location occurred on wet pavement. Taken as a percentage of the wet and dry accidents only the percentage of wet accidents increases to almost 53. These figures indicate that the pavement at this intersection becomes slippery when wet. For this reason it is recommended that skidometer tests be conducted.

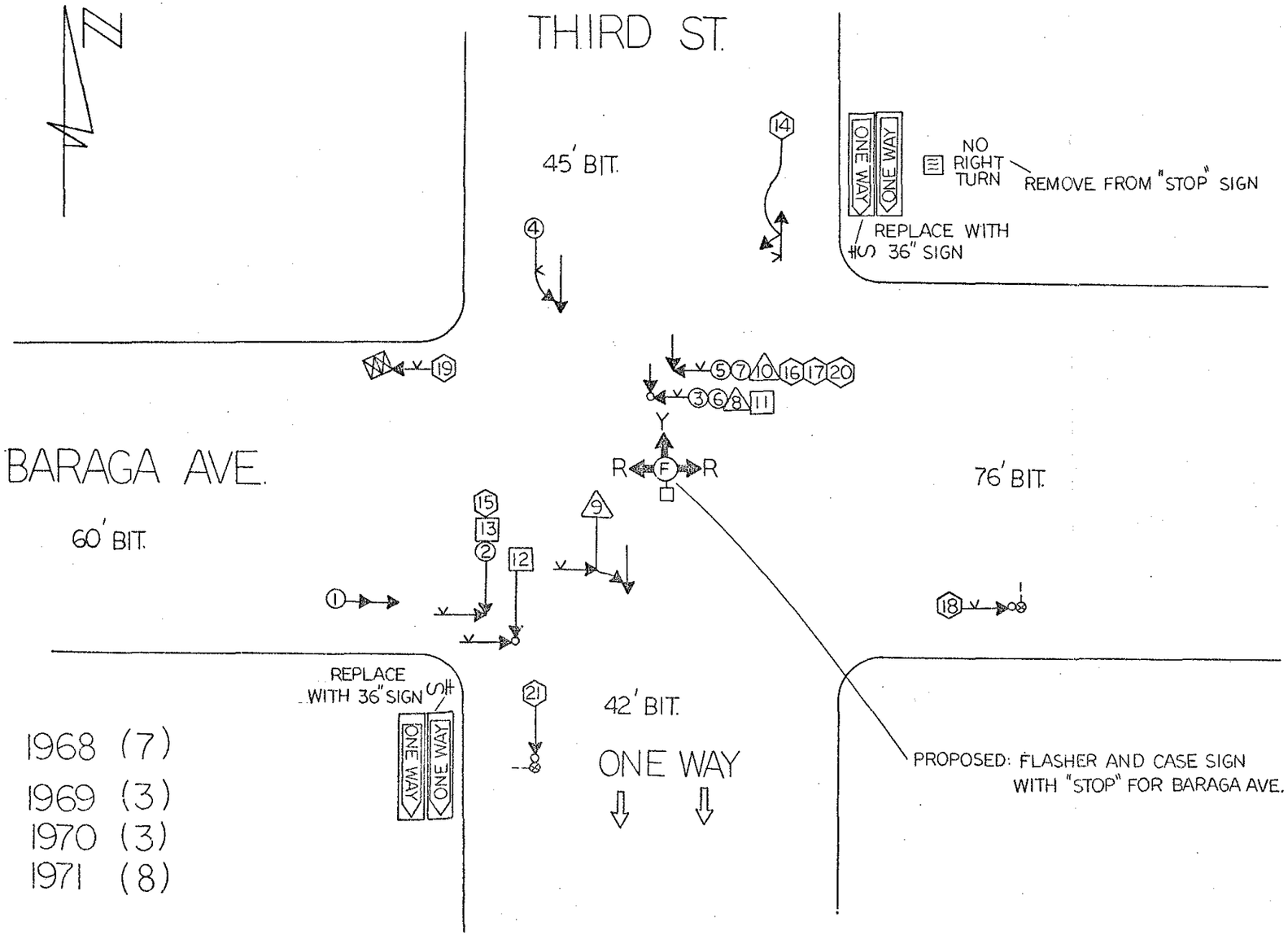


FIGURE 38

LEGEND

Fatal	Out of Control	Pedestrain	Tree
Injury	Driver Intent		
Skidding	Deer	Stop & Go Signal	Stop Sign S
Jackknife	Violator		
Overturned	Backing	Flashing Beacon	Yield Sign Y

Period: 1968 THRU 1971

Accidents – Total 21 P.D. 14

Injury 7 (8) Fatal 0 ( )

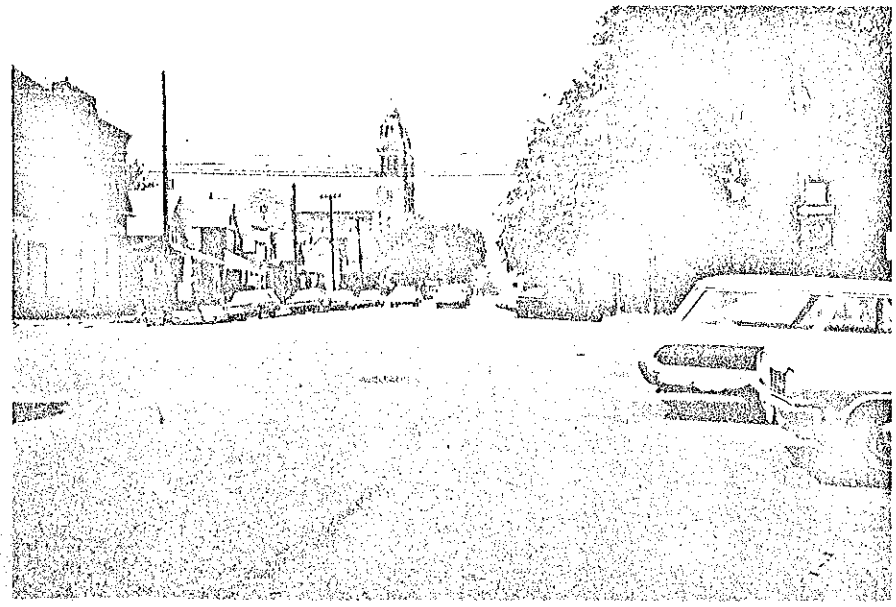
C.S. _____ Miles _____ Drawn DVW

Plan No. LOCATION 15 Date 2-28-73

MICHIGAN DEPARTMENT OF STATE HIGHWAYS
TRAFFIC AND SAFETY DIVISION

Location THIRD ST. at BARAGA AVE.
CITY OF MARQUETTE
MARQUETTE CO.

FORM NO. 1547 REV. 5-71



WESTBOUND

BARAGA AVENUE

SOUTHBOUND

THIRD STREET

EASTBOUND

BARAGA AVENUE

FIGURE 39

LOCATION 16 PINE STREET AT HEWITT AVENUE

Pine Street and Hewitt Avenue form a four-legged intersection in a residential area. Pine Street, which has the right-of-way, is a two lane, 26 ft wide bituminous roadway south of Hewitt Avenue and a 28 ft wide bituminous roadway north of Hewitt Avenue. Twenty-four in. "Stop" signs control traffic on Hewitt Avenue, which has a 40 ft wide bituminous pavement.

There were 19 accidents at this location during the four year study period. Almost 74 percent of these accidents involved right-angle collisions. The remaining accidents at this location did not form any distinct pattern.

Recommendations

Nine of the operators involved in the right-angle accidents indicated that they did not see the "Stop" signs. For this reason it is recommended that the existing 24 in. "Stop" signs be replaced by 36 in. signs.

To ensure that the larger "Stop" signs will be seen, it is recommended that parking on Hewitt Avenue be prohibited a distance of 75 ft from both the northeast and southwest corners. Also, the trees that hang over the roadway should be kept trimmed and the large bush located in front of the "Stop" sign on the northeast corner should be removed.

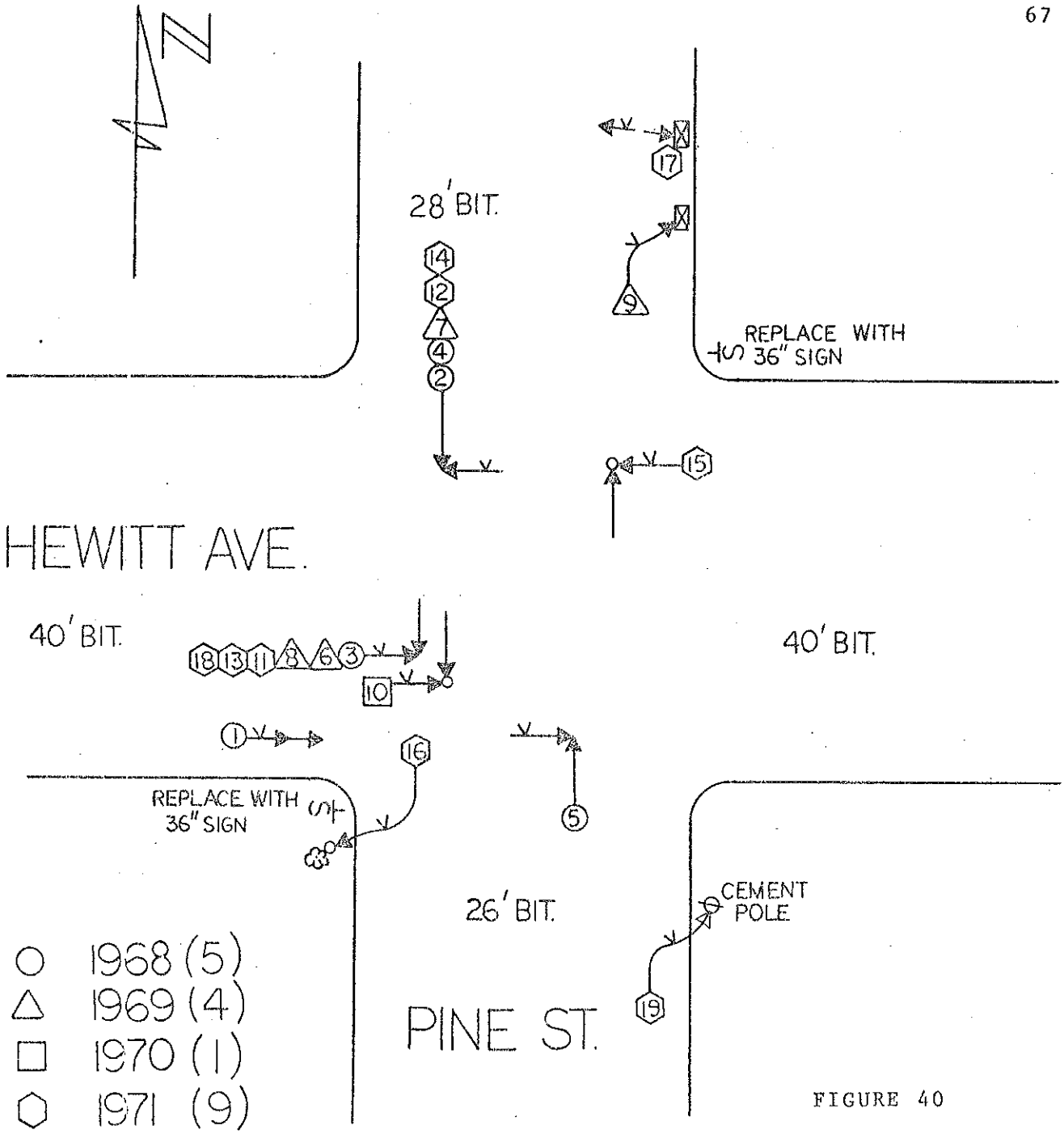


FIGURE 40

LEGEND	MICHIGAN DEPARTMENT OF STATE HIGHWAYS TRAFFIC AND SAFETY DIVISION
Stop & Go Signal (S, R, Y, F, Y) — Stop Sign S Flashing Beacon — Yield Sign Y	Location PINE ST. at HEWITT AVE. CITY OF MARQUETTE MARQUETTE CO.
Fatal Injury Skidding Jackknife Overturned Backing Pedestrian (X) Tree Out of Control Driver Intent Deer (V) Violator	Period: 1968 THRU 1971 Accidents – Total 19 P.D. 16 Injury 3 (4) Fatal 0 ( ) C.S. ____ Miles ____ Drawn DVW Plan No. LOCATION 16 Date 2-28-73

EASTBOUND

HEWITT AVENUE

SOUTHBOUND

PINE STREET

WESTBOUND

HEWITT AVENUE

FIGURE 41

LOCATION 17 THIRD STREET AT MICHIGAN STREET

Total	Property Damage	Injury	Fatal
18	16	2	0

LOCATION 18 THIRD STREET AT COLLEGE AVENUE

Third Street and College Avenue form a four-legged intersection with Third Street having the right-of-way. Third Street, which is a one-way road in the southerly direction, has a two-lane, 38 ft wide bituminous pavement. Twenty-four in. "Stop" signs control traffic on College Avenue which has a two lane, 24 ft wide bituminous pavement.

There were 18 accidents at this location during the four year study period. Right-angle accidents accounted for the largest total with eight. The remaining accidents did not form any distinct patterns.

Recommendations

Four of the eight violators involved in the right-angle accidents indicated that they did not see any vehicles on Third Street. The sight distance from College Avenue is poor due to parked cars on Third Street. For this reason it is recommended that the parking on Third Street be removed a distance of 75 ft from the northeast and northwest corners.

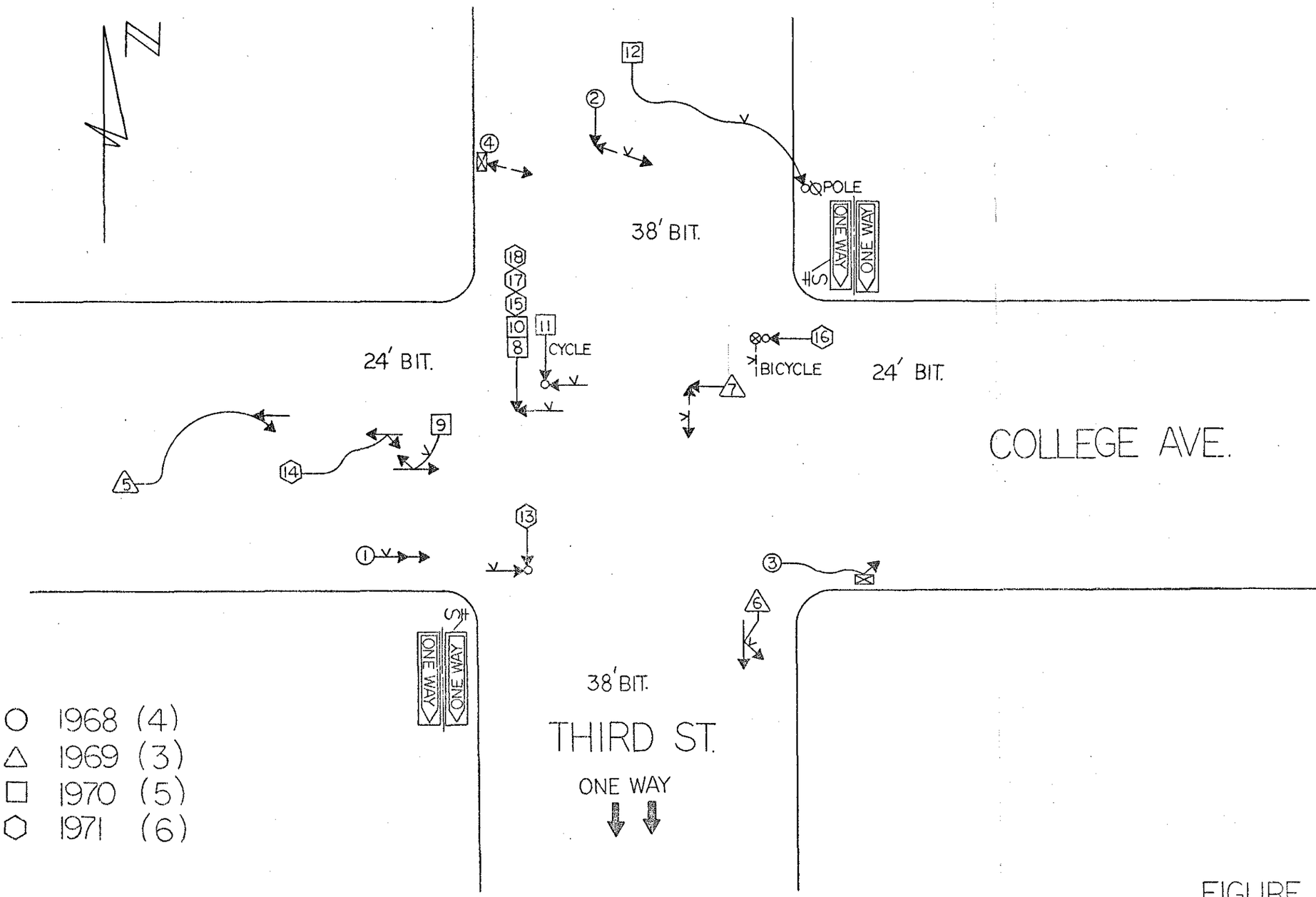


FIGURE 42

LEGEND

Fatal	Out of Control	Pedestrain		Tree	
Injury	Driver Intent				
Skidding	Deer	Stop & Go Signal		Stop Sign	S
Jackknife	Violator				
Overturned	Backing	Flashing Beacon		Yield Sign	Y

Period: 1968 THRU 1971

Accidents – Total 18 P.D. 14

Injury 4 (4) Fatal 0 ( )

C.S. _____ Miles _____ Drawn D/W

Plan No. LOCATION 18 Date 2-28-73

MICHIGAN DEPARTMENT OF STATE HIGHWAYS
TRAFFIC AND SAFETY DIVISION

Location THIRD ST. at COLLEGE AVE.
CITY OF MARQUETTE
MARQUETTE CO.

FORM NO. 1547 REV. 5-71

EASTBOUND

COLLEGE AVENUE

SOUTHBOUND

THIRD STREET

WESTBOUND

COLLEGE AVENUE

FIGURE 43

LOCATION 19 FOURTH STREET AT HEWITT AVENUE

Total	Property Damage	Injury	Fatal
18	12	6	0

LOCATION 20 THIRD STREET AT SPRING STREET

Total	Property Damage	Injury	Fatal
17	12	5	0

LOCATION 21 THIRD STREET AT CRESCENT STREET

Total	Property Damage	Injury	Fatal
15	14	1	0

LOCATION 22 THIRD STREET AT MAGNETIC STREET

Total	Property Damage	Injury	Fatal
15	11	4	0

LOCATION 23 PRESQUE ISLE AVENUE AT WRIGHT STREET

Presque Isle Avenue and Wright Street form a four-legged intersection that is under flasher control. The north leg of Presque Isle Avenue has a 35 ft wide bituminous pavement while the south leg has a 47 ft wide bituminous pavement. The west leg of Wright Street has a 25 ft wide bituminous pavement while the east leg has a 30 ft wide bituminous pavement. Parking is prohibited on both sides of the west leg of Wright Street.

There were 14 accidents during the four year study period. Seventy-one percent of these accidents occurred on wet, snowy or icy pavement. The most prevalent accident type involved right-angle collisions. However, six of the seven right-angle accidents occurred during inclement weather.

Recommendations

Almost 43 percent of the accidents at this location occurred on wet pavement. For this reason it is recommended that skidometer tests be conducted. Due to the apparent deterioration in the pavement, resurfacing may prove to be necessary.

There is no stop sign for the east leg of Wright Street. It is recommended that a 24 in. "Stop" sign be erected on the northeast corner to accompany the flasher signal.

The flasher head at this intersection is painted green. To obtain the best possible contrast with the visual background, it is desirable to paint signal head housings highway yellow. The inside of visors (hoods) and the entire surface of louvers, fins and the front surface of backplates shall have a dull black finish to minimize light reflection to the side of the flasher. It is recommended that these paint guidelines be followed at this intersection.

Also, there are no pavement markings at this intersection. It is recommended that both legs of Presque Isle Avenue and both legs of Wright Street have the center line applied.

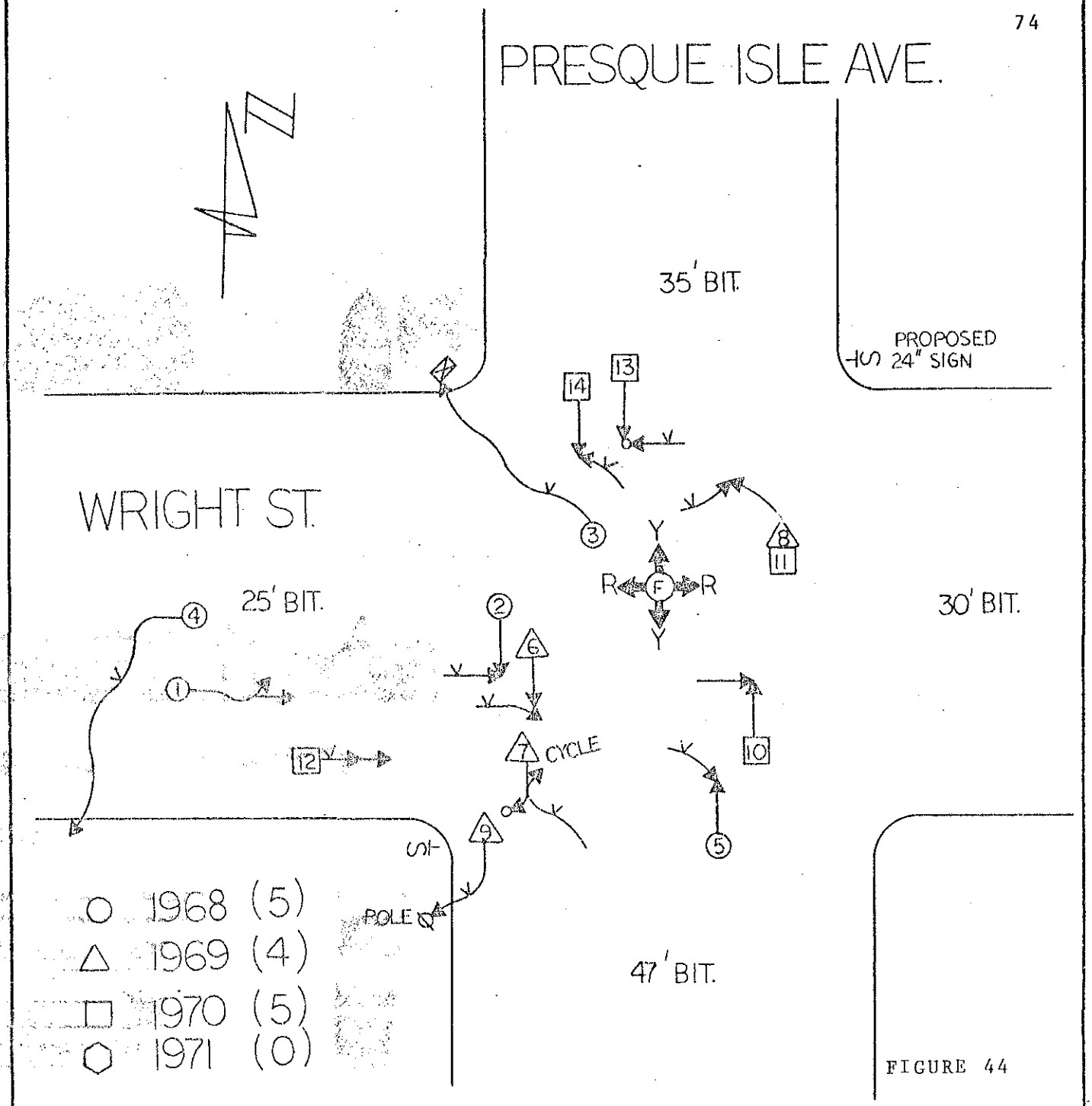
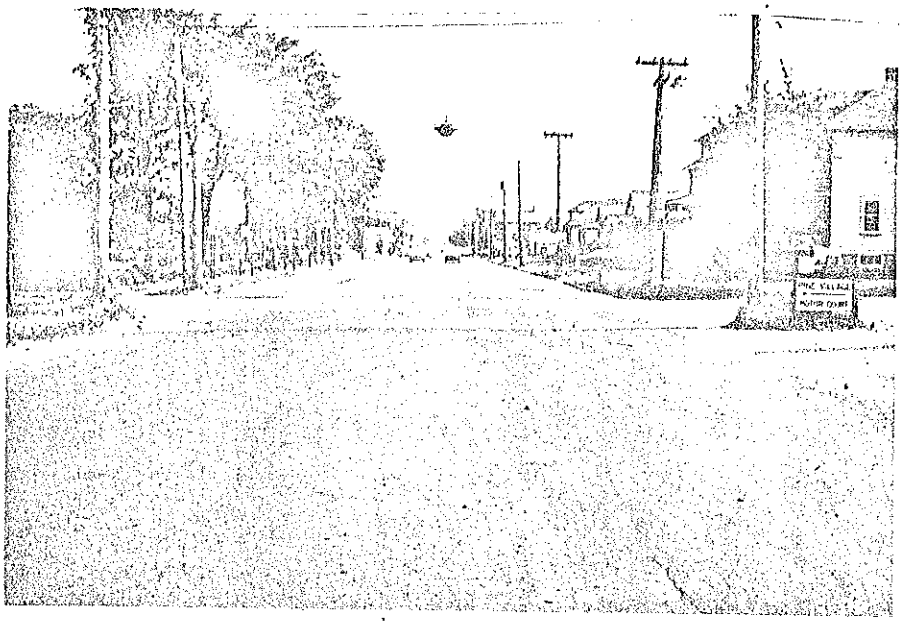


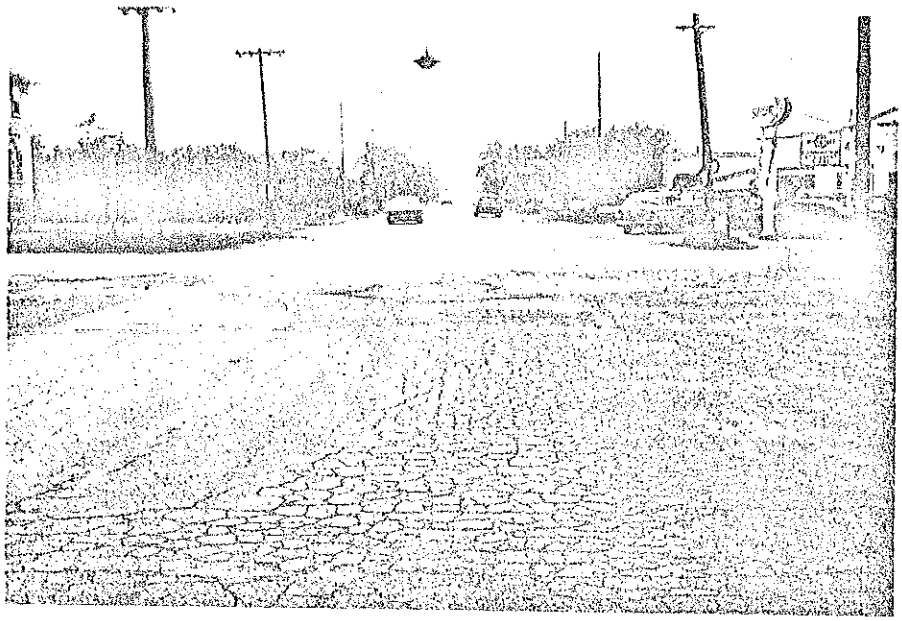
FIGURE 44

LEGEND	MICHIGAN DEPARTMENT OF STATE HIGHWAYS TRAFFIC AND SAFETY DIVISION
Stop & Go Signal (S, R, Y, F) — Stop Sign S Flashing Beacon — Yield Sign Y	Location PRESQUE ISLE AVE. at WRIGHT ST. CITY OF MARQUETTE MARQUETTE CO.
Fatal Injury Skidding Jackknife Overturned Backing Pedestrian (X) Tree Out of Control Driver Intent Deer Violator (V)	Period: 1968 THRU 1971 Accidents – Total 14 P.D. 12 Injury 2 (2) Fatal 0 ( ) C.S. ____ Miles ____ Drawn DVW Plan No. LOCATION 23 Date 2-28-73



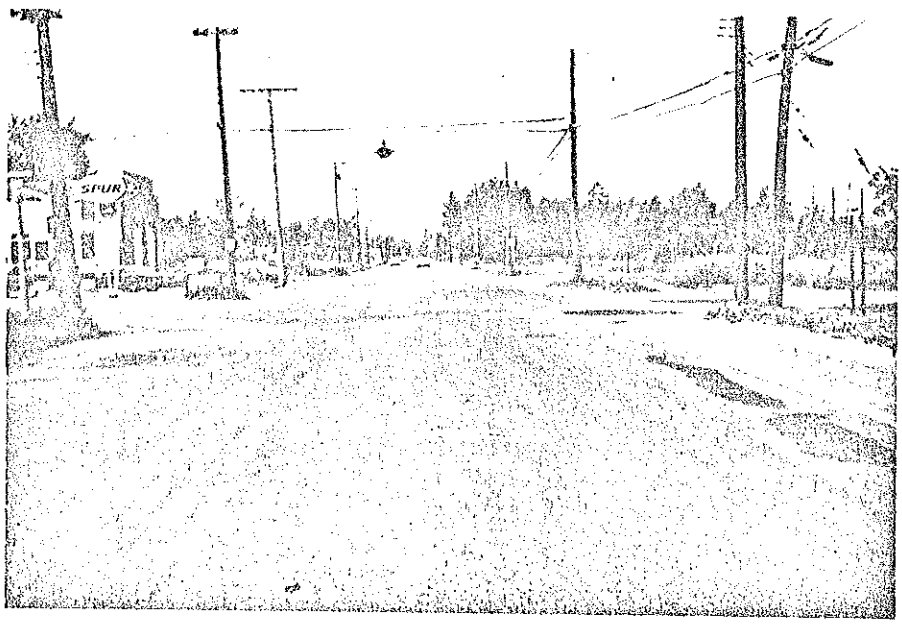
SOUTHBOUND

PRESQUE ISLE AVENUE



WESTBOUND

WRIGHT STREET



NORTHBOUND

PRESQUE ISLE AVENUE

FIGURE 45

LOCATION 24 THIRD STREET AT ARCH STREET

Total	Property Damage	Injury	Fatal
13	8	5	0

LOCATION 25 HEBARD COURT AT KAYE STREET

Total	Property Damage	Injury	Fatal
9	9	0	0

SUMMARY OF RECOMMENDATIONS

High Accident Locations

The Department of State Police submitted 25 high accident locations for the City of Marquette to the Michigan Department of State Highways and Transportation. After an in depth study of these locations recommendations were formulated for 15 of them. The locations, their recommendations and a cost estimate for these recommendations are as follows:

Location Number	Description	Recommendations	Cost Estimate
1	Presque Isle Avenue at College Avenue	A 70 second cycle with a 6 percent clearance interval should be established.	
		Install two signal heads with 12 in. lenses.	$ 1,200.00
		The existing signal head should be painted according to the Michigan Manual.	60.00
		The utility company should be contacted for relocation of the utility pole on the southeast corner.	
		Construct a 50 ft taper in the southeast quadrant.	750.00
		The painted arrows on the west leg of College Avenue should be changed to reflect the new lane assignments.	210.00
		The word "ONLY" should be applied under each left turn arrow.	210.00
		Six Lane-Use Control signs should be erected.	165.00
		TOTAL	$ 2,595.00
2	Lincoln Avenue at College Avenue	A 70 second cycle with a 6 percent clearance interval should be established.	
		Install an extra signal head.	$ 450.00
		Lincoln Avenue should be restriped for two 11 ft through lanes and a 10 ft center lane.	20.00

Location Number	Description	Recommendations	Cost Estimate
		The radii in the northeast and southwest quadrants should be increased to 40 ft.	
		The east leg of College Avenue should be restriped according to the Michigan Manual.	10.00
		The symbol arrows for Lincoln Avenue will have to be repainted.	280.00
		The word "ONLY" should accompany the left turn arrows for Lincoln Avenue and the east leg of College Avenue.	210.00
		Erect six Lane-Use Control signs.	165.00
		Skidometer tests should be conducted.	250.00
		Construct curbing and driveways for the grocery store located in the southwest quadrant.	410.00
		TOTAL	$1,795.00
3	Seventh Street at Magnetic Street	Skidometer tests should be conducted.	$ 250.00
		Install a flashing beacon.	1,000.00
		Erect two 36 in. "Stop" signs.	66.00
		TOTAL	$1,316.00
4	Presque Isle Avenue at Fair Avenue	Skidometer tests should be conducted.	$ 250.00
		Erect a Bi-Directional Target arrow.	28.00
		Erect a 36 in. "Stop" sign.	33.00
		Erect two Lane-Use Control signs.	55.00
		Apply lane lines and a center line to Presque Isle Avenue.	40.00

Location Number	Description	Recommendations	Cost Estimate
		Change the center line for Fair Avenue from white to yellow.	10.00
		Apply the word "ONLY" just before each left turn arrow and each through arrow.	140.00
			$ 556.00
5	Presque Isle Avenue at Kaye Avenue	Erect an extra signal head.	$ 450.00
		Paint existing signal head yellow and black.	60.00
		Establish a 70 second cycle with a 6 percent clearance interval.	
		Investigate the feasibility of increasing the stop and go operation to 11 p.m.	
		Remove the angle parking from the north side of the west leg of Kaye Avenue. Parallel parking can be added to the south side of the west leg of Kaye Avenue.	
		Construct a 50 ft taper in the southeast quadrant.	750.00
		Apply a center line and lane lines to the west leg of Kaye Avenue.	40.00
		Apply painted arrows accompanied by the word "ONLY" to indicate lane assignments for the west leg of Kaye Avenue.	420.00
		Increase the radius for the northwest corner to 40 ft.	
		Apply the word "ONLY" to the center lane of Presque Isle Avenue.	140.00
		Erect four Lane-Use Control signs for Presque Isle Avenue.	150.00

Location Number	Description	Recommendations	Cost Estimate
		Erect three Overhead Lane-Use Control signs for the west leg of Kaye Avenue.	2,500.00
		TOTAL	$ 4,510.00
6	Lincoln Avenue at West Fair Avenue	Erect 36 in. "Stop" signs.	$ 66.00
		Convert the east leg of West Fair Avenue to three lanes.	15.00
		Repaint the west leg of West Fair Avenue.	15.00
		Apply painted arrows to the east leg of West Fair Avenue.	140.00
		Paint the word "ONLY" under each left turn arrow.	140.00
		Erect two roadside Lane-Use Control signs.	55.00
		Apply broken yellow center lines to the entire length of both legs of Lincoln Avenue.	25.00
		Create clear vision corners in all four quadrants. Increase the radius in the southeast quadrant to 40 ft.	
		TOTAL	$ 456.00
9	Front Street at Ridge Street	Apply lane line marking to Front Street.	$ 25.00
		TOTAL	$ 25.00
10	Third Street at Hewitt Avenue	Erect an extra signal head to provide two signal faces per approach.	$ 450.00
		Establish a 7 percent clearance interval.	
		TOTAL	$ 450.00

Location Number	Description	Recommendations	Cost Estimate
11	College Avenue at Seventh Street	A 70 second cycle with a 6 percent clearance interval should be established.	
		A second signal head should be installed.	$ 450.00
		College Avenue should be painted for 3 lanes.	20.00
		Painted symbol arrows should be applied on College Avenue.	280.00
		The word "ONLY" should accompany the left turn arrows.	140.00
		Erect 4 Lane-Use Control signs.	110.00
		TOTAL	$ 1,000.00
12	Main Street at Third Street	Change the 90° angle parking on eastbound Main Street to 45° angle parking.	$ 25.00
		TOTAL	$ 25.00
14	County Road 553 at Pioneer Road and Division Street	Erect three 36 in. Turn signs with accompanying 20 mph advisory speed panels.	$ 170.00
		Erect a 48 in. x 96 in. Target Arrow.	120.00
		Remove the "Stop" sign for County Road 553.	
		Remove the "Stop Ahead" signs on County Road 553.	
		TOTAL	$ 290.00
15	Third Street at Baraga Avenue	Skidometer tests should be conducted.	$ 250.00
		Erect a flasher with a 12 in. lens and a suspended case sign which reads "Stop" for Baraga Avenue.	1,000.00
		Erect two 36 in. "Stop" signs.	66.00

Location Number	Description	Recommendations	Cost Estimate
		Exclude the existing "No Right Turn" sign from the proposed "Stop" sign for the northeast corner.	
		Apply a yellow center line marking to Baraga Avenue.	25.00
		Apply a broken white lane line the entire length of Third Street.	100.00
		TOTAL	$ 1,441.00
16	Pine Street at Hewitt Avenue	Erect two 36 in. "Stop" signs.	$ 66.00
		Remove parking on Hewitt Avenue a distance of 75 ft from the northeast and southwest corners.	
		Remove the large bush on the northeast corner.	
		Keep the trees that line Hewitt Avenue trimmed.	
		TOTAL	$ 66.00
18	Third Street at College Avenue	Remove parking on Third Street a distance of 75 ft from the northeast and northwest corners.	
23	Presque Isle Avenue at Wright Street	Skidometer tests should be conducted.	$ 250.00
		Erect a 24 in. "Stop" sign on the northeast corner.	25.00
		The existing flasher should be painted according to the Michigan Manual.	50.00
		Apply a yellow center line on all four legs of the intersection.	40.00
		TOTAL	$ 365.00

The total cost of the recommendations formulated at the 15 high accident locations is $14,890.00.

City-Wide Recommendations

1. Apply wet pavement accident criteria to locations throughout the city to determine where slippery pavement conditions exist.

2. At any signalized location a minimum of two vehicular signal faces should be provided per approach.

3. All signal installations should have a minimum clearance interval of four seconds and a maximum time of 4.5 seconds.

4. All signal and flasher head housings should be painted highway yellow while the insides of visors and the entire surface of louvers, fins and the front surface of backplates shall have a dull black finish.

5. The 1973 edition of the Michigan Manual indicates that all center line markings should be yellow.

6. The City of Marquette should establish a city-wide program to increase the radii at all intersections where the existing radii are inadequate.

APPENDIX I

SIGHT DISTANCE AT INTERSECTIONS

The operator of a vehicle approaching an intersection at grade should have an unobstructed view of the whole intersection and a length of the intersecting highway sufficient to permit control of the vehicle to avoid collisions. When traffic at the intersection is controlled by signals or signs, the unobstructed view may be limited to the area of control. The minimum sight distance considered safe under various assumptions of physical conditions and driver behavior is related directly to vehicle speeds and to the resultant distances traversed during perception and reaction time and during braking.

Minimum Sight Triangle

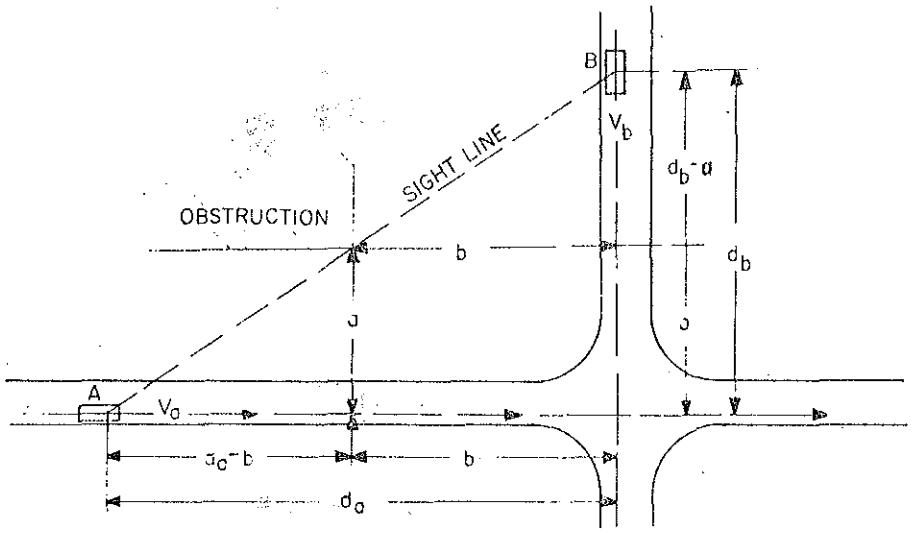
There must be unobstructed sight along both roads at an intersection and across their included corner for distances sufficient to allow the operators of vehicles approaching simultaneously to see each other in time to prevent collision at the intersection. See Figure VIII-3. Three general cases at intersections are considered. In each case assumptions are made of a physical layout and of the actions of vehicle operators on both intersecting roads. For each, the space-time-velocity relations indicate the minimum sight triangle required to be free of obstructions or, if a sight triangle below the desirable minimum must be used, they fix the necessary modifications in approach speeds.

Any object within the sight triangle high enough above the elevation of the adjacent roadways to constitute a sight obstruction should be removed or lowered. Such objects include cut slopes, hedges, bushes, or tall crops. This requires the elimination of parking within the sight triangle. This applies whether the intersecting roads are level or on grades.

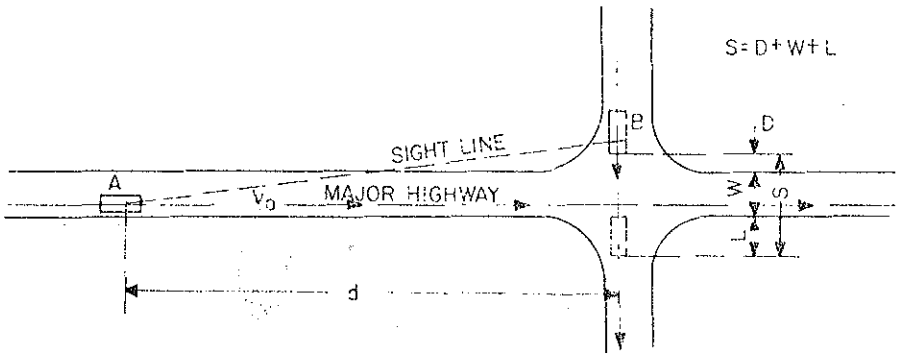
No Stop or Signal Control at Intersection

Case I - Enabling Vehicles to Adjust Speed

Where a crossing is not controlled by YIELD signs, STOP signs or traffic signals, the operator of a vehicle approaching an intersection must be able to perceive a hazard in sufficient time to alter the speed of his vehicle as necessary before reaching the intersection. The minimum time in which deceleration can be started is the driver perception and reaction time which, for intersection design, can be assumed to be 2 seconds. In addition, the driver should begin actual braking some distance from the intersection to accomplish deceleration to avoid collision. An arbitrary minimum for the distance from an intersection, where a driver can first see a vehicle approaching the intersection on the intersecting road, is that traversed during 2 seconds for perception and reaction plus 1 additional second to actuate braking or



NO STOP OR SIGNAL CONTROL AT INTERSECTION
— CASES I & II



STOP CONTROL ON MINOR ROAD
CASE III

SIGHT DISTANCE AT INTERSECTIONS

MINIMUM SIGHT TRIANGLE

FIGURE VIII-3

accelerating to regulate speed. The distances traveled by a vehicle in 3 seconds are:

Speed, mph	20	30	40	50	60	70
Distance, feet	90	130	180	220	260	310

Under Case I for given speeds the minimum sight triangle is determined by these minimum distances along the road. Referring to the upper part of Figure VIII-3, highway A with 50 mph speed and highway B with 30 mph speed would require an unobstructed sight triangle between points on highways A and B with legs extending at least 220 feet and 130 feet, respectively, from the intersection. These or greater distances would permit a vehicle on either road to change speed, before reaching the intersection.

Intersections with sight triangles having road distances no greater than those indicated above are not necessarily safe since there is possible confusion between vehicle operators and the possibility of a driver on one highway being confronted with a succession of vehicles on the intersecting highway even when the time and distance are sufficient only to avoid one vehicle. Even where only one vehicle on each of adjacent legs approaches an intersection, both vehicles may begin to slow down and reach the intersection at the same time. The use of the above distances, which are only one-half to two-thirds of the safe stopping distances, to determine the unobstructed sight triangle is minimum and not a desirable practice. They should be used only in the design of rural intersections on lightly traveled highways and where the removal of corner sight obstructions would be costly. Where the triangle described is not open to view, signs should be erected to effect a slowing down or stopping of vehicles on one road even if both roads are lightly traveled.

Case II - Enabling Vehicles to Stop

In this set of conditions for crossings not controlled by YIELD signs, STOP signs or traffic signals, it is assumed that the operator of a vehicle on either highway must be able to see the intersection and the intersecting highway in sufficient time to stop his vehicle, if necessary, before reaching the intersection. The safe stopping distances for intersection design are the same as those used for design at any other section of highway, the minimum stopping distance developed in chapter III. These are:

Design speed, mph	30	40	50	60	70
Safe stopping distance feet	200	275	350	475	600

For two highways of known design speeds, the minimum sight triangle determined by these case II minimum distances is a much safer design than that with the limited case I distances. An operator

sighting a vehicle on the intersecting road may stop, if necessary, or otherwise change speed to avoid hazard. There is some danger of confusion between drivers because both may slow down and reach the intersection at the same time, but this danger is slight due to the great number of speed-change possibilities, the time available, and the normal decrease in speed as an intersection is approached under such conditions.

Obstructions to Sight. Where an obstruction, which cannot be removed except at prohibitive cost, fixes the vertices of the sight triangle at points that are less than the safe stopping distances from the intersection, vehicles may be brought to a stop (after sighting other vehicles on the intersecting road) only if they are traveling at a speed appropriate to the available sight distance. If vehicles on one of the roads are permitted to travel at the design speed, the critical corresponding speed on the other road can be evaluated in terms of this design speed and the dimensions to the known obstruction.

Referring to the upper diagram in figure VIII-3, in the typical case speed V_a is known and a and b are the known distances to the sight obstruction from the respective paths of vehicles A and B. The critical speed (V_b) of vehicle B can then be evaluated in terms of these known factors. Distance d_a is the minimum stopping distance for vehicle A. When vehicle A is at a distance d_a from the intersection and the drivers of vehicles A and B first sight each other, vehicle B is at a distance d_b from the intersection. By similar triangle proportion

$$d_b = \frac{ad_a}{d_a - b}$$

and the critical speed V_b is that for which the stopping distance is d_b. The signs on road B, showing the safe speed with which to approach the intersection, should be so located that a driver can reduce his speed to V_b by the time he reaches the point that is the distance d_b from the intersection. Similar calculations may be used to determine how far back an obstruction need be moved to provide sufficient sight for safe driving at desired vehicle speeds on the respective roads.

Stop Control on Minor Road

Case III - Enabling Stopped Vehicles to Cross a Major Highway

At an intersection where traffic is controlled by STOP signs on the minor road, it is necessary for safety reasons that the driver of a stopped vehicle see enough of the major highway to cross before

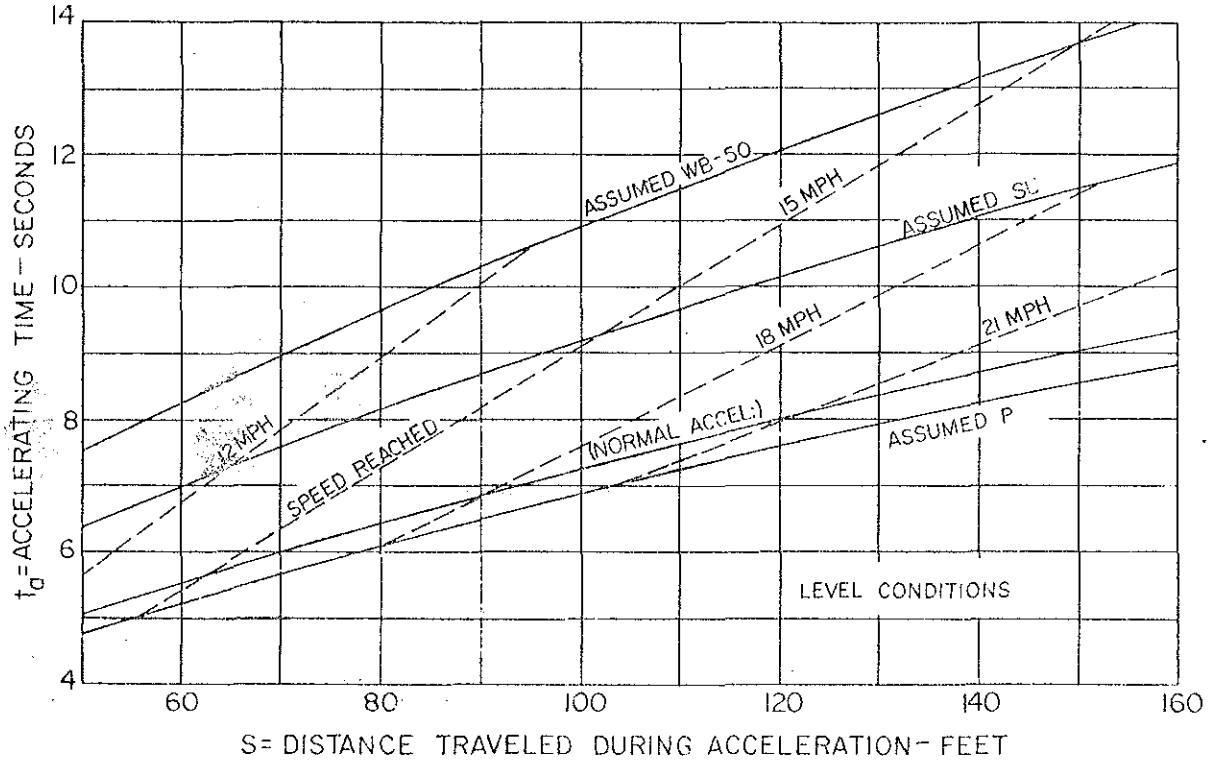
a vehicle on it reaches the intersection, even though this vehicle comes into view just as the stopped vehicle starts to cross. The length of the major highway open to view must be greater than the product of its design speed and the time necessary for the stopped vehicle to start and cross the road. The required sight distance along the major highway can be expressed as:

$$d = 1.47\ V\ (J + t_a)$$

where d = minimum sight distance along the major highway from the intersection, feet
V = design speed on the major highway, mph
J = sum of the perception time and the time required to shift to first gear or actuate an automatic shift, seconds
t_a = time required to accelerate and traverse the distance S to clear the major highway pavement, seconds.

The term J represents the time necessary for the vehicle operator to look in both directions on the roadway, to perceive that there is sufficient time to safely cross the road, and to shift gears, if necessary, preparatory to starting. It is the time from his first look for possible oncoming traffic until the instant his car begins to move. Some of these operations are done simultaneously by many drivers, and some operations, such as shifting of gears, may be done before looking up or down the road. Even though most drivers may require only a fraction of a second, an amply large value of J should be used in design to represent the time taken by a small percentage of slower drivers. A value of 2 seconds is assumed. In urban or suburban areas, where drivers generally use many intersections with STOP sign control, a somewhat lower value might apply, but reducing J to ½ or 1 second reduces the calculated minimum sight distances only about 15 percent.

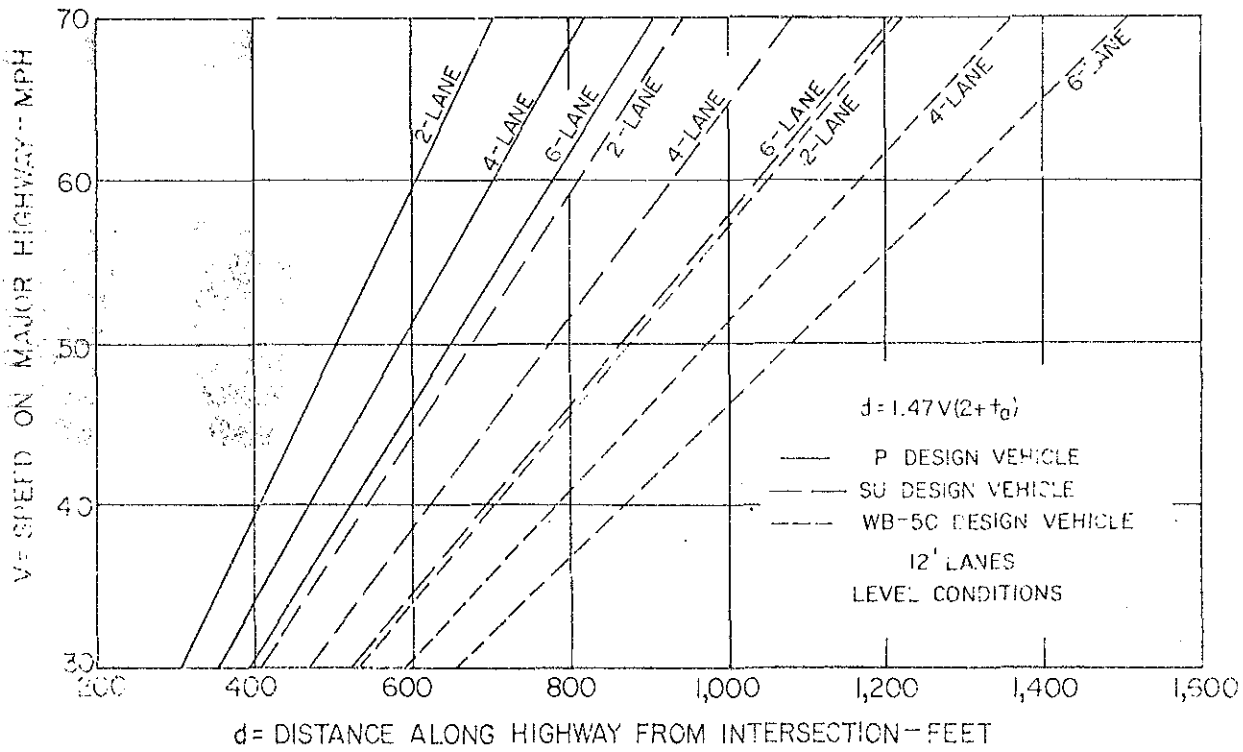
The time t_a required to cover a given distance during acceleration depends upon the vehicle acceleration, which in the case of passenger cars seldom equals the rate of which the vehicle is capable. Rather it is considerably less as governed by the temperament and other characteristics of the individual driver and the instant conditions. The time-distance relations of typical passenger cars accelerating from a stopped position, as normally driven are shown by the light solid line curve (normal acceleration) in the lower part of figure VIII-4. For the case III intersection condition, the "normal" acceleration operation should not be used directly for sight distance evaluation. While it is true that few drivers operate at the maximum acceleration of their vehicles, most drivers do accelerate somewhat more rapidly than "normal" in crossing a major highway but less than the full vehicle acceleration rate. The lower heavy solid line curve is the relation assumed for



SIGHT DISTANCE AT INTERSECTIONS - CASE III

DATA ON ACCELERATION FROM STOP

FIGURE VIII - 4



SIGHT DISTANCE AT INTERSECTIONS - CASE III

REQUIRED SIGHT DISTANCE ALONG MAJOR HIGHWAY

FIGURE VIII - 5

passenger vehicles in computing t_a, the time required to cross the major highway.

The acceleration of buses and trucks is substantially lower than that of passenger vehicles, particularly for heavily loaded trucks and truck combinations. The high gear ratios (low gear) necessary in moving the larger units result in very low acceleration. From truck operation studies (data not published), the time-distance relations for acceleration of SU and WB-50 design vehicles have been determined, resulting in the assumed relations shown in figure VIII-4. On flat, grades, the accelerating time for the SU and WB-50 vehicles is about 135 and 160 percent, respectively, of that for passenger vehicles.

The value of t_a can be read directly from figure VIII-4 for nearly level conditions for a given distance S, in feet. Referring to the case III sketch in figure VIII-3, the distance S that the crossing vehicle must travel to clear the preference highway is the sum of three distances, in feet, or:

$$S = D+W+L$$

where D = distance from near edge of pavement to front of stopped vehicle
W = width of pavement along path of crossing vehicle
L = overall length of vehicle.

Most drivers stop their vehicles as close to the edge of the intersecting pavement as convenient, but many leave several feet. For general design purposes a value of D = 10 feet is assumed for the case III conditions.

The value of W is measured along the path of the accelerating vehicle. The principal variation in W is the number of lanes on the major highway; lane widths of 12 feet are used.

The value of L, overall length of design vehicles, has been shown in chapter II to be 19, 30, 50, and 55 feet for the P, SU, WB-40 and WB-50 vehicles, respectively.

Figure VIII-5 shows the minimum sight distance d necessary for safe crossing from a stopped position of pavements with 12-foot lanes at nearly right-angle intersections. The sets of sloping lines give the values for the three types of crossing vehicles, each with reference to 2-, 4-, and 6-lane widths. Values for other pavement widths can be calculated readily by the use of proper t_a as determined from figure VIII-4. These values are for level conditions; for grade adjustments, see Effect of Grades.

In testing whether sight distance along a major highway is adequate at an intersection as given in figure VIII-5, the distance should

be measured from height of eye of 3.75 feet to top of object 4.5 feet above the pavement. Comparing the d values from figure VIII-5 with the design sight distances shown in table III-1, in nearly all cases it is necessary to have sight distance along the major highway in excess of the usual design minimum in order to provide for safe crossing from a stopped position.

In the case of divided highways, widths of median equal to or greater than the length of a vehicle enable the crossing to be made in two steps. The vehicle crosses the first pavement, stops within the protected area of the median opening, and there awaits an opportunity to complete the second crossing step. For divided highways with medians less than L, the median width should be included as part of the W value.

Where the sight distance along a major highway is less than the case III distance at an intersection, it is unsafe for vehicles on the major highway to proceed at the assumed design speed of the highway, and signs indicating the safe approach speed should be provided. The safe speed may be obtained directly from figure VIII-5, or computed, for a known sight distance and the width of pavement on the path of the crossing vehicle.

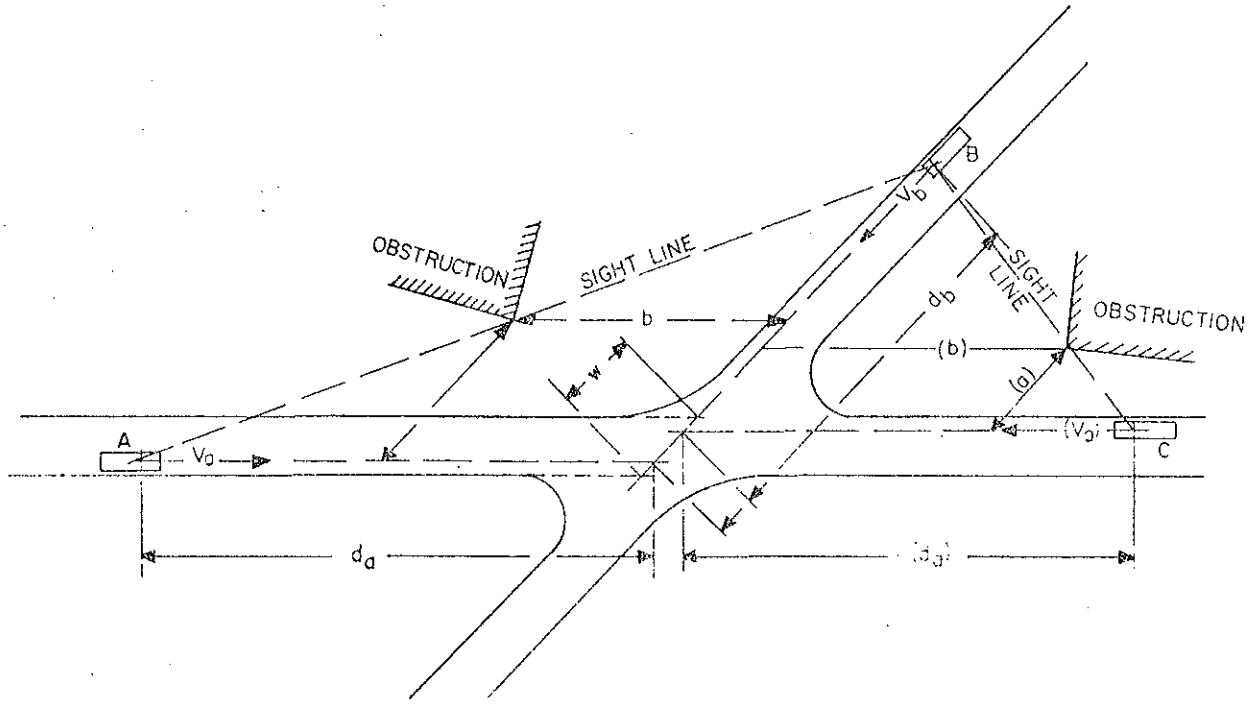
The case III distances required for high design speed highways, especially the multilane type, are large and there is some question as to the average driver's keenness of perception or ability to judge for proper utilization of such distances. Drivers may be able to cross in openings in the through traffic stream that are less than the case III distances. To do this, either the crossing driver must accelerate at a high rate, or through drivers must either be traveling at a lower speed or slow down to permit the crossing. Since these types of operation may be hazardous, it is desirable to use the indicated case III sight distances for the control type vehicle.

In many cases, the effects of skew and grades, as discussed below, require that sight distance along the major highway be much greater than the distances of figure VIII-5. Where it is not feasible to provide the required sight distance, it may be necessary to introduce effective means of reducing speed on the major highway or utilize signal control at the intersection.

Effect of Skew

When two highways intersect at an angle considerably less than a right angle, say less than 60 degrees, and realinement to increase the angle of intersection is not justified, some of the factors for corner sight distance determination may need adjustment.

Figure VIII-6 shows the sight triangles at an oblique-angle intersection. The length of the sight line AB and BC is smaller or



SIGHT DISTANCE AT INTERSECTIONS

EFFECT OF SKEW

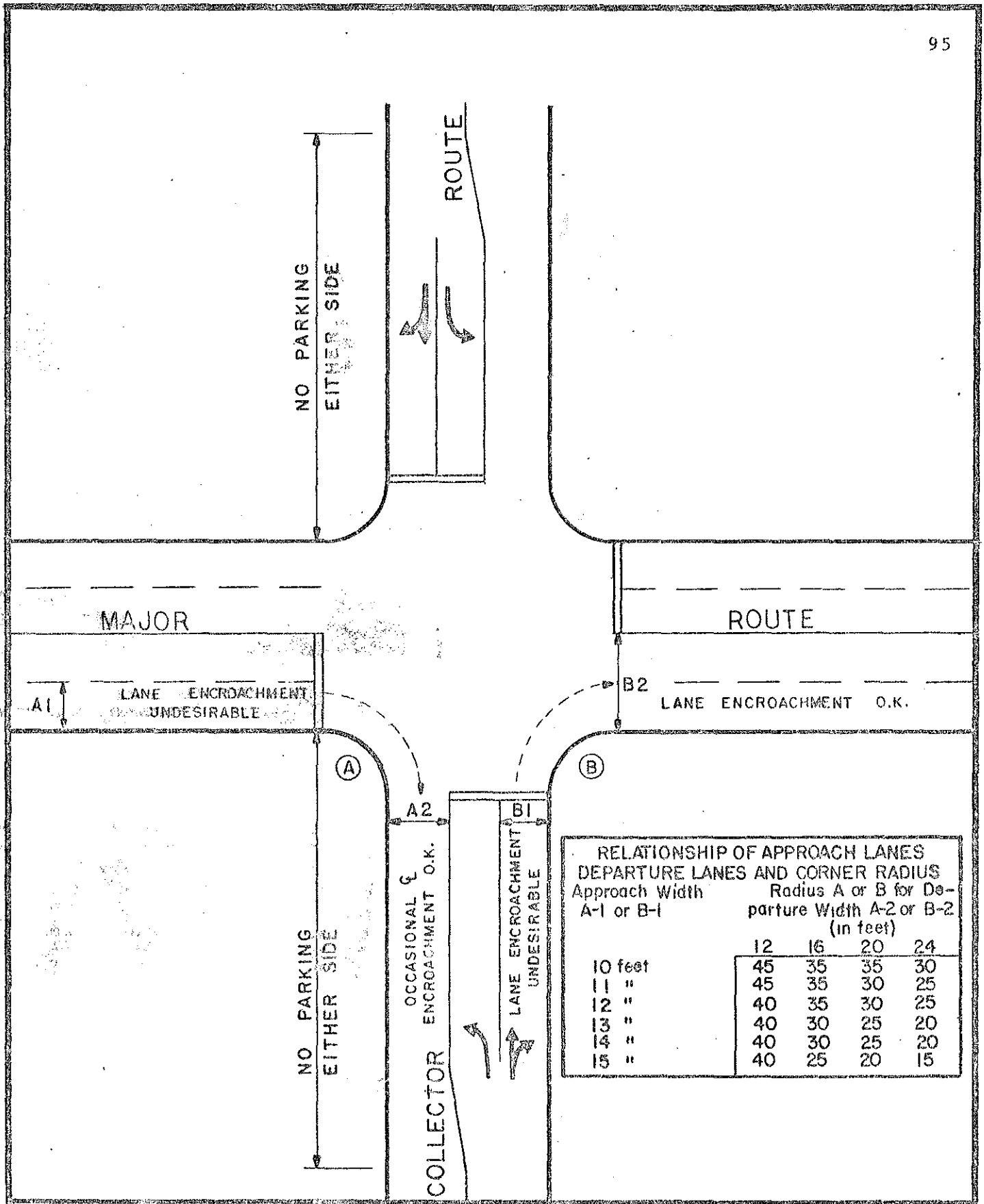
FIGURE VIII - 6

larger than it would be for a right-angle intersection, but since the derivations are based on the relations of speed and distances along the roads, the actual distance AB is immaterial so long as the area within the triangle, having legs d_a and d_b measured along the road, is free of sight obstructions.

Where obstructions at oblique intersections limit sight distances, the distance a and b to be used in the calculations (formula under heading of Obstructions to Sight) should be measured parallel to the roads as shown in figure VIII-6.

In the case of an obtuse-angle quadrant, the angle between the sight line AB and the path of either vehicle is small and the vehicle operators can look across the full sight triangle area with but little side glance from the vehicle path. In the case of an acute-angle quadrant, sight line BC, each operator is required to turn his head considerably to see across the whole of the sight triangle area. The difficulty of looking for approaching traffic makes it undesirable to treat the intersection for the assumptions of case I even where traffic on both roads is light. Treatment by case II or case III, whichever is the larger for the case, should be used at oblique-angle intersections.

In case III the S distance is larger for oblique- than for right-angle intersections, The width of pavement on the path of the crossing vehicle, W, is the pavement width divided by the sine of the intersection angle. The d distance along the highway in such case cannot be read directly from VIII-5 but can be computed by the formula $d = 1.47\ V\ (2 + t_a)$ reading t_a directly from figure VIII-4.



RELATIONSHIP OF APPROACH LANES DEPARTURE LANES AND CORNER RADIUS

Approach Width A-1 or B-1	Radius A or B for Departure Width A-2 or B-2 (in feet)			
	12	16	20	24
10 feet	45	35	35	30
11 "	45	35	30	25
12 "	40	35	30	25
13 "	40	30	25	20
14 "	40	30	25	20
15 "	40	25	20	15

STATE OF MICHIGAN
DEPARTMENT OF STATE HIGHWAYS
TRAFFIC & SAFETY DIVISION

AUTH. NO.
CONT. SEC.
REF.
SHEET OF PLAN

DRAWN DFK
DATE 7-26-74
SCALE

RELATIONSHIP OF APPROACH LANES, DEPARTURE LANES, AND CORNER RADIUS

FORM 1558 (REV. 10-69)

EDCO• 196M 5-71 45820