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Iowa Department of Transportation
Highway Division

Traffic Engineering Study
for the
City of Boone, Iowa

Federal Highway Safety Grant
Federal Highway Administration
U.S. Department of Transportation

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By: Brice, Petrides & Associates, Inc., Engineers, Waterloo, Iowa

TRAFFIC ENGINEERING STUDY
FOR THE
CITY OF BOONE, IOWA

PREPARED FOR
IOWA DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION

FEDERAL HIGHWAY SAFETY GRANT
FEDERAL HIGHWAY ADMINISTRATION
U.S. DEPARTMENT OF TRANSPORTATION

This report was prepared through a Grant provided by the United States Department of Transportation, Federal Highway Administration, pursuant to the provisions of Section 402 of Title I of the Highway Safety Act of 1966.

The opinion, findings and conclusions expressed in this publication are those of the authors and not necessarily those of the Iowa Department of Transportation, Highway Division, Division of Highway Safety or the Federal Highway Administration.

Brice, Petrides & Associates, Inc.
engineers · planners

Honorable Mayor Elmer Ohlman
and City Council
City of Boone
Municipal Building
923 Eighth Street
Boone, Iowa 50036

Dear Mayor and Council:

We are pleased to present herewith this Traffic Engineering Study for the City of Boone, Iowa. This study was initiated in December, 1976, and was prepared through a Grant provided by the United States Department of Transportation, Federal Highway Administration, pursuant to the provisions of Section 402 of Title I of the Highway Safety Act of 1966.

This report makes recommendations relative to improving traffic control devices, transportation arteries, ordinances, and other traffic appurtenances in order to provide a safer flow of traffic within the City of Boone. The scope of the report pertains to present conditions and no projections are made for future anticipated changes.

The results of this report, when implemented, should provide for improved traffic flow, in addition to reducing traffic accidents, injuries, and property damage within the City of Boone.

Comments and suggestions of the Iowa Department of Transportation, Highway Division, and the Federal Highway Administration are hereby gratefully acknowledged. We would also like to express our appreciation to the staff of the City of Boone for providing assistance, comments, and documentation in the accomplishment of this report.

Respectfully submitted,

BRICE, PETRIDES & ASSOCIATES, INC.

Fedon N. Petrides

191 West Fifth Street, Waterloo, Iowa 50701, Phone (319) 232-6531

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I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION OR REPORT WAS PREPARED BY ME OR UNDER MY DIRECT PERSONAL SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF IOWA.

SIGNED DATE

Charles E. Spicher August 30, 1978

CHARLES E. SPICHER, P.E. IOWA REG. NO. 5078

SUMMARY OF RECOMMENDATIONS

SCOPE

This section of the report serves as a summary of the recommendations and data presented within the previous portions of this report.

TRAFFIC REGULATIONS AND ENFORCEMENT

1. Update present City ordinances relative to traffic. Such revisions should include provisions for recommended modifications and deletion of existing ordinances that are no longer applicable.

2. Law enforcement relative to speed limits, parking and other traffic regulations should remain a continuing effort.

TRAFFIC CONTROL DEVICES

Traffic Signals

1. Provide a new mast-arm pole at the intersection of Story Street and Mamie Eisenhower Avenue, with signals overhanging the center of the inside lane relative to northbound traffic on Story Street. Install left-turn signal indications on mast-arms over inside lanes relative to northbound and southbound traffic on Story Street.

2. Provide three-phase signalization at the intersection of Mamie Eisenhower Avenue and Story Street, with a separate left-turn phase on Story Street.

3. Remove existing traffic signals at the Story Street intersections of Sixth, Ninth, Tenth and Eleventh Streets, as signals are not warranted.

d. Arden Street and Eighth Street; Arden Street Northbound and Southbound.

2. Remove temporary stop signs at Sunday stop locations.

3. Remove portable four-way stop sign at center of intersection of Eighth Street and Allen Street.

4. Provide four-way plates for all stop signs at four-way stop intersections.

5. Check all stop signs relative to height and lateral clearance requirements of the MUTCD. Reinstall signs on longer posts, if necessary, to obtain a minimum distance of seven feet from pavement to bottom of sign in areas where parking is permitted.

Yield Signs

1. Install yield signs at the following locations:

   a. Sixth Street and Carroll Street; Sixth Street Eastbound and Westbound.

   b. Tenth Street and Carroll Street; Tenth Street Eastbound and Westbound.

   c. Sixth Street and Tama Street; Tama Street Northbound and Southbound.

Miscellaneous Signs

1. "Speed Limit" signs to be installed for all changes in speed limits, and to update signing according to City ordinances.

2. "Pavement Width Transition" and "Right Lane Must Turn Right" signs on Mamie Eisenhower Avenue, in advance of the lane drops at Boone Street and Marshall Street.

3. "Left Lane Must Turn Left" signs on Story Street, in advance of its intersection with Mamie Eisenhower Avenue, relative to both northbound and southbound traffic.

4. "No Parking" signs on all sides of streets where parking is recommended to be prohibited and at other locations designated by City ordinances.

5. "No Parking From Here To Corner" signs in those areas where emphasis on such prohibition is needed.

6. "School Advance" signs to be provided in advance of all designated school crossings and school grounds.

7. "School Crossing" signs at all designated school crossings.

8. "Signal Ahead" signs in advance of the first traffic signal installations on Story Street.

9. "One Way" signs to be installed at one-way alleys where traffic is not permitted to enter.

10. "Double Arrow" signs and "Large Arrow" signs where required at T-intersections and abrupt changes in roadway alignment.

11. "Turn" signs in advance of all right-angle turns. Such signs are recommended to include advisory speed plates.

12. "Curve" signs in advance of curves on Mamie Eisenhower Avenue near Division Street.

13. Replace outdated "Do Not Enter" signs with new-style red-on-white-signs.

14. "Left Turn Signal" signs near the recommended left turn signals at the intersection of Story Street and Mamie Eisenhower Avenue.

15. "T-Symbol" signs in advance of all T-intersections not protected by other traffic control devices.

16. "No Turn On Red" signs at the intersection of Mamie Eisenhower Avenue and Story Street (north and south approaches), and at approaches at the intersections of Seventh and Eighth Streets at Story Street.

17. Install new two-piece "Low Clearance" signs on the east side of Benton Street between Seventh and Eighth Streets; on the west side of Linn Street between Tenth and Ninth Streets and on the north side of Ninth Street east of Linn Street.

    Replace existing "Low Clearance" signs on the east side of Benton Street north of Eighth Street and on the east and west sides of Benton Street at the railroad bridge with up-to-date style signs.

18. Remove existing portable "Do Not Enter" signs on Crawford Street at Sixth and Seventh Streets. Install new barricades with signing reading "Street Closed to Through Traffic."

Pavement Markings and Delineators

1. Eliminate parking spaces near or within intersections to comply with Manual on Uniform Traffic Control Devices for Streets and Highways and to improve sight distances at corners. Provide yellow curb markings for the no parking zones so resulting. (Supplementary to "No Parking" signs).

2. Paint new parking stall lines relative to recommended changes in parking arrangements in the vicinity of the central business district.

Eradicate existing markings where parking arrangements are changed. (Relocate parking meters as necessary.)

3. Provide turn arrow markings, supplemented by the word "Only", for all exclusive left-turn lanes.

4. Provide center line markings for all through streets within the community, including the following: Story Street, from U.S. Highway 30 to 22nd Street; Mamie Eisenhower Avenue, from the West City Limits to the East City Limits; Marion Street, North of Mamie Eisenhower Avenue; Division Street, North of Mamie Eisenhower Avenue; Eleventh Street, from Division Street to Linn Street; Benton Street, from Mamie Eisenhower Avenue to Industrial Road; Linn Street, from Industrial Road to 22nd Street; Industrial Road, East of Linn Street.

5. Provide reflective markings for curbs near the railroad viaduct, and renew reflective markings on the viaduct wingwalls.

6. Install a series of post-mounted delineators and a hazard marker in advance of the railroad viaduct for northbound traffic on Benton Street.

7. Paint stop lines on pavement at all stop sign and traffic signal controlled intersections, to define stop locations where conflicts with pedestrian or vehicular traffic would otherwise be likely.

8. Provide pedestrian crosswalk markings for all designated crosswalks.

9. Maintain all pavement markings in good condition.

Traffic Operations

1. Reconstruct the northwest corner of the intersection of Mamie Eisenhower Avenue and Benton Street to provide a 30-foot corner radius.

2. Revise speed limits along the following streets:

   Mamie Eisenhower Avenue, from Ringold Street to Main Street - recommended 30 m.p.h.

   North Linn Street, 15th Street to 22nd Street - recommended 30 m.p.h.

   Story Street, U.S. Highway 30 to Hancock Drive - recommended 40 m.p.h.

3. Remove left-turn lanes at the intersections of Story Street with Sixth, Seventh, Eighth, Ninth, Tenth and Eleventh Streets. Mark center lines at the center of the respective streets.

4. Turn off a portion of existing street lights within the central business district, especially during nights when businesses are not open.

5. Concentrate future lighting programs in residential areas.

Parking

1. Prohibit parking within 30 feet of the crosswalk at signalized intersections, and within 20 feet of the crosswalk at unsignalized intersections.

2. Remove parking on sides of arterial streets where street widths are insufficient to accommodate both parking and through traffic Recommended no-parking zones are shown in Figure 5-3.

3. Prohibit parking on one side of narrow streets where such streets approach a stop sign.

4. Paint parallel parking stalls within the business district as individual stalls.

5. Increase width of diagonal parking stalls to 9 feet.

6. Encourage development of off-street parking facilities relative to future public or private developments within the community, and especially within the central business district.

Additional Traffic Counts

Before City requests are made for use of State or Federal funding for upgrading traffic signals, additional traffic counts should be conducted to insure that signals are warranted.

CHAPTER 1
INTRODUCTION

SCOPE

The scope of this traffic engineering study is to analyze the existing system of streets and highways in Boone, Iowa, with major emphasis on the central business district and the arterial street system, and to make recommendations to afford a safe and efficient system for movement of vehicular and pedestrian traffic.

EXISTING CONDITIONS

The City of Boone is located in the central portion of Iowa and is the county seat of Boone County. According to the 1970 census, Boone has a population of 12,468 residents.

U.S. Highway No. 30, an east-west highway located in the southern portion of Boone, is the major primary highway serving the City. In addition, Boone is connected to the secondary road system via several county roads, and is served by a segment of Iowa Highway No. 164 in the southern part of the City.

Two railroads currently provide service to the City of Boone. The Chicago and North Western Transportation Company operates a major freight route through the City, and the Fort Dodge, Des Moines and Southern Railroad provides an additional railroad line to the City. One railroad grade separation is present within the City, being located on the Chicago and North Western trackage near Linn Street. The remaining railroad crossings are at grade.

Industrial activity within Boone is concentrated along the above railroad lines, and along portions of Mamie Eisenhower Avenue (Old U.S. Highway No. 30). Commercial activity is centered in two business districts within the City, one being located along Story Street and adjacent streets generally between Fifth and Eleventh Streets, and the other being located along West Mamie Eisenhower Avenue near Main Street. Additional business establishments are scattered along the remaining portions of Story Street and Mamie Eisenhower Avenue.

Other traffic generators, in addition to those listed above, include several schools throughout the City and the Boone Junior College located in the South portion of the City east of Story Street. The Boone Municipal Airport is located in the eastern portion of the City, south of Mamie Eisenhower Avenue.

METHODOLOGY

The first step in the development of the study was to obtain data pertaining to City mapping, accident experience, City ordinances, traffic control devices and parking.

Upon subsequent analysis of the established system of through streets and highways, accident records, and through meetings with City Officials of the City of Boone, traffic count locations were established. Traffic volumes were then obtained by counting all traffic entering those street intersections selected.

During the course of the traffic counting phase of this study, each selected intersection was measured to establish its physical layout

regarding pavement, traffic control devices, utility poles, sidewalks, buildings and parking. Additional investigations were made relative to parking usage and turnover, existing street lighting facilities, locations of visual obstructions and pavement markings and driving speeds.

Based on the data obtained and the measurements and counts conducted, the following chapters of this report are presented as analyses of individual subject areas.

The second chapter, "Traffic Accidents," represents an analysis of data obtained from five years of accident reports for 1972 through 1976. The results of this analysis serve to supplement the findings of succeeding chapters.

The third chapter, "Traffic Regulations and Control Devices," presents data relative to existing City ordinances and resolutions and traffic control devices that affect traffic movements, such as functional classification of the existing street system, speed limits and the location of stop signs and traffic signals.

The fourth chapter, "Traffic Operations," presents analyses and recommendations relative to intersection geometrics, street widths, obstructions, vehicular and pedestrian volumes, intersection capacity and levels of service, speed limits and traffic control devices (traffic signals, stop signs, yield signs, markings and other signing).

The fifth chapter, "Parking," presents data concerning on-street and off-street parking facilities, their usage and a study of parking supply and demand for present conditions.

The sixth chapter, "Estimated Cost, Funding, Staging and Implementation," includes the estimated cost of recommended improvements, sources of funding and recommended staging and implementation of improvements.

The "Summary of Recommendations," located near the front of this report, serves as a summary of the recommendations included and discussed hereinafter in the report.

CHAPTER 2
TRAFFIC ACCIDENTS

SCOPE

An analysis was made of existing traffic accident records in order to determine high accident frequency locations, establish existing deficiencies, and make recommendations for improvements.

COMPILATION OF ACCIDENT RECORDS

Accident records were obtained for the calendar years 1972, 1973, 1974, 1975 and 1976. All traffic accidents occurring within the corporation limits of Boone were recorded and then categorized by computer. Data taken from individual accident reports included the following: intersection at or near which accident occurred, location of accident with respect to the intersection, the date of the accident, the day of week, time of day, number of non-pedestrian injuries, number of non-pedestrian fatalities, number of pedestrian injuries, number of pedestrian fatalities, total property damage for the accident, types of vehicles involved in the accident, lighting conditions, weather conditions, road surface conditions, street gradient condition, vehicle defects, drinking condition of driver, physical condition of driver, age and sex of driver, direction of movements of respective vehicles and/or pedestrians, the type of violation and whether charges were filed. The types of violations considered are listed in the table in Table 2-1.

TABULATION OF ACCIDENTS

Accident histories of the various intersections within the City of Boone were analyzed relative to accident frequency and severity, number

01 Assured clear distance - Accident when vehicle in front is hit while stopped or moving forward, by vehicle from behind. Commonly referred to as a rear-end collision.

02 Changing lanes - Accident caused by one vehicle changing lanes and in the process hit another vehicle or pulling suddenly into the path of travel of another vehicle. Both vehicles must be going in same direction.

03 Inattention - Use only if there are statements or comments that driver was inattentive.

04 Speeding - Use only if accident was caused by driver traveling 20 MPH over the speed limit.

05 Improper backing - Accident caused by the action of a vehicle while backing, such as backing into another vehicle or into the right-of-way of another vehicle.

06 Wrong side of center - Accident caused by one or both vehicles being left of center, excluding ran-off-roadway where no oncoming car involved and including hitting parked vehicle. Example: head-on collision.

07 Red light - Accident caused by one or both vehicles going through red light.

08 Flashing red - Accident caused by vehicle not obeying flashing red signal.

09 Right-of-way on green light - Accident caused by one entering an intersection on a green light and driving into another vehicle that has legally entered the intersection from the other street but for some reason has failed to clear intersection.

10 Violation of railroad signal - Accident caused by a driver disregarding a railroad signal and thus colliding with train.

11 Non stop - Accident caused by one or both vehicles going through a stop sign without stopping first.

12 Right-of-way after stop - Accident caused by one vehicle driving into the right-of-way of another vehicle after stopping for a stop sign.

13 Violation of yield sign - Accident caused by a vehicle proceeding through a yield sign into the path of travel of a vehicle who did not have a yield sign, excluding left turns by first vehicle.

14 Right-of-way left turn - Accident caused by one vehicle driving into the right-of-way of an oncoming vehicle.

15 Right-of-way from curb - Accident caused by one vehicle driving from parking place along the curb into the path of travel of another vehicle.

16 Right-of-way to right - Accident caused by one vehicle failing to yield the right-of-way to the vehicle on the right at all unsigned intersections.

17 Right-of-way from private drive - Accident caused by one vehicle proceeding from a private drive into the path of travel of another vehicle.

18 Right-of-way from alley - Accident caused by one vehicle driving from an alley into the path of travel of another vehicle.

19 Right-of-way to emergency vehicle - Accident caused by a vehicle failing to yield the right-of-way to an emergency vehicle that has an operating flashing red light and siren.

20 Right-of-way to pedestrian - Accident caused by a vehicle failing to yield to a pedestrian who is in legal use of the roadway.

21 Jay walking - Accident caused by a pedestrian unlawfully walking into the path of a vehicle.

22 Playing in roadway - Accident caused by children playing in roadway.

23 Improper right turn - Accident caused by any type of improper action while making a right turn, including turning too wide so as to go left-of-center and hitting another car or too narrow so as to hit a parked car.

24 Improper left turn - Same as code 23 except for left turn.

25 Right turn wrong lane - Accident caused by a vehicle making a right turn from any lane other than the far right lane or a lane that is specifically designated as a right turn lane.

26 Left turn wrong lane - Accident caused by a vehicle making a left turn from any lane other than the far left lane in his direction of travel or a lane that is specifically designated as a left turn lane.

27 Improper passing - Accident caused by improper passing at or near intersection, in restricted zone, etc., including passing on right.

28 Driving over curb - Accident resulting from a vehicle driving over the curb and as a result, loosing control and veering back into the flow of traffic.

29 Hit object or parked vehicle on roadway - Accident caused by hitting object or parked vehicle on roadway, excluding improper turns, wrong side of center and various right-of-way violations.

30 Improper parking - Accident caused by striking another parked vehicle while entering or leaving an adjacent parking space, excluding improper backing and including illegal parking.

31 U turn - Accident resulting from vehicle making a "U" turn.

32 Wrong way on one-way street, including alleys - Accident caused by a vehicle going the wrong way in any one way street.

33 Straight thru from lane marked right or left turn - Accident caused by a vehicle driving straight through from a lane marked right turn only or left turn only.

34 Running off roadway - Accident involving a vehicle running off either side of the roadway or running into something off either side of roadway, excluding hitting parked vehicle or oncoming vehicle.

35 Defective or no lights - Accident caused by a vehicle driving without proper lights, including defective lights.

36 Mechanical failure - Accident which is caused by some mechanical failure other than defective brakes or defective lights.

37 Defective brakes - Accident which is caused by defective brakes.

38 Open door in traffic - Accident which is caused by someone opening a vehicle door in traffic.

39 Failure to signal - Accident caused by a driver failing to signal a change in direction.

40 Miscellaneous - Accident which cannot be explained by any of the other violations.

41 Hit and run - Accident not observed, including those possibly occurring in parking lots.

Table 2-1. Classification of Traffic Accident Violations

of injuries and number of fatalities occurring during the five-year study period. Based on such analysis, and through consultations with Federal, State, and City Officials, 24 intersections were selected for further detailed study. Fifteen or more accidents occurred at each of the selected intersections during the five-year period analyzed.

Table 2-2 is a summary of traffic accident data for the 24 studied intersections, as well as totals for all other intersection and non-intersection accidents reported during the five-year study period. Totals are given for all street and alley accidents, and a percentage distribution for such accidents is included for each item in this table.

The information shown in Table 2-2 includes the number of fatalities, injuries, pedestrian injuries, pedestrian fatalities, total accidents, accidents according to types of violations and dollar value of property damage. Additional data in Table 2-2 indicates the lighting condition, surface condition, and number of drivers that obviously were drunk or driving while ability was impaired by alcohol or drugs. In cases where no dollar amount of damages was listed on the accident reports, the cost of property damage was estimated from the description of the damages stated.

The totals of the respective columns for all street and alley accidents include the following data: There were 12 non-pedestrian fatalities, 530 non-pedestrian injuries, one pedestrian fatality, 27 pedestrian injuries and property damage totaling $1,177,823.00 for the 2,380 reported accidents. Other data for street and alley accidents indicates that 64.7 percent of all accidents occurred during daylight hours and 59.7 percent occurred on dry roadway surfaces.

INT. NO.	INTERSECTION	FATALITIES & INJURIES: NUMBER OF FATALITIES	NUMBER OF NON-PEDESTRIAN INJURIES	NUMBER OF PEDESTRIAN INJURIES	TOTAL NO. ACCIDENTS	% OF TOTAL ACCIDENTS	TRAFFIC ACCIDENT VIOLATIONS: 01 REAR END	02 CHANGE LANES	03 INATTENTION	04 SPEEDING	05 IMPROPER BACKING	06 WRONG SIDE CENTER	07 RED LIGHT VIOLATION	08 FLASHING RED VIOLATION	09 R-O-W GREEN LIGHT	10 VIOLATION R.R. SIGNAL OR SIGN	11 NON-STOP AT STOP SIGN	12 R-O-W AFTER STOP	13 VIOLATION YIELD SIGN	14 R-O-W LEFT TURN	15 R-O-W FROM CURB	16 R-O-W TO RIGHT	17 R-O-W FROM PRIVATE DRIVE	18 R-O-W FROM ALLEY	19 R-O-W TO EMERGENCY VEHICLE	20 R-O-W TO PEDESTRIAN	21 JAYWALKING	22 PLAYING IN ROADWAY	23 IMPROPER RIGHT TURN	24 IMPROPER LEFT TURN	25 RIGHT TURN WRONG LANE	26 LEFT TURN WRONG LANE	27 IMPROPER PASSING	28 DRIVING OVER CURB	29 HIT OBJECT OR PARKED VEHICLE OR ROADWAY	30 IMPROPER PARKING	31 U-TURN	33 STRAIGHT THRU ON LANE MARKED RIGHT OR LEFT TURN	34 RUN OFF ROADWAY	35 DEFECTIVE OR NO LIGHTS	36 MECHANICAL FAILURE (EXCEPT BRAKES)	37 DEFECTIVE BRAKES	38 OPEN DOOR IN TRAFFIC	39 FAILURE TO SIGNAL	40 MISCELLANEOUS	41 HIT & RUN	PROPERTY DAMAGE COST $	LIGHT CONDITION: DUSK OR DAWN	DARK-W/ STREET LIGHT	DARK-W/O STREET LIGHT	DAYLIGHT	NO DATA	SURFACE CONDITION: DRY	WET	SNOWY	ICY	MUDDY	NO DATA	NO. OF OBVIOUSLY DRUNK DRIVERS OR WITH ABILITY IMPAIRED	INT. NO.	INTERSECTION
1	STORY STREET & 8TH STREET		3	2	85	3.6	23				22		2								7												3					3				4	15,051	6	24		51	4	61	15		6		5	3	1	STORY STREET & 8TH STREET
2	STORY STREET & MAMIE EISENHOWER AVE.	1	21	1	81	3.4	18	8			3		7							13			4																1	39,835	4	18		58	1	54	18	3	5		1	4	2	STORY STREET & MAMIE EISENHOWER AVE.
3	STORY STREET & 7TH STREET		1	2	79	3.3	27	1			8		2							1	18			1						1	2	10		3		2	3			2	21,762	1	23	2	51	2	59	11	2	2		5		3	STORY STREET & 7TH STREET
4	STORY STREET & 6TH STREET		9	2	65	2.7	20	3			12		2							1	10			3					1		5						3	1			16,757	5	15	1	40	4	43	10	4	4		4		4	STORY STREET & 6TH STREET
5	STORY STREET & 11TH STREET	1	5		42	1.8	9		1		6		8							4	8		2							2				3		1					30,170		12		30		28	8	1	5			2	5	STORY STREET & 11TH STREET
6	ALLEN STREET & 8TH STREET				38	1.6	5				14										3	7	2							3							1			1	1	13,999	2	6		30		23	8	2	4		1	3	6	ALLEN STREET & 8TH STREET
7	STORY STREET & 10TH STREET		2		36	1.5	5				7		2							1	7						1	2	1						5		1				4	10,423	1	14		20	1	21	6	1	6		2	1	7	STORY STREET & 10TH STREET
8	STORY STREET & 9TH STREET				35	1.5	14	1			5									1	4								1	2	1				2	2				2	1	8,445	2	11		19	3	21	8		3		3		8	STORY STREET & 9TH STREET
9	KEELER STREET & 8TH STREET	1	1		29	1.2	1				17											2													1	2			1		3	9,766	1	6		22		21	5	1	2			1	9	KEELER STREET & 8TH STREET
10	STORY STREET & 5TH STREET		1		28	1.2	1	1			3							2		2									1		7		4		3				2		1	7,922	3	7		17	1	22	4		1		1		10	STORY STREET & 5TH STREET
11	GREENE STREET & 7TH STREET	1*	5	1	23	1.0					1					1	9				2				1		2		3	1					1						10,080		4	1	18		16	2	1	4			1	11	GREENE STREET & 7TH STREET
12	LINN STREET & 9TH STREET AT UNDERPASS		5		23	1.0	3					6				3													1						1				7	1			1	9,385	2	7		13	1	7	4		12			1	12	LINN STREET & 9TH STREET AT UNDERPASS
13	DIVISION STREET & 7TH STREET		4		23	1.0	7				3					2	5												4						2						9,110	1	9		13		11	4	1	7			1	13	DIVISION STREET & 7TH STREET
14	MARSHALL STREET & MAMIE EISENHOWER AVE.		7		21	0.9	2				2					3	10											2		1	1									14,495	1	2		18		15	4		2				14	MARSHALL STREET & MAMIE EISENHOWER AVE.
15	BENTON STREET & MAMIE EISENHOWER AVE.		4		20	0.8	7				1					2	7											1		1	1									9,930	3	2		14	1	8	2		10				15	BENTON STREET & MAMIE EISENHOWER AVE.
16	GREENE STREET & 11TH STREET		4		19	0.8	9				2					4	2		1		1																				8,330	1	3		15		8	2	1	8			1	16	GREENE STREET & 11TH STREET
17	CARROLL STREET & 6TH STREET		7		18	0.8					1	1							1		9								1							1	3				16,085		6		11	1	10	7		1			1	17	CARROLL STREET & 6TH STREET
18	GREENE STREET & 8TH STREET		5		17	0.7	3				1					3	4		1										1			1				2	1				6,300	1	1		15		7	4	2	4				18	GREENE STREET & 8TH STREET
19	CARROLL STREET & 10TH STREET		11		16	0.7										1					10								1						3				1		9,539	1	4		10	1	8		5	3				19	CARROLL STREET & 10TH STREET
20	BENTON STREET & 8TH STREET		10		16	0.7	2				1	1				2	3												1		1				1				3		9,350		9		6	1	8			6		2	1	20	BENTON STREET & 8TH STREET
21	MARION STREET & MAMIE EISENHOWER AVE.		3		16	0.7	4				1	1				2	2					1							1		2				2						7,318	2	2		12		11	3	1	1			1	21	MARION STREET & MAMIE EISENHOWER AVE.
22	STORY STREET & U.S. HIGHWAY 30		6		15	0.6	4			1						1	2		2		1							1						2		1					11,830	1	3	2	9		10	1		4			4	22	STORY STREET & U.S. HIGHWAY 30
23	GREENE STREET & MAMIE EISENHOWER AVE.		5		15	0.6	4					1				3	3		2										1						1						10,743		3		12		7	2	1	3		2	2	23	GREENE STREET & MAMIE EISENHOWER AVE.
24	TAMA STREET & 6TH STREET		5		15	0.6	1				1										13																				8,875	1	1		12	1	11	1	1	1		1	1	24	TAMA STREET & 6TH STREET
	TOTALS FOR STUDIED INTERSECTIONS	4	124	8	775	32.6	169	14	1	2	111	10	23	1	2		27	49		29	59	44	10	5	2	6	2	4	24	17	20	2	12		35	15	3	1	26		4	7	13	1	8	17	315,500	39	192	6	516	22	490	129	27	102		27	29		TOTALS FOR STUDIED INTERSECTIONS
	TOTALS FOR ALL OTHER INTERSECTIONS	7	402	19	1518	63.8	155	17	2	4	235	55	1			7	47	135	9	32	23	204	21	19	2	5	7		44	35	7	5	17	5	168	7		1	141	2	5	10	8	1	21	61	829,050	75	326	66	980	71	883	229	63	274	5	64	80		TOTALS FOR ALL OTHER INTERSECTIONS
	TOTALS FOR NON-INTERSECTIONS		3		61	2.6	3	2			7	5								2	1		3						1			2		8				14		1			2		10	26,849		16	7	27	11	33	7	2	12		7	4		TOTALS FOR NON-INTERSECTIONS
	TOTALS FOR ALLEYS (NON-INTERSECTIONS)	1	1		26	1.1					10					1		1			1		2							2								6							3	6,424	2	3	4	16	1	15	3	2	1	1	4	1		TOTALS FOR ALLEYS (NON-INTERSECTIONS)
	TOTALS	12	530	27	2380		327	33	3	6	363	70	24	1	2	8	74	185	9	63	84	248	36	24	4	11	9	4	69	54	27	9	29	5	211	22	3	2	187	2	10	17	21	4	29	91	1,177,823	116	537	83	1539	105	1421	368	94	389	6	102	114		TOTALS
	% DISTRIBUTION						13.7	1.4	0.1	0.3	15.3	2.9	1.0	0.0	0.1	0.3	3.1	7.8	0.4	2.6	3.5	10.4	1.5	1.0	0.2	0.5	0.4	0.2	2.9	2.3	1.1	0.4	1.2	0.2	8.9	0.9	0.1	0.1	7.9	0.1	0.4	0.7	0.9	0.2	1.2	3.8		4.9	22.6	3.5	64.7	4.4	59.7	15.5	3.9	16.3	0.3	4.3	4.8		% DISTRIBUTION

*PEDESTRIAN FATALITY

Table 2-2. Tabulation of Accident Data.

Table 2-2 also contains the number of accidents per violation classification and gives the percentage of total accidents for each classification. As an example, the highest percentages of street or alley accidents were due to improper backing, which accounted for 15.3 percent of all accidents. Other major violations included rear-end collisions (13.7 percent of all the accidents), failure to yield right-of-way-to-right (10.4 percent), and hitting object or parked vehicle on roadway (8.9 percent).

During the five-year period studied, there were a total of 376 accidents that occurred in off-street areas such as in parking lots. These have been listed in Table 2-3.

TABLE 2-3

TABULATION OF OFF-STREET ACCIDENTS

LOCATION	NUMBER OF ACCIDENTS
Randall's Super Valu	38
Boone High School	24
Fareway Parking Ramp	21
Safeway	20
Hospital Parking Lot	16
Gibsons	16
Casey's	9
Hardees	8
Others	224
TOTAL	376

The 24 studied intersections have been ranked from most dangerous to least dangerous, as shown in Table 2-4. When ranked according to the highest incidence of accidents, the intersection of Story Street and Eighth Street ranked most dangerous, followed by the intersections of Story Street with Mamie Eisenhower Avenue and Story Street with Seventh Street. (Lower numbers are indicative of more dangerous intersections.) In instances where two or more intersections have the same number of accidents, these are ranked in regard to their respective total property damage cost, with the higher such cost corresponding to a lower numerical rating.

By another ranking regarding the total number of injuries, (pedestrian and non-pedestrian) the intersection of Story Street with Mamie Eisenhower Avenue ranked most dangerous, with 22 reported injuries. The intersections of Carroll Street with Tenth Street and Story Street with Sixth Street each accounted for eleven traffic injuries. In instances where two or more intersections have identical numbers of injuries, they are ranked so that those with the greatest number of injuries per number of accidents receive the lower rating.

The third ranking shown in Table 2-4 is in regard to the total property damage costs of the respective intersections. The intersection of Story Street with Mamie Eisenhower Avenue was also the scene of greatest property damage, followed by Story Street and Eleventh Street, and Story Street and Seventh Street.

Generally, as traffic volumes rise, an increase in number and rate of traffic accidents can be expected, with accompanying increases in fatalities, injuries and property damage. Accident rankings previously noted in Table 2-4 are based entirely on number of accidents, injuries, and dollars. If two

TABLE 2-4

RANKING OF ACCIDENTS RELATIVE TO ACCIDENTS

	INTERSECTION IDENTIFICATION NUMBER	RANK			AVERAGE DAILY TRAFFIC ENTERING INTERSECTION
		Number of Accidents	Number of Injuries	Property Damage	
1.	8th Street and Story Street	1	14	6	9,300
2.	Mamie Eisenhower Avenue and Story Street	2	1	1	15,100
3.	7th Street and Story Street	3	19	3	9,400
4.	6th Street and Story Street	4	3	4	8,700
5.	11th Street and Story Street	5	13	2	6,900
6.	8th Street and Allen Street	6	24	8	6,800
7.	10th Street and Story Street	7	20	11	5,400
8.	9th Street and Story Street	8	23	20	7,200
9.	8th Street and Keeler Street	9	22	14	4,900
10.	5th Street and Story Street	10	21	22	7,700
11.	7th Street and Greene Street	11	8	12	8,400
12.	Linn Street and 9th Street - Underpass	12	12	16	8,700
13.	7th Street and Division Street	13	17	18	4,300
14.	Mamie Eisenhower Avenue and Marshall Street	14	6	7	9,100
15.	Mamie Eisenhower Avenue and Benton Street	15	16	13	9,500
16.	11th Street and Greene Street	16	15	21	6,100
17.	6th Street and Carroll Street	17	5	5	2,200
18.	8th Street and Greene Street	18	11	24	8,500
19.	10th Street and Carroll Street	19	2	15	800
20.	8th Street and Benton Street	20	4	17	9,700
21.	Mamie Eisenhower Avenue and Marion Street	21	18	23	7,200
22.	U.S. 30 and Story Street	22	7	9	13,200
23.	Mamie Eisenhower Avenue and Greene Street	23	10	10	9,800
24.	6th Street and Tama Street	24	9	19	1,100

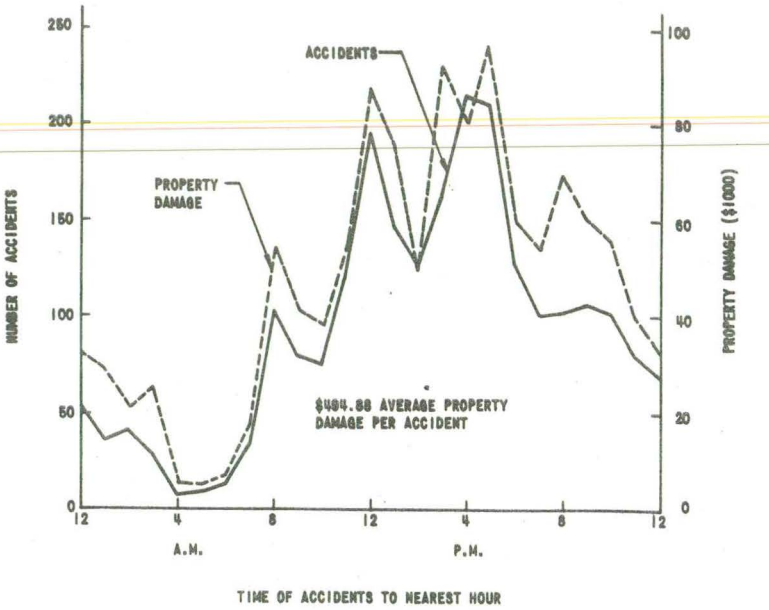
intersections with exactly the same statistics relative to accidents, injuries and property damage were compared only on the basis of such figures, they would be equally ranked. However, if one such intersection had an average traffic volume of only half of that of the other intersection, it could be readily recognized that this intersection is actually twice as dangerous as the latter.

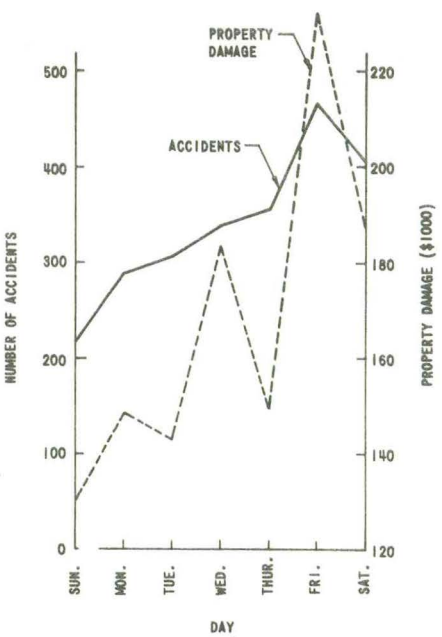
The final column in Table 2-4 shows the estimated number of vehicles entering each intersection during an average day. It is apparent that certain intersections, such as Story Street and Mamie Eisenhower Avenue, have both heavy traffic volumes and high accident frequencies. Other intersections, such as Story Street and U.S. Highway 30, appear to be relatively safe considering the heavy traffic volumes present.

The graphs in Figure 2-1 summarize the hourly, daily and monthly variations in accident occurrence. According to these figures, derived from five years of accident data, it is evident that most accidents occur during the month of December, that Fridays are generally more dangerous than other days of the week and that more accidents occur between 4:30 and 5:30 P.M. when compared on an hourly basis.

During the aforementioned five-year period, the frequency of traffic accidents has been relatively stable, except for the year 1975 when an increased number of accidents were reported. The following is a listing of the total number of accidents for the respective years:

1972 - 548 accidents
1973 - 537 accidents
1974 - 529 accidents
1975 - 609 accidents
1976 - 533 accidents
Average - 551 accidents per year





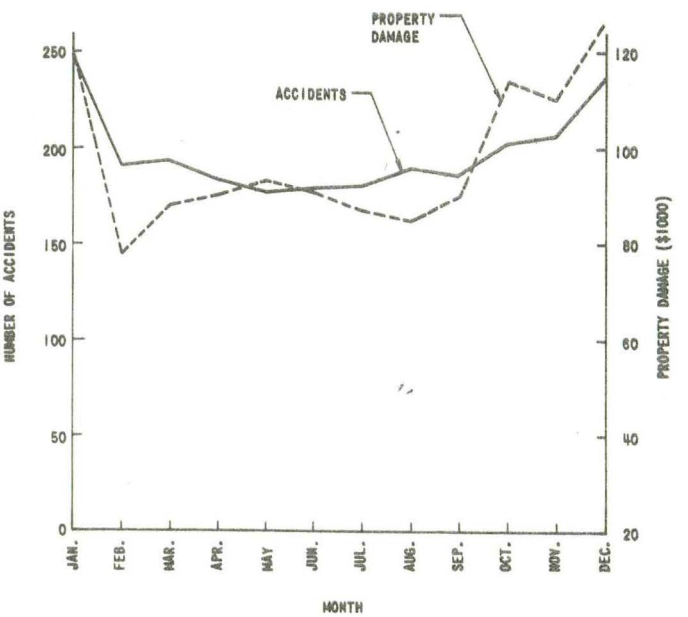


Fig. 2-1. Hourly, Daily and Monthly Variation in Accident Experience.

TABLE 2-5

TYPES OF VEHICLES INVOLVED IN ACCIDENTS

VEHICLE TYPE, PEDESTRIAN OR OBJECT	NUMBER OF VEHICLES	PERCENTAGE OF VEHICLES
Passenger Car	3,771	81.9
Pick-up Truck or Van	305	6.6
Motorcycle	83	1.8
Bicycle	33	0.7
Pedestrian	27	0.6
Truck or Bus	227	4.9
Train	12	0.3
Animal	4	0.1
Unknown	141	3.1
TOTALS	4,603	100.0%

Table 2-5 lists the various types of vehicles that have been involved in accidents in Boone during the five-year period analyzed. Those listed as "unknown" are due to absence of such information on accident reports, including hit-and-run accidents. From Table 2-5, it is apparent that the most common type of vehicle involved in accidents is the passenger car.

Table 2-6 indicates the types of vehicles at fault relative to collisions with other vehicles. Passenger cars have been the vehicle at fault in 1,885 of the 2,380 total accidents. Pick-up trucks have been at fault in 167 of the collisions, while trucks or buses have been at fault in 126 collisions. Table 2-6 contains similar data for other combinations of vehicles, pedestrians and animals.

TABLE 2-6

TYPES OF VEHICLES AT FAULT IN ACCIDENTS

VEHICLE AT FAULT	PASSENGER CAR	PICK-UP OR VAN	TRUCK OR BUS	MOTORCYCLE	BICYCLE	PEDESTRIAN	PARKED VEHICLE	ANIMAL	OBJECT ON ROADWAY	RAN OFF ROADWAY	RAN OFF ROADWAY AND HIT FIXED OBJECT	TRAIN	OTHER NON-COLLISION	OVERTURNED ON ROADWAY	UNKNOWN	NO DATA
Passenger Car	1,138	71	64	28	9	8	343	1	10	36	153	8	4	2	6	4
Pick-up or Van	92	8		2			38		3	5	18		1			
Truck or Bus	68	3	8			1	32		1		7	2	1	2		1
Motorcycle	19	2	1	2			3			3		2	1	6		
Bicycle	13	5		1												
Pedestrian	11	1		1												
Animal	2			1												
Unknown	19	1	3		1		104									

A breakdown of driver characteristics relative to age and sex for the 2,380 street and alley accidents occurring within the five-year period analyzed is shown in Table 2-7. Of the 3,990 drivers involved in these accidents, 62.3 percent were males and 32.9 percent were females. According to the age of drivers involved in accidents, the highest percentage age group was under 21 years of age, accounting for 28.8 percent of the involvements.

TABLE 2-7

DRIVER CHARACTERISTICS

AGE OF DRIVER	SEX OF DRIVER								AGE OF DRIVER AT FAULT*	
	MALE		FEMALE		UNKNOWN OR NO DATA		TOTAL			
	Number of Drivers	Percent of Total	Number of Drivers	Percent of Total	Number of Drivers	Percent of Total	Number of Drivers	Percent of Total	Number of Drivers	Percent of Total Drivers at Fault
Under 21	799	20.0	350	8.8	--	--	1,149	28.8	687	29.1
21-25	371	9.3	160	4.0	--	--	531	13.3	316	13.4
26-30	232	5.8	130	3.3	--	--	362	9.1	177	7.5
31-40	266	6.7	190	4.8	--	--	456	11.4	237	10.1
41-50	193	4.8	145	3.6	--	--	338	8.5	182	7.7
51-60	191	4.8	129	3.2	--	--	320	8.0	167	7.1
61-70	193	4.8	96	2.4	--	--	289	7.2	164	7.0
Over 70	183	4.6	80	2.0	--	--	263	6.6	193	8.2
Unknown or No Data	60	1.5	32	0.8	190	4.8	282	7.1	234	9.9
Totals For Sex and Age	2,488	62.3	1,312	32.9	190	4.8	3,990	100.0		
Sex of* Driver at Fault	1,471	62.4	716	30.4	170	7.2	2,357	100.0		

*Figures exclude 23 accidents caused by unattended vehicles.

A further breakdown in Table 2-7 includes data relative to the drivers at fault in the 2,380 accidents, as opposed to the previous data which included all drivers involved in accidents. According to sex of driver at fault, 62.4 percent of the accidents were caused by male drivers. When compared according to age groups, 29.1 percent of the accidents were caused by drivers younger than 21 years of age.

Tables 2-8 and 2-9 present additional miscellaneous data not contained in Table 2-2, including weather, gradient, and vehicle defects. Most of the data in Tables 2-5 through 2-9 is included as general information, with little comment relative to such being made herein. It is evident that the majority of accidents occur during clear weather and on level streets, and that vehicle defects account for only a small percentage (2.9%) of the accidents.

TABLE 2-8

WEATHER AND GRADIENT CONDITIONS RELATIVE TO ACCIDENTS

WEATHER	NUMBER OF ACCIDENTS	PERCENTAGE OF ACCIDENTS
Cloudy	705	29.6
Foggy	24	1.0
Raining	169	7.1
Snowing	124	5.2
Sleeting	13	0.5
Misting	44	1.9
Clear	1,202	50.5
No Data	99	4.2
GRADIENT		
Level	1,795	75.4
Upgrade/Downgrade	474	19.9
Hillcrest	7	0.3
No Data	104	4.4

TABLE 2-9

VEHICLE DEFECTS RELATIVE TO ACCIDENTS

*VEHICLE DEFECTS	NUMBER OF VEHICLES	PERCENTAGE OF VEHICLES
Defective Brakes	37	1.6
Defective Lights	5	0.2
Tire or Power Failure	3	0.1
Accelerator Stuck	2	0.1
Other Defects	21	0.9
No Defects	1,680	70.6
No Data	632	26.5

*Vehicle of Driver at Fault

Table 2-10 is a tabulation of data relative to the physical and drinking condition of drivers at fault in accidents in Boone for the five-year period. The greatest percentages of drivers at fault were normal regarding physical condition and had not been drinking. The next largest percentage of the accident reports contained no information regarding either physical condition or drinking condition.

According to data obtained from the individual accident reports, charges were filed for approximately 39.1 percent of the 2,380 street and alley accidents. Many times, neither driver was charged due to the various conditions present at the time of the accident. At other occasions, however, no charges were filed when it appeared that driver fault was the cause of the accident.

TABLE 2-10

CONDITIONS OF DRIVER AT FAULT

PHYSICAL CONDITION	NUMBER OF DRIVERS	PERCENTAGE OF DRIVERS
Fatigued	21	0.9
Asleep	11	0.5
Ill	9	0.4
Physical Defect	28	1.2
Normal	1,784	74.9
No Driver*	23	0.9
Unknown or No Data	504	21.2
DRINKING CONDITION		
Drunk	28	1.2
Ability Impaired	86	3.6
Ability Not Impaired	81	3.4
Not Known if Drinking	219	9.2
Had Not Been Drinking	1,649	69.3
No Driver*	23	1.0
No Data	294	12.3

*Accidents Caused by Unattended Vehicles.

COLLISION DIAGRAMS

The diagrams in Figures 2-2 through 2-14 represent the various types of accidents that have occurred within the study period (1972 through 1976) for each respective street intersection included. The fold-out sheet following Figure 2-14 indicates the legend used for Figures 2-2 through 2-14 and includes an intersection identification number system index for each intersection studied in detail. These collision diagrams are useful in visualizing what types of accidents have been most common for each respective intersection. Other data included on the collision diagrams include the geometric characteristics of the intersection, the date and time of occurrence

of each accident, and the type of violation which caused the respective accidents. (This data may differ somewhat from that of Table 2-2, as the previous includes additional data on accidents near but not necessarily within the respective intersections. In general, accidents which occurred more than 50 feet from the intersections do not appear on the collision diagrams.) The location of the arrows in the collision diagrams were drawn as closely as possible to the likely point of occurrence of the respective accidents. For clarity, however, the point of occurrence of some accidents was shifted, particularly for intersections at which many accidents have occurred.

Generally, according to the aforementioned five years of traffic accident records, accidents are more numerous at intersections where some type of traffic control device is present. Most rear-end collisions result from vehicles running into other vehicles that are waiting at a traffic signal or stop sign. Most improper backing violations have occurred in the central business district whereby motorists back from a parking stall either into the path of an oncoming vehicle or into a vehicle that was parked nearby. Most common types of accidents at locations of stop signs are caused by failure to stop or by driving into the right-of-way of another vehicle after stopping.

Several intersections which have no traffic control devices have also been the scene of frequent traffic accidents. The most common cause of accidents at such uncontrolled intersections is failure to yield right-of-way to the vehicle to the right.

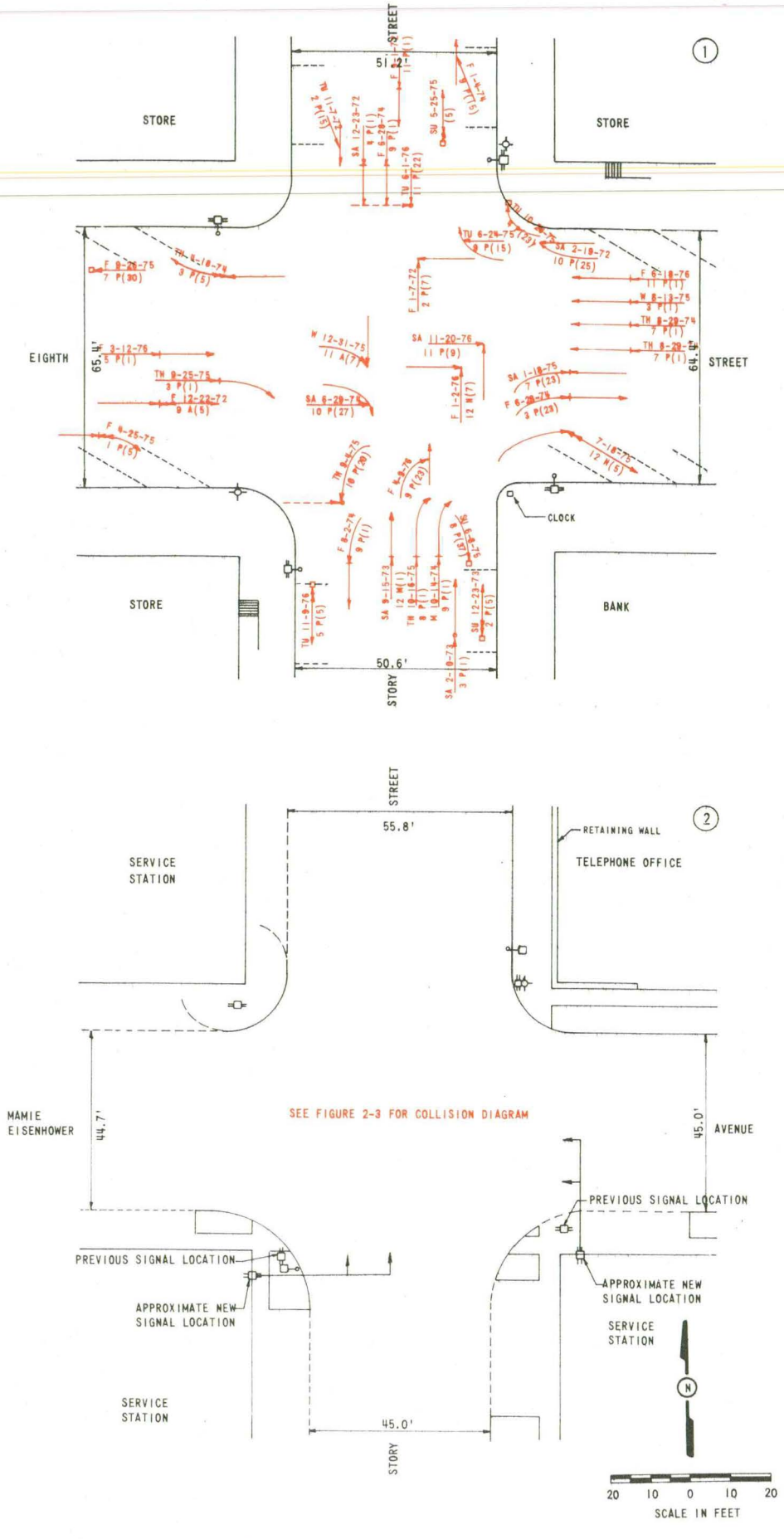


Fig. 2-2. Collision Diagram for Intersection No. 1.

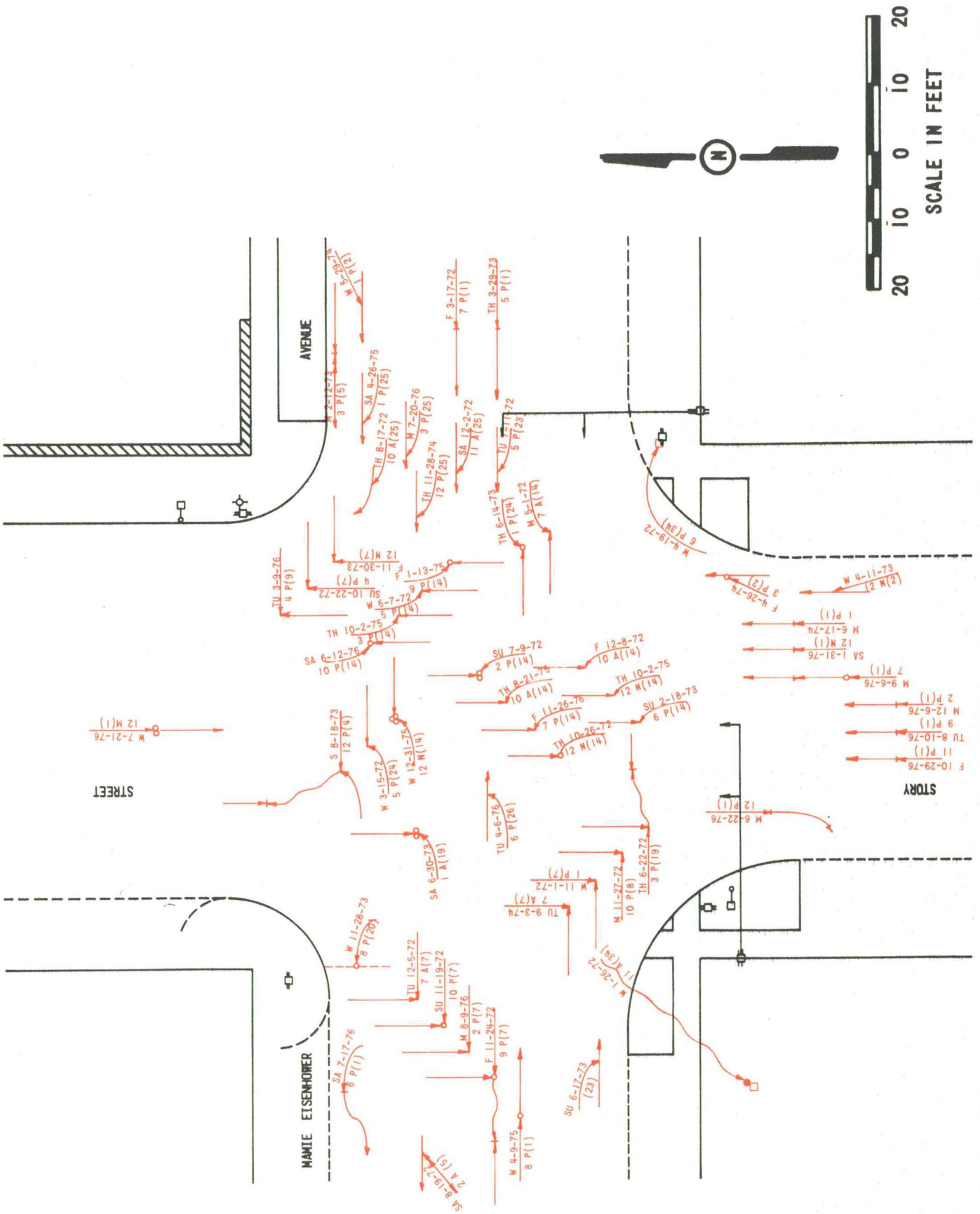


Fig. 2-3. Collision Diagram for Intersection No. 2.

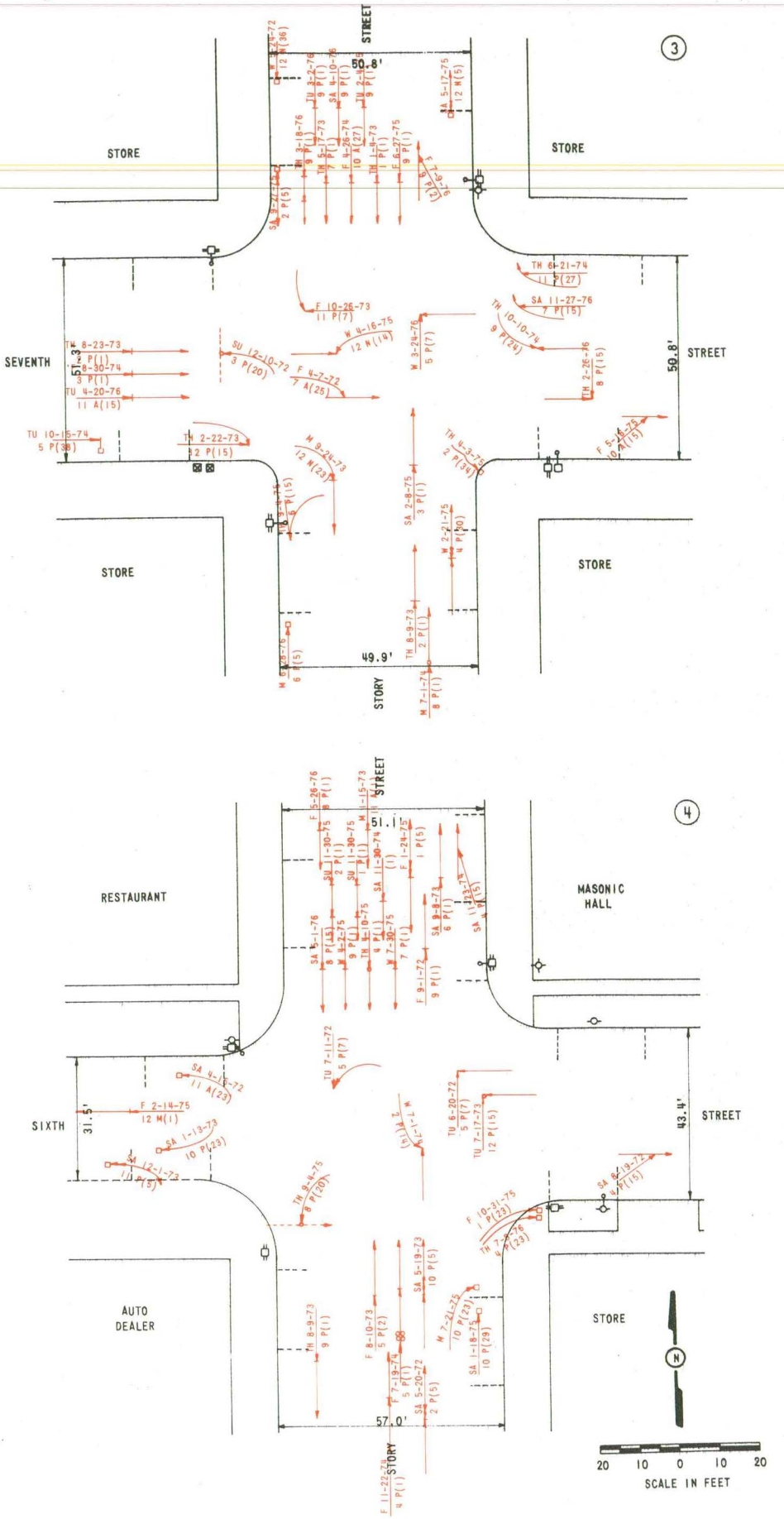


Fig. 2-4. Collision Diagrams for Intersection Nos. 3 and 4.

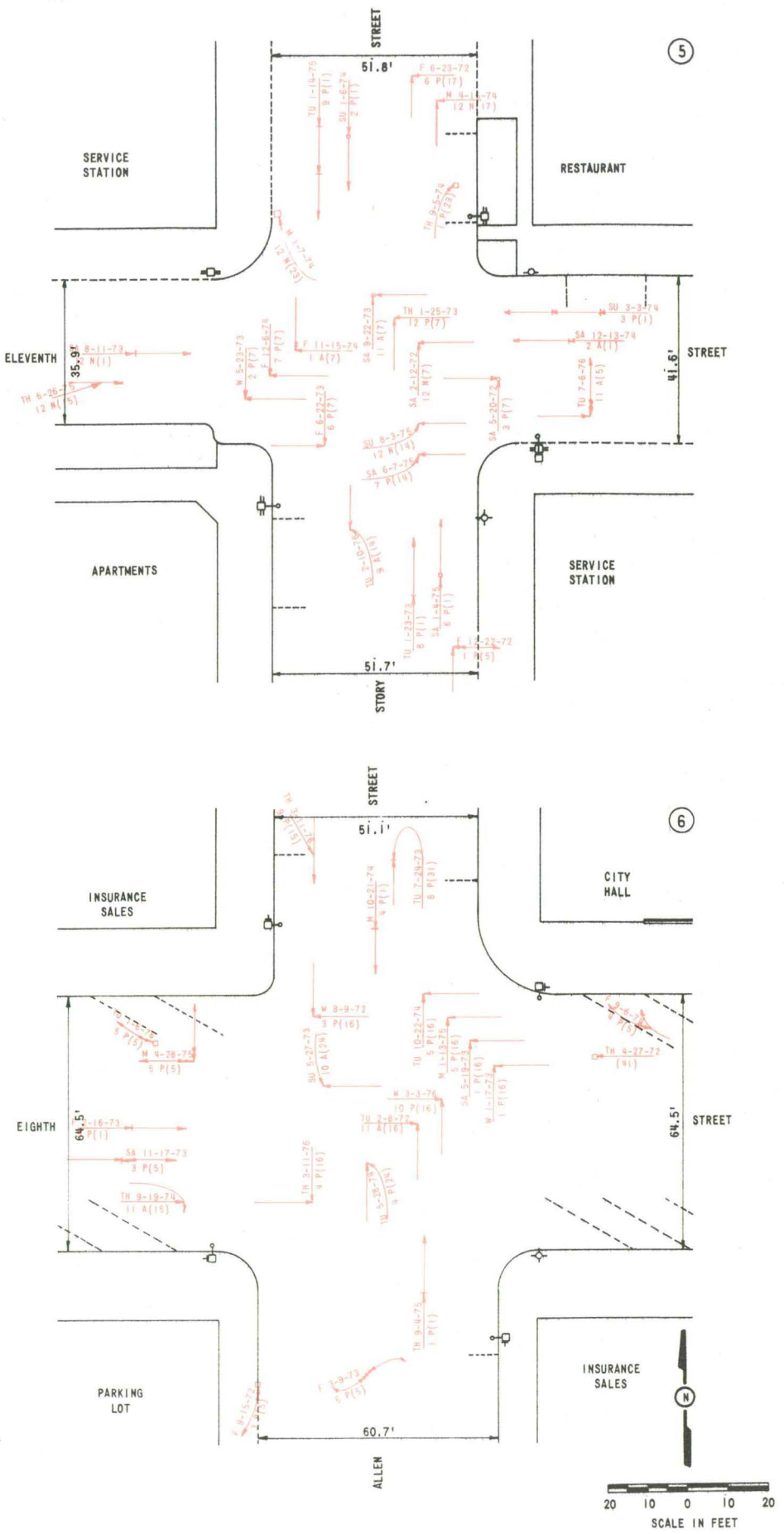


Fig. 2-5. Collision Diagrams for Intersection Nos. 5 and 6.

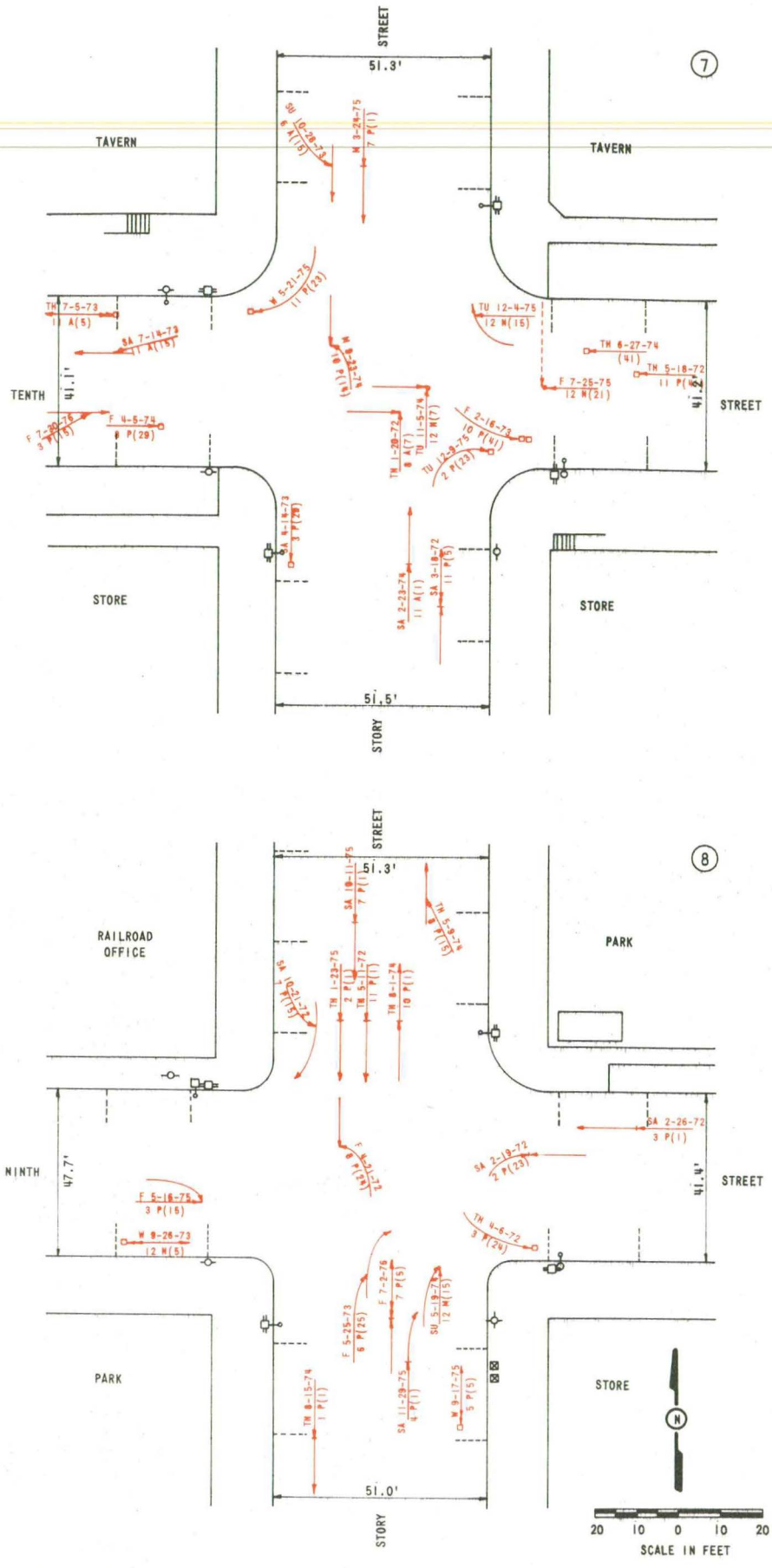


Fig. 2-6. Collision Diagrams for Intersection Nos. 7 and 8.

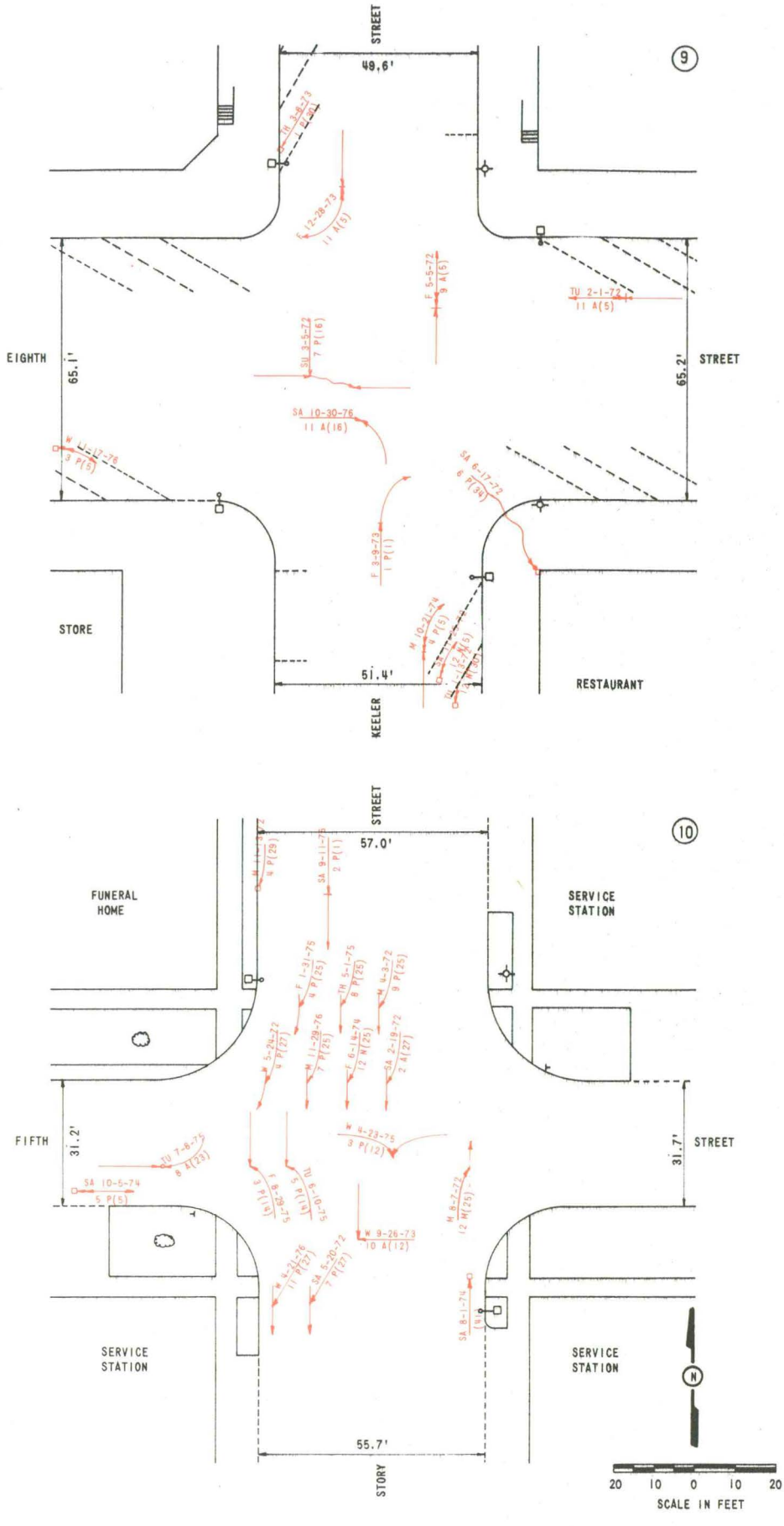


Fig. 2-7. Collision Diagrams for Intersection Nos. 9 and 10.

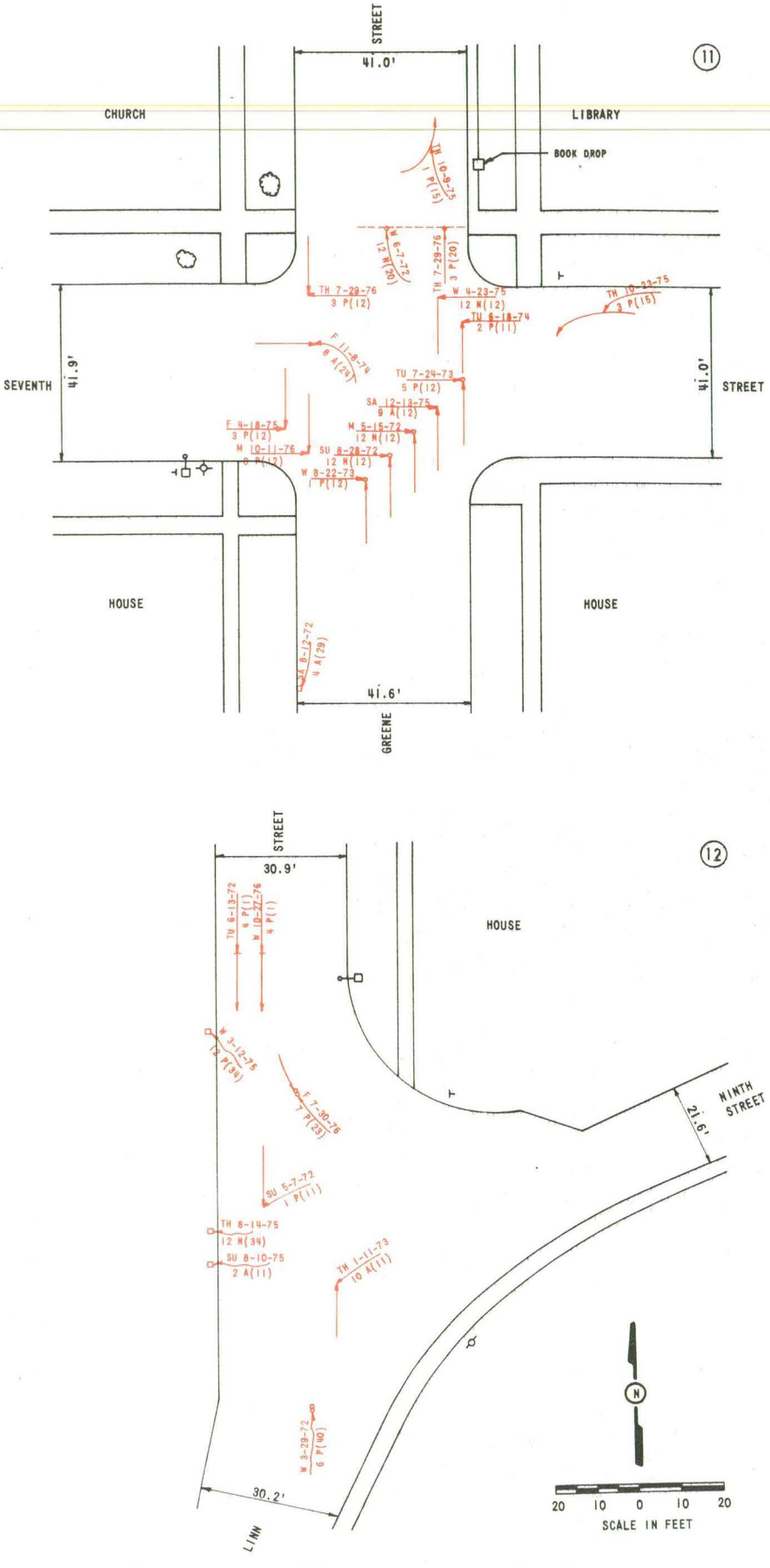


Fig. 2-8. Collision Diagrams for Intersection Nos. 11 and 12.

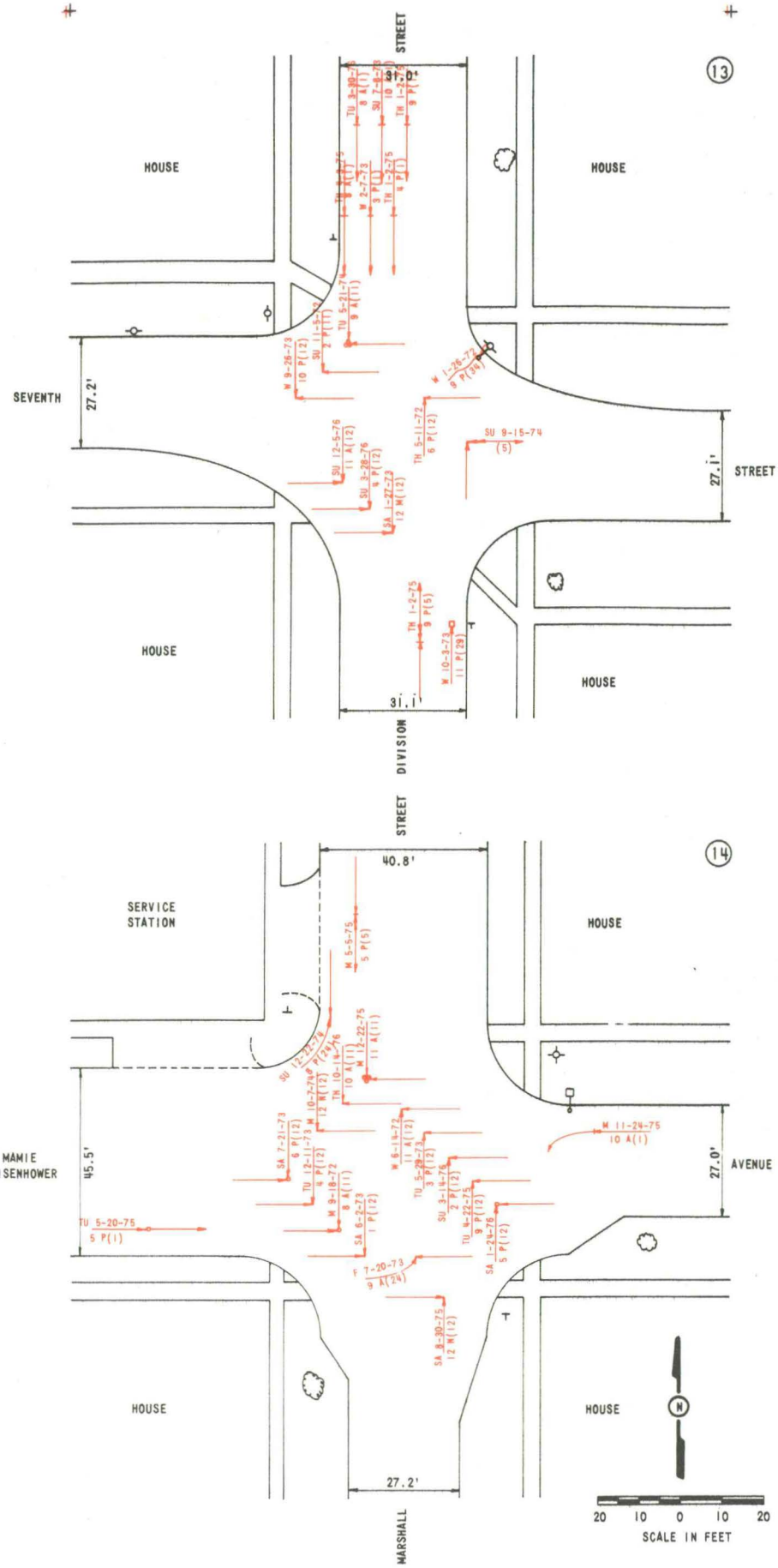


Fig. 2-9. Collision Diagrams for Intersection Nos. 13 and 14.

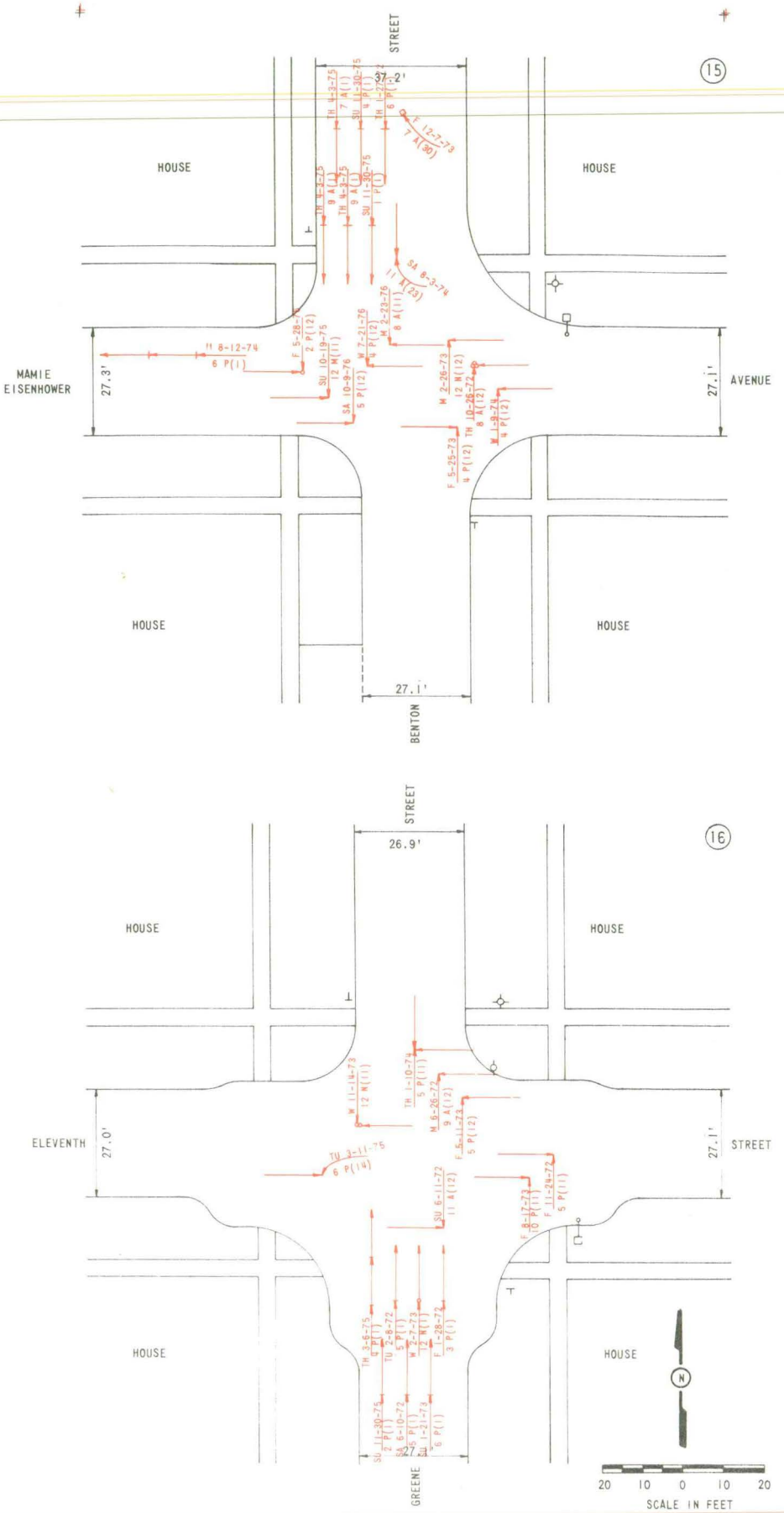


Fig. 2-10. Collision Diagrams for Intersection Nos. 15 and 16.

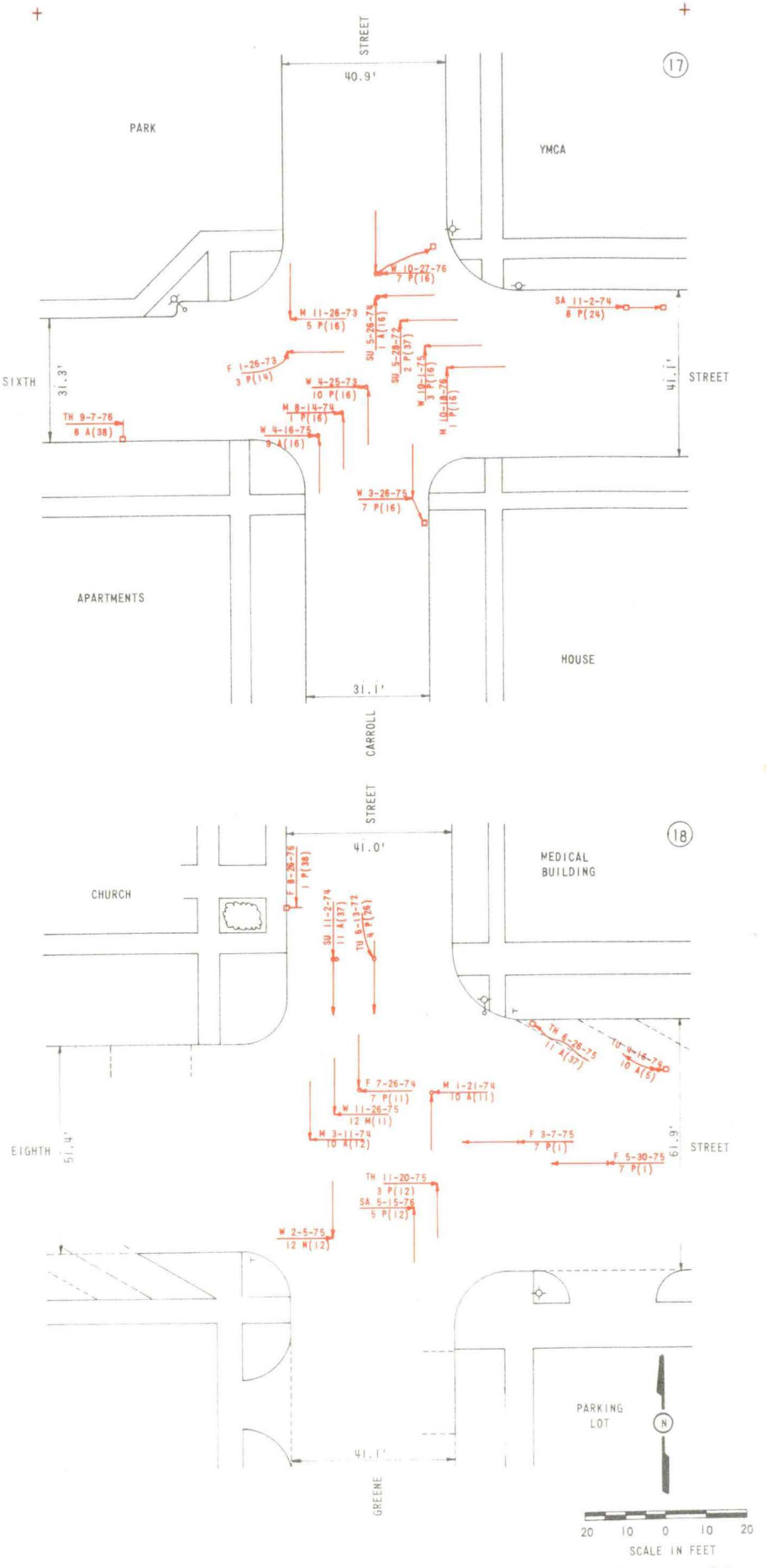


Fig. 2-11. Collision Diagrams for Intersection Nos. 17 and 18.

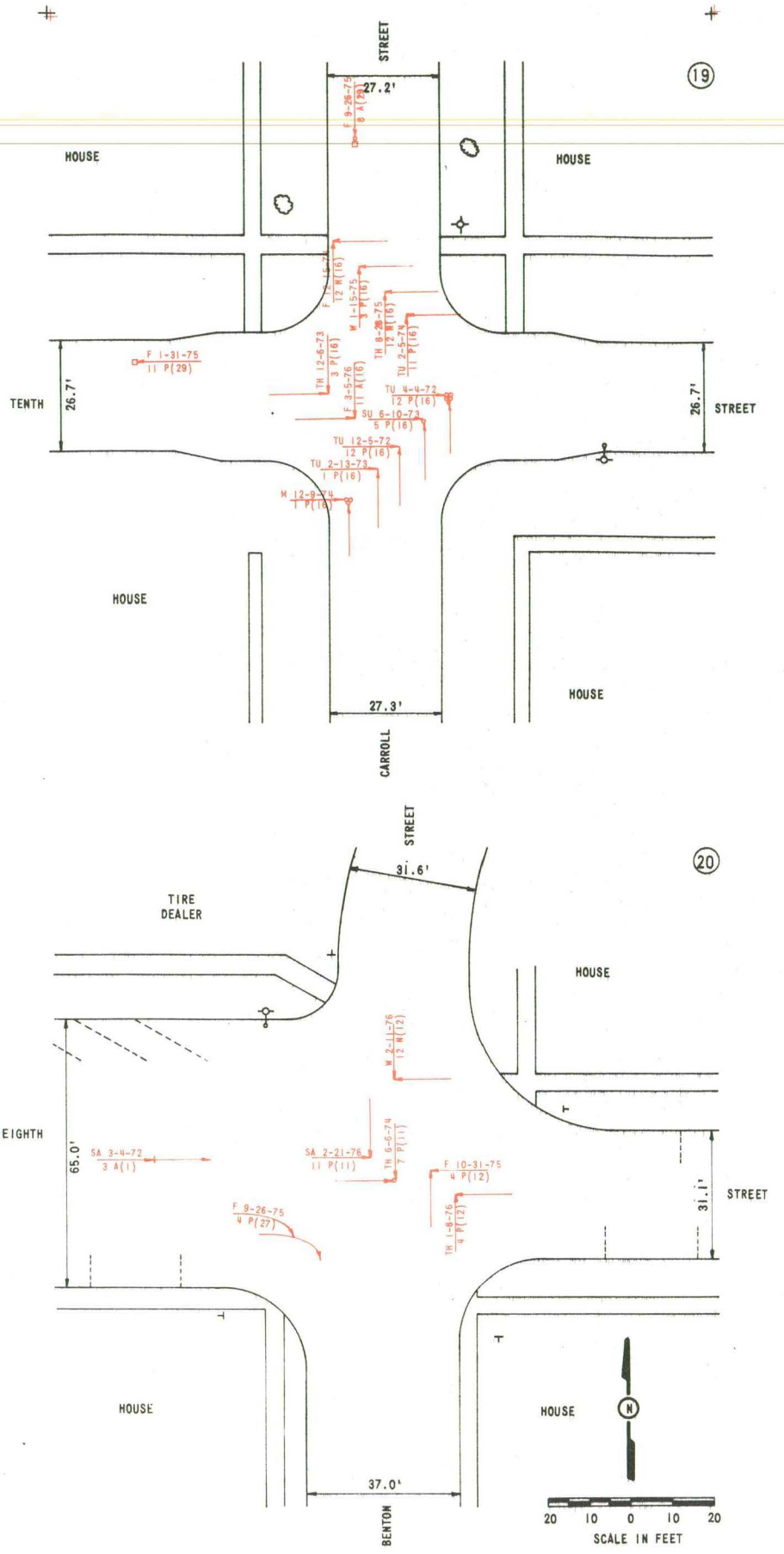


Fig. 2-12. Collision Diagrams for Intersection Nos. 19 and 20.

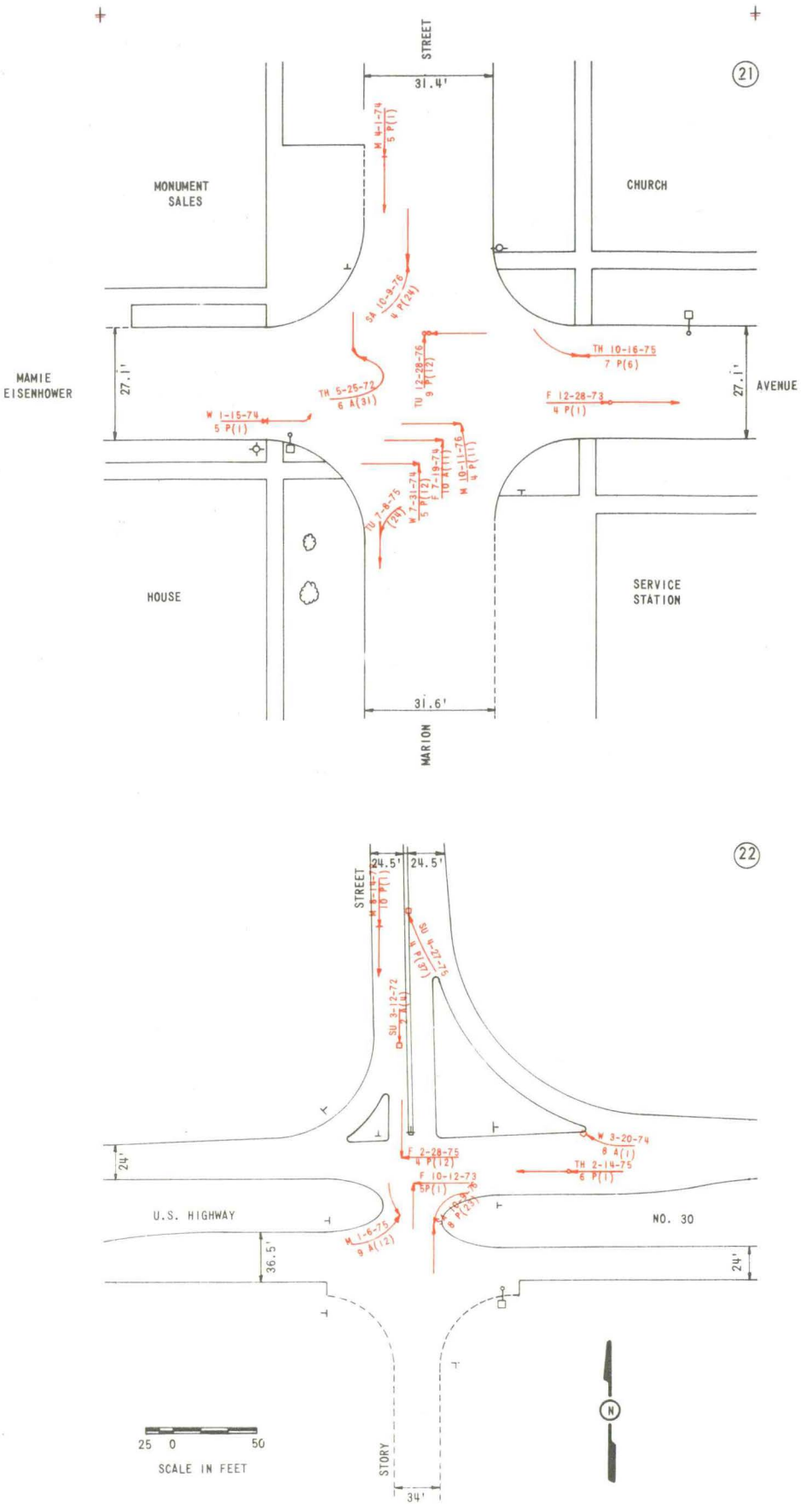


Fig. 2-13. Collision Diagrams for Intersection Nos. 21 and 22.

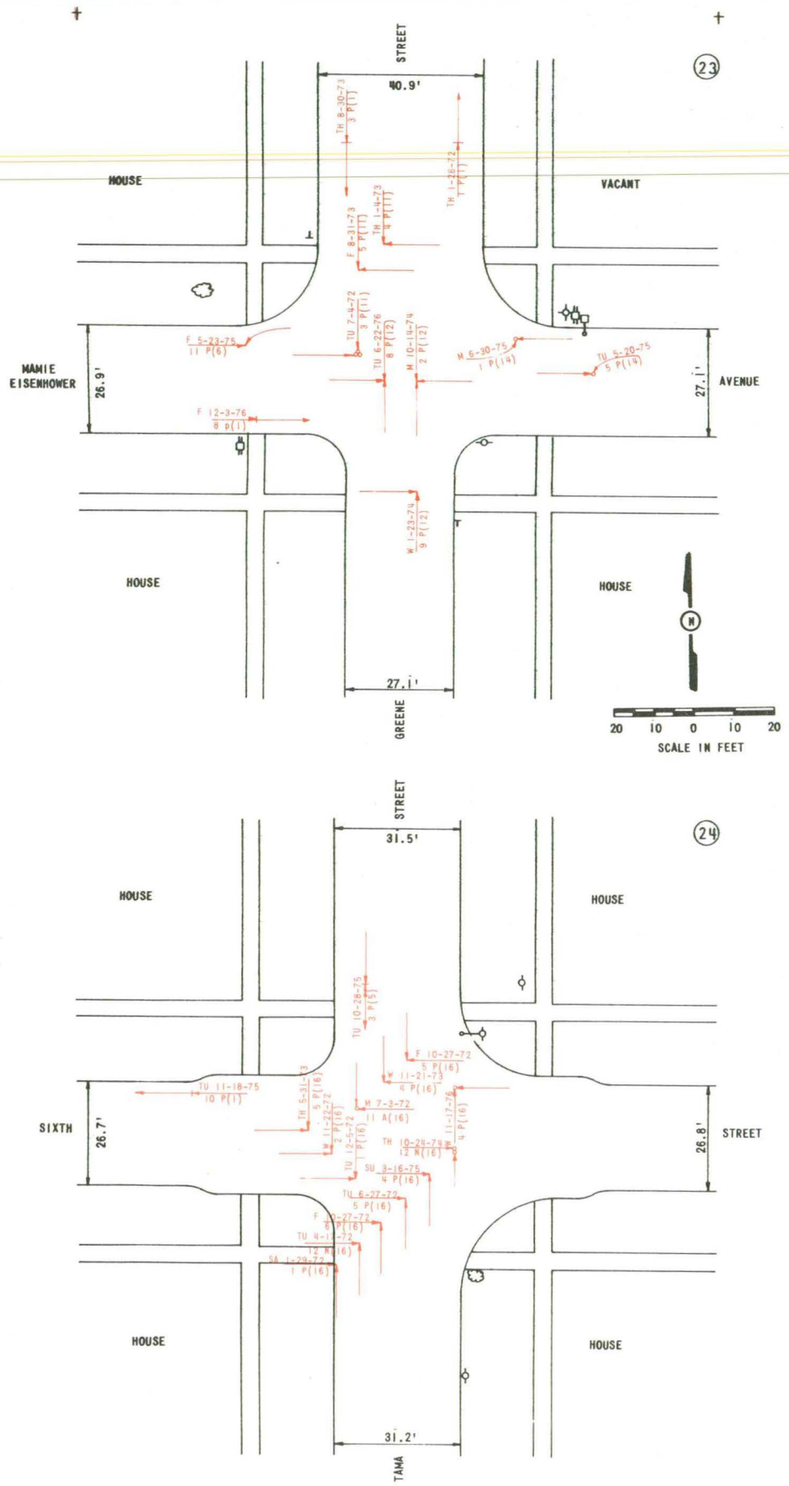


Fig. 2-14. Collision Diagrams for Intersection Nos. 23 and 24.

LEGEND

- UTILITY POLE
- FIRE HYDRANT
- MAIL BOX
- TRAFFIC SIGNAL
- STOP SIGN
- STREET LIGHT ON POWER POLE
- STREET LUMINAIRE
- TREE
- (5) COUNTING STATION
- 5 INTERSECTION IDENTIFICATION NUMBER
- PATH OF MOVING VEHICLE
- PATH OF PEDESTRIAN OR BICYCLE
- PATH OF BACKING VEHICLE
- OUT OF CONTROL VEHICLE
- PARKED VEHICLE
- OBJECT IN ROADWAY
- TRAFFIC INJURY
- OPEN DOOR IN TRAFFIC
- TRAFFIC FATALITY

M 12-8-72
6 P(01)

DAY OF WEEK
SU-SUNDAY
M-MONDAY
TU-TUESDAY
W-WEDNESDAY
TH-THURSDAY
F-FRIDAY
SA-SATURDAY
MONTH-DAY-YEAR
TIME
A-A.M.
P-P.M.
12N-NOON
12M-MIDNIGHT
CODE INDICATING TYPE OF TRAFFIC ACCIDENT VIOLATION

NOTE: ACCIDENT DATA INCLUDING TYPE OF TRAFFIC ACCIDENT VIOLATION, DESIGNATES VEHICLE CAUSING ACCIDENT

INDEX OF INTERSECTION DIAGRAMS

FIGURE NUMBER FOR COLLISION DIAGRAM	FIGURE NUMBER FOR GEOMETRICS AND TRAFFIC VOLUMES	INTERSECTION IDENTIFICATION NUMBER	INTERSECTIONS
2-2	4-2	1	8TH STREET & STORY STREET
2-3		2	MAMIE EISENHOWER AVE. & STORY STREET
2-4	4-3	3	7TH STREET & STORY STREET
		4	6TH STREET & STORY STREET
2-5	4-4	5	11TH STREET & STORY STREET
		6	8TH STREET & ALLEN STREET
2-6	4-5	7	10TH STREET & STORY STREET
		8	9TH STREET & STORY STREET
2-7	4-6	9	8TH STREET & KEELER STREET
		10	5TH STREET & STORY STREET
2-8	4-7	11	7TH STREET & GREENE STREET
		12	LINN STREET & 9TH STREET - UNDERPASS
2-9	4-8	13	7TH STREET & DIVISION STREET
		14	MAMIE EISENHOWER AVE. & MARSHALL STREET
2-10	4-9	15	MAMIE EISENHOWER AVE. & BENTON STREET
		16	11TH STREET & GREENE STREET
2-11	4-10	17	6TH STREET & CARROLL STREET
		18	8TH STREET & GREENE STREET
2-12	4-11	19	10TH STREET & CARROLL STREET
		20	8TH STREET & BENTON STREET
2-13	4-12	21	MAMIE EISENHOWER AVE. & MARION STREET
		22	U.S. 30 & STORY STREET
2-14	4-13	23	MAMIE EISENHOWER AVE. & GREENE STREET
		24	6TH STREET & TAMA STREET

The following paragraphs summarize the most frequent accident causes at the 24 studied intersections:

Story Street Intersections (Nos. 1,2,3,4,5,7,8,10 and 22).

1. Story Street and Eighth Street (Figure 2-2, No. 1). Although the greatest number of accidents occurred near this intersection, the points of occurrence have been very scattered, with 36 of the 85 accidents occurring 60 feet or more from the intersection. (Such accidents are not depicted on the collision diagrams.) The majority of these accidents were improper backing violations and other parking-related accidents, Rear-end collisions accounted for 23 of the reported accidents, many of which involved vehicles waiting for a red traffic signal light. The remaining accidents were attributed to a variety of violations, with no other significant trends being evident.

2. Story Street and Mamie Eisenhower Avenue (Figure 2-3, No. 2). Although ranking second in total number of accidents, this intersection was the most dangerous location within the study area, accounting for 22 injuries and one fatality during the five-year study period. Left-turn violations were one of the most frequent causes, accounting for 13 accidents and 10 injuries. Right-turns from the wrong lane, improper lane changing and red-light violations were most prevalent on the east approach. Rear-end collisions caused the greatest number of accidents, although only 12 such accidents occurred within 50 feet of the intersection. The one traffic fatality at this intersection was not traffic related, but occurred when the driver suffered a coronary and struck a gas pump and light pole.

3. Story Street and Seventh Street (Figure 2-4, No. 3). Rear-end collisions were the major violation at this location, accounting for over one-third of the reported accidents. The majority of these accidents occurred on the north and south approaches. Failure to yield right-of-way from the curb was the cause of 18 additional accidents, while improper backing was listed as the cause in 8 instances. The remaining accidents were attributed to miscellaneous violations.

4. Story Street and Sixth Street (Figure 2-4, No. 4). Rear-end collisions were again the predominant type of accidents at this intersection, and were especially frequent on the north approach. Improper backing maneuvers and failure to yield right-of-way from the curb followed as major accident causes, although most such accidents occurred near parking spaces away from the intersection. Two trucks collided with the signal pole at the southeast corner of the intersection.

5. Story Street and Eleventh Street (Figure 2-5, No. 5). Red light violations and rear-end collisions were responsible for the most accidents at this intersection, with such accidents occurring on all four approaches. Parking-related accidents such as failure to yield right-of-way from the curb and improper backing were also frequent. One traffic fatality occurred 75 feet south of this intersection when a southbound vehicle struck a parked car and then struck a building.

6. Story Street and Tenth Street (Figure 2-6, No. 7). Of the 36 reported accidents at this intersection, 23 were related to parking maneuvers such as improper backing, failure to yield right-of-way from the curb and striking a parked car. Five additional accidents were caused by rear-end collisions, with the remainder being miscellaneous violations.

7. Story Street and Ninth Street (Figure 2-6, No. 8). Of the 35 reported accidents at this intersection, 14 were caused by rear-end collisions. A variety of other violations caused the remaining accidents, including 5 improper backing violations and 4 right-of-way from curb violations.

8. Story Street and Fifth Street (Figure 2-7, No. 10). At this intersection, 9 accidents on the north approach were attributed to vehicles being in the wrong lane, including improper passing violations and right turns from the left lane. No other significant accident trends are apparent at this location.

9. Story Street and U.S. Highway 30 (Figure 2-13, No. 22). Drivers approaching this intersection from the east have been responsible for the majority of the reported accidents, including three stop sign violations and two rear-end collisions at the intersection.

SUMMARY - STORY STREET INTERSECTIONS

Total Accidents at Studied Intersections - 466
Non-pedestrian Fatalities - 3
Pedestrian Fatalities - 1
Non-pedestrian Injuries - 32
Pedestrian Injuries - 2

Rear-end Collisions	121(26.0%)
Improper Backing Accidents	66(14.2%)
Right-of-Way from Curb Violations	54(11.6%)
Red Light Violations	23(4.9%)
Miscellaneous	202(43.3%)

Eighth Street Intersections (Nos. 6,9,18 and 20).

1. Eighth Street and Allen Street (Figure 2-5, No. 6). Improper backing violations were responsible for 14 of the 38 reported accidents at this intersection, although many such accidents involved parking maneuvers along the respective streets. The predominant cause of accidents within the intersection was failure to yield right-of-way to a vehicle

on the right. Traffic control, at this intersection consists of stop signs at all four approaches to the intersection.

2. Eighth Street and Keeler Street (Figure 2-7, No. 9). The only significant accident trend at this intersection involved improper backing maneuvers, which accounted for 17 of the 29 reported accidents. Two right-of-way-to-right violations have resulted in accidents; no traffic control devices are present at the intersection. One traffic fatality resulted when a driver suffered a coronary and struck a building.

3. Eighth Street and Greene Street (Figure 2-11, No. 18). Stop sign violations resulted in 7 of the 17 accidents at this intersection. Three eastbound drivers and four westbound drivers were at fault in such accidents.

4. Eighth Street and Benton Street (Figure 2-12, No. 20). Five accidents have been caused by stop sign violations at this intersection, where a four-way stop is in effect. Nine of the 11 injuries associated with this intersection occurred on the north leg of the intersection near the railroad viaduct, outside the limits of the collision diagram.

SUMMARY - EIGHTH STREET INTERSECTIONS (Excluding Story Street and Eighth Street).

Total Accidents at Studied Intersections - 100
Non-pedestrian Fatalities - 1
Non-pedestrian Injuries - 16

Improper Backing	33(33.0%)
Right-of-Way at Stop Sign	19(19.0%)
Rear-end Collisions	11(11.0%)
Miscellaneous	37(37.0%)

Mamie Eisenhower Avenue Intersections (Nos. 14,15,21 and 23).

1. Mamie Eisenhower Avenue and Marshall Street (Figure 2-9, No. 14). Stop sign violations were the predominant cause of accidents at this intersection, resulting in 13 accidents and 6 injuries. Seven of these accidents were caused by southbound vehicles, while 6 involved violations by northbound vehicles.

2. Mamie Eisenhower Avenue and Benton Street (Figure 2-10, No. 15). Nine of the 20 reported accidents at this intersection were attributed to stop sign violations, while rear-end collisions accounted for an additional 7 accidents. The majority of the rear-end collisions occurred on the north approach, and involved vehicles waiting at the stop sign.

3. Mamie Eisenhower Avenue and Marion Street (Figure 2-13, No. 21). Four stop sign violations resulted in accidents at this intersection, all being caused by northbound drivers. No other significant accident trends are apparent.

4. Mamie Eisenhower Avenue and Greene Street (Figure 2-14, No. 23). Stop sign violations were involved in 6 of the 15 reported accidents at this intersection, 5 of which were caused by southbound vehicles. Four rear-end collisions were also reported near the intersection.

SUMMARY - MAMIE EISENHOWER AVENUE INTERSECTIONS (Excluding Mamie Eisenhower Avenue and Story Street).

Total Accidents at Studied Intersections - 72
Non-pedestrian Injuries - 19

Stop sign Violations	32(44.4%)
Rear-end Collisions	17(23.6%)
Miscellaneous	23(31.9%)

Other Intersections (Nos. 11,12,13,16,17,19 and 24).

1. Greene Street and Seventh Street (Figure 2-8, No. 11). Ten of the 23 accidents at this location, as well as four injuries, were the result of stop sign violations. Of these accidents, 7 were caused when eastbound drivers stopped and then proceeded into the path of an approaching vehicle. Two pedestrians were struck in the north crosswalk, resulting in one injury and one fatality.

2. Railroad Viaduct Near Linn Street and Ninth Street (Figure 2-8, No. 12). The most frequent causes of accidents at this location include vehicles traveling to the left of the centerline, and vehicles striking a fixed object such as the viaduct structure. Nine injuries have resulted from such accidents.

3. Division Street and Seventh Street (Figure 2-9, No. 13). Vehicles approaching this intersection from the north have caused the majority of the accidents at this intersection. Rear-end collisions and stop sign violations each accounted for 7 of the 23 reported accidents.

4. Greene Street and Eleventh Street (Figure 2-10, No. 16). Rear-end collisions on the south approach were the most frequent cause of accidents at this intersection. Stop sign violations were also a significant cause of accidents, with northbound vehicles at fault in most occurrences.

5. Carroll Street and Sixth Street (Figure 2-11, No. 17). Half of all reported accidents at this intersection involved failure to yield right-of-way to a vehicle on the right. No stop signs or yield signs are presently installed at the intersection.

6. Carroll Street and Tenth Street (Figure 2-12, No. 19). Failure to yield right-of-way to a vehicle on the right resulted in 11 accidents and 9 injuries at this intersection. No stop or yield signs are presently in use at this location.

7. Tama Street and Sixth Street (Figure 2-14, No. 24). At this intersection, 13 of the 15 accidents during the study period were attributed to right-of-way violations. No traffic stop or yield signs are currently installed at the intersection.

Other Fatality Accidents

Eight fatalities occurred at other than the 24 studied intersections.

Separate accidents and two resulting fatalities occurred on Division Street at the signalized grade-crossing of the Chicago and North Western Transportation Company tracks. Each fatality resulted from a collision with a train. In one case, the motorist waited for an eastbound train to clear the crossing, then crossed the track into the path of an oncoming westbound train. The second accident occurred when the motorist attempted to cross the track in violation of the existing railroad crossing signal.

Another fatality resulted when a motorcycle went out of control on a McHose Park drive. The fourth fatality occurred on a trail on an old railroad right-of-way when a vehicle went over a 30-foot embankment.

The four remaining fatalities are tabulated in Table 2-11.

TABLE 2-11

DATA REGARDING OTHER FATALITY ACCIDENTS

LOCATION	ACCIDENT CODE	FAULT REGARDING DECEASED
Intersection of U.S. No. 30 and County Road No. R-27	12	At fault
Intersection of South Story Street and Frontage Road	24	Not at fault
Intersection of Story Street and Second Street	12	At fault
130' West of Intersection of Franklin and College Streets	34	Not at fault but Passenger of Driver at fault

None of the above-mentioned eight other fatalities can be attributed to any distinguishing features of the respective roadways. Based on the accident reports reviewed, all such accidents appeared to be caused by driver errors of the deceased or of other motorists.

LAW ENFORCEMENT RELATIVE TO TRAFFIC OFFENSES

According to annual reports of the Boone Police Department, numerous summonses have been issued to operators of motor vehicles, although, in many instances, no accidents occurred as a result of such offenses. Table 2-12 is a summary of the various offenses cited during the past two and one-half years. (January 1974 to June 1976) Arrests for speeding accounted for nearly one-half of the enforcement effort (43.78%), while drivers license and registration violations (13.54%), running stop signs (7.84%), and failure to yield right-of-way (6.29%) were also frequent

TABLE 2-12

BREAKDOWN OF TRAFFIC VIOLATIONS,
EXCLUDING PARKING VIOLATIONS.

	1974	1975	1976*	TOTAL	% of TOTAL
1. Speeding	491	261	208	960	43.78
2. Reckless Driving	18	15	8	41	1.87
3. Running Stop Signs	89	50	33	172	7.85
4. Illegal Passing and/or Turning	16	32	8	56	2.55
5. Failure to Set Hand Brakes	5	0	0	5	0.23
6. Failure to Yield Right-of-way	58	56	24	138	6.29
7. Failure to Have Vehicle under Control	18	18	9	45	2.05
8. Failure to Yield Half of Roadway	15	3	2	20	0.91
9. Following too Close	14	17	2	33	1.50
10. Improper start from Parked Position	10	3	2	15	0.69
11. Defective Lights or Brakes (memos)	86	23	34	143	6.52
12. Failure to Yield to Emergency Vehicle	0	2	0	2	0.09
13. Failure to Leave Aid and Information	14	6	1	21	0.96
14. Unnecessary Noise	57	50	15	122	5.56
15. Drivers License and Registration Violations	143	113	41	297	13.54
16. Driving with Obstructed Windshield	4	2	0	6	0.27
17. Failure to Stop in Assured Distance Ahead	7	1	3	11	0.50
18. Failure to Obey a Traffic Control Device	2	28	0	30	1.37
19. Illegal Stop on Roadway	1	2	1	4	0.18
20. Faulty Equipment (Summons)	20	14	8	42	1.92
21. Improper Lights	1	1	2	4	0.18
22. Striking Unattended Vehicle	2	2	3	7	0.32
23. Snowmobile Violations	3	1	0	4	0.18
24. Failure to report Personal Inj. Accd.	0	1	1	2	0.09
25. Throwing Snowballs	0	1	0	1	0.05
26. No Helmet	0	2	6	8	0.36
27. Spot Lamps	0	1	0	1	0.05
28. Drag Racing	0	2	0	2	0.09
29. Improper Eye Protection	0	1	0	1	0.05
TOTALS	1,074	708	411	2,193	100.0

*Includes January 1, 1976 - June 30, 1976 Only.

occurrences. In addition to those summonses listed in Table 2-11, the Boone Police Department issued 16,404 courtesy parking tickets and 70,619 illegal and overtime parking tickets during the same 2½-year period.

A comparison of law enforcement with traffic accidents shows that speeding violations result in a large share of traffic summonses, although only a small percentage of traffic accidents (0.3%) have been attributed to speeding. Improper backing maneuvers and rear-end collisions were the most frequent causes of accidents (29.0% of all accidents), while relatively few summonses have been issued for such offenses (approximately 1.2% of all summonses.) Stop sign violations and right-of-way violations have also resulted in numerous accidents, and a relatively large number of summonses have been issued for such violations. As previously stated, charges have been filed for 39.1% of the traffic accidents during the study period.

Since many traffic violations are unobserved except in the event of an accident, no conclusions have been drawn relative to the correlation between law enforcement and traffic accidents.

SUMMARY

During the evaluation of accident records covering the years 1972 through 1976, the following maps and tables were compiled:

1. Classification of accidents according to type of accident.

2. Tabulation of accidents, in vicinity of respective intersections, indicating numbers of injuries and accidents, amount of property damage, number of accidents of each type, light condition, surface condition, and rankings with respect to number of accidents, injuries and property damage.

3. Collision diagrams showing general location of each accident within their respective intersections, along with data regarding time of occurrence, number of fatalities and injuries, and cause of the respective accidents.

4. Graphs showing hourly, daily and monthly variations in accident occurrence for the five-year period, 1972-1976.

5. Discussion regarding predominant types of accidents per intersection or street.

6. Discussion relative to fatality accidents occurring at other than the 24 studied intersections.

7. Review of law enforcement regarding traffic violations.

It would appear that many or most of these accidents could have been averted if the respective drivers had been more careful while driving, stopping and parking, or had been more observant of the traffic control devices provided. In addition, numbers of accidents might never have occurred without the presence of conditions such as ice, snow or rain.

As many of the intersections displayed significant accident trends, these intersections will be studied in greater detail with the goal of preventing or reducing future accidents. The consequences that any modifications might have in other areas will also be considered. For example, accidents caused by improper backing from parking stalls may be decreased by modification of parking arrangements, but such may decrease the supply of on-street parking and could necessitate the creation of additional off-street parking. Further, installation of traffic control devices at an intersection where none exist presently will decrease the

number of "right-of-way-to-right" violations now occurring but might result in a corresponding increase in other types of accidents. A significant number of the reported accidents occurred at some distance from any intersection. Many of these accidents were caused solely by driver error, and cannot be attributed to any deficiencies in the roadway design.

As the scope of this report is to correlate the incidence of accidents with such factors as faulty road width, roadway design, signalization and existence of parking, specific recommendations will be made elsewhere in this report, where the aforementioned information will be used.

CHAPTER 3

TRAFFIC REGULATIONS & CONTROL DEVICES

SCOPE

The purpose of this chapter is to determine the existing conditions in the City of Boone regarding traffic regulations and control devices, and to assess their compliance with City ordinances and the Manual on Uniform Traffic Control Devices. (The MUTCD has been adopted by the State of Iowa as part of the Iowa Code.) Topics to be discussed in this chapter include functional classification of the existing street system, location and operation of existing traffic control devices and speed limits. This chapter serves as an evaluation of existing conditions, while most recommendations concerning these topics will be presented in subsequent chapters.

FUNCTIONAL CLASSIFICATION OF EXISTING STREET SYSTEM

The map in Figure 3-1 shows the functional classification of the existing street system in Boone, according to the Federal Aid Urban System (FAUS) classification. Several proposed street connections are shown on this map, in addition to existing streets. The following classifications are indicated for various streets, in descending order of functional importance:

1. Connecting link of rural principal arterial.
2. Connecting link of rural minor arterial.
3. Principal arterial.
4. Minor arterial.
5. Collector.

The majority of the arterial streets shown in Figure 3-1 have been included in this study, relative to inventory of traffic control devices, traffic regulations and traffic operations. General comments and recommendations regarding these subjects, as presented in the following chapters, are equally applicable to collector streets and other local municipal streets.

TRAFFIC CONTROL DEVICES

Traffic control devices are "all signs, signals, markings and devices placed on or adjacent to a street or highway by authority of a public body or official having jurisdiction to regulate, warn or guide traffic" (from Manual on Uniform Traffic Control Devices for Streets and Highways, U.S. Department of Transportation, Federal Highway Administration, 1971). In future references to this manual within this report, its title will be abbreviated as "MUTCD."

An inventory was made to generally locate all traffic signals, pedestrian crossing signals and signs, stop signs, speed limit signs and other traffic control devices along the arterial street system of Boone. The map in Figure 3-1 shows the location of existing stop signs, traffic signals, school crossing signals and railroad signals on the arterial street system.

TRAFFIC SIGNALS

Traffic signals, other than school and railroad crossing signals, are presently installed at seven locations in Boone. Each of the existing signals is a pre-timed type of installation, whereby the signal indications follow a preset timing sequence. Table 3-1 lists the existing signal timing and other related data.

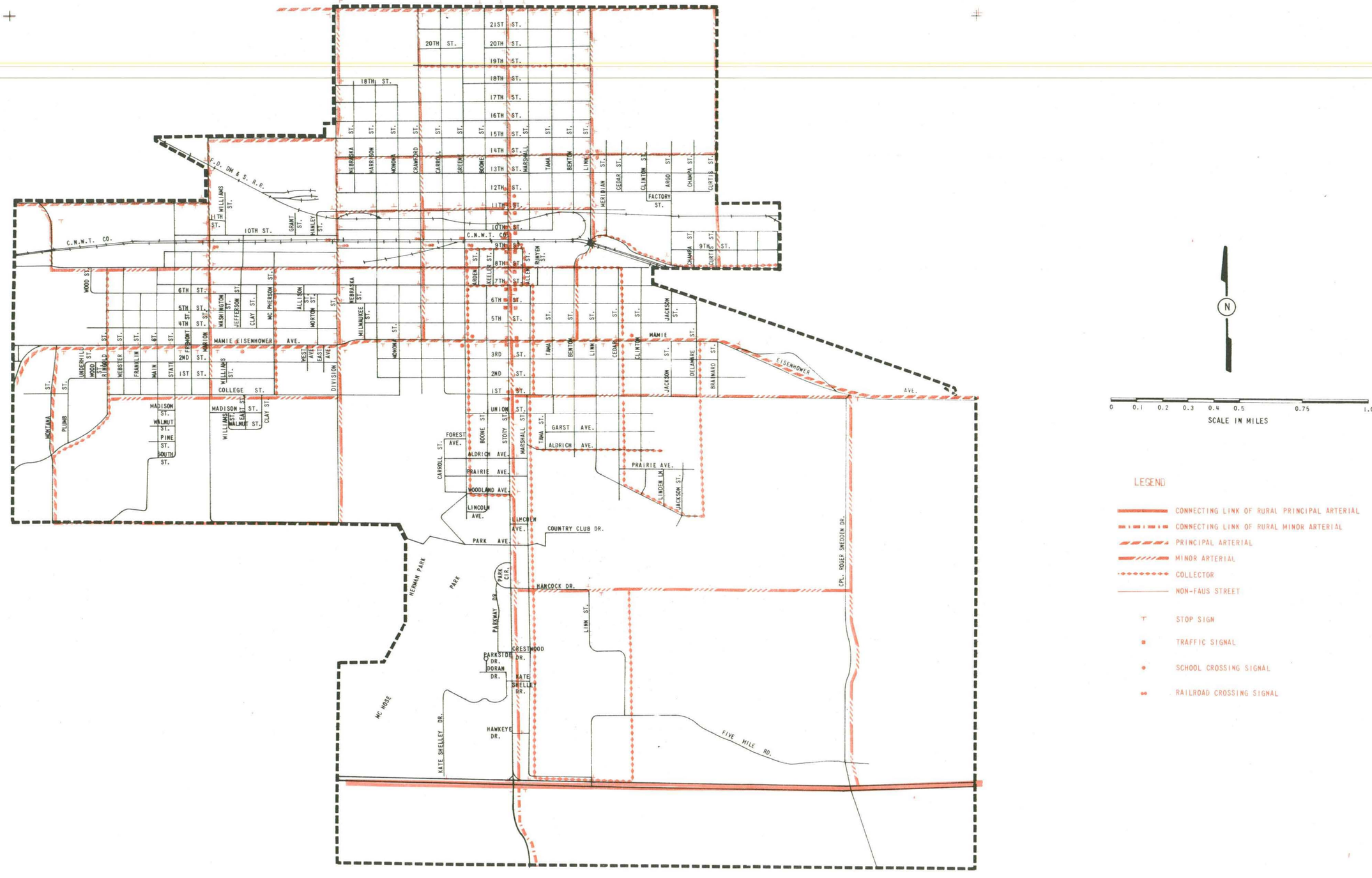


Fig. 3-1. Existing Traffic Control Devices and Functional Classification of Existing Street System.

TABLE 3-1

EXISTING TRAFFIC SIGNAL DATA

INTERSECTION	TYPE OF TRAFFIC SIGNAL INSTALLATION	SIGNAL TIMING (SECONDS)				PEDESTRIAN SIGNAL TIMING (SECONDS)				RIGHT TURN ON RED AFTER STOP PERMITTED
		Green	Yellow	Red	Total	Walk	Flashing Don't Walk	Don't Walk	Total	
Mamie Eisenhower Avenue and Story Street	Pre-Timed	24.0	4.8	31.2	60	--	--	--	--	All Approaches
		25.2	6.0	28.8	60	--	--	--	--	
6th Street and Story Street	Pre-Timed	25.2	4.8	30.0	60	--	--	--	--	All Approaches
		25.2	4.8	30.0	60	--	--	--	--	
7th Street and Story Street	Pre-Timed	22.2	4.8	33.0	60	17.4	9.6	33.0	60	All Approaches
		28.2	4.8	27.0	60	23.4	9.6	27.0	60	
8th Street and Story Street	Pre-Timed	22.2	4.8	33.0	60	17.4	9.6	33.0	60	All Approaches
		28.2	4.8	27.0	60	23.4	9.6	27.0	60	
9th Street and Story Street	Pre-Timed	25.2	4.8	30.0	60	--	--	--	--	All Approaches
		25.2	4.8	30.0	60	--	--	--	--	
10th Street and Story Street	Pre-Timed	25.2	4.8	30.0	60	--	--	--	--	All Approaches
		25.2	4.8	30.0	60	--	--	--	--	
11th Street and Story Street	Pre-Timed	25.2	4.8	30.0	60	--	--	--	--	All Approaches
		25.2	4.8	30.0	60	--	--	--	--	

The data in Table 3-1 shows the time allowed for each traffic movement at the respective intersections. As an example, at the intersection of Story Street and Seventh Street, traffic on Story Street receives 28.2 seconds of green indication, followed by a 4.8 second yellow clearance and 27.0 seconds of red indication. Traffic on Seventh Street faces a red indication for 33.0 seconds (corresponding to the green and yellow indications on Story Street), followed by a 22.2 second green and 4.8 second yellow indication to complete the cycle. The pedestrian signals at Seventh and Eighth Streets follow a similar pre-timed sequence, as indicated in Table 3-1.

Mast-arm signal poles are presently installed at the intersection of Story Street and Mamie Eisenhower Avenue, while the remaining signals are post-mounted. At some locations yellow signal poles are provided, although the majority of existing signals are mounted on gray-colored street light poles. The visibility of such signals is rather poor at some locations.

Existing traffic signals generally consist of 8-inch diameter red, yellow and green lenses, although 12-inch diameter red lenses have been substituted at a number of locations. Additionally, WALK and DON'T WALK pedestrian signals are in use at the intersections of Story Street with Seventh Street and Eighth Street. Presently, there are no signs to prohibit right turns on red at any of the seven signalized intersections.

At the intersection of Story Street and Tenth Street, additional green arrow signal lenses have been attached to certain signals, to prohibit traffic from turning south toward the railroad crossing. Such green arrow indications were formerly operated during times of train crossings, but according to City Officials they were frequently ignored by drivers and have since been disconnected. Presently, no railroad pre-emption or other interconnection between the railroad and the traffic signal systems is in operation. It is

recommended that the green arrow signal lenses be removed from these signals, as the present railroad crossing gates and signals provide adequate traffic control during train crossings.

Interconnection of existing traffic signals is provided between each intersection along Story Street from Sixth Street to Eleventh Street. A time clock at the intersection of Story Street and Eighth Street controls the system, which currently reverts to a flashing operation between the hours of 11:00 P.M. and 7:45 A.M. During the remainder of the day, the signals operate on a time sequence which allows traffic progression through the system.

Signals at the intersection of Story Street and Mamie Eisenhower Avenue are not included in the interconnected system, but operate independently on another time clock. At this location, a flashing operation is presently in effect between 12:00 Midnight and 6:15 A.M. During the nighttime at each of the aforementioned signalized intersections, traffic on Story Street receives a flashing yellow indication, while traffic on each cross street receives a flashing red indication.

The existing traffic signal installations in Boone (excluding school and railroad crossing signals) are in general conformance with the MUTCD. The present time allowed for pedestrian clearance, however, is somewhat insufficient for pedestrian traffic to clear the street before opposing traffic receives the right-of-way at the intersections of Seventh and Eighth Streets at Story Street. According to the MUTCD, the required clearance interval is the time necessary to allow a pedestrian crossing in the crosswalk to leave the curb and travel to the center of the farthest traveled lane before opposing vehicles receive a green indication.

Traffic signals and signal timing will be discussed in greater detail in Chapter 4.

SCHOOL CROSSING SIGNALS

School crossing signals were observed to be located at the following locations in Boone in the spring of 1977:

Linn Street and 14th Street.

Story Street and 12th Street.

Story Street and 1st Street.

Mamie Eisenhower Avenue and Cedar Street.

Mamie Eisenhower Avenue and Greene Street.

Mamie Eisenhower Avenue East of Marion Street at Lincoln School.

For the purpose of discussion only within this report, existing school crossing signals have been herein classified as Type I, Type II and Type III, as shown in Figure 3-2.

Type I Signals

These signals are located at the northwest and southeast corners of the intersection of Story Street and 12th Street. Each signal face consists of a single 12-inch diameter red lens facing the north and south approaches. Stop signs are presently erected on the east and west approaches. In addition to the traffic signals, a sign reading "No Turn on Solid Red" faces northbound traffic, although no such sign was present for southbound traffic at the time of this survey. Push buttons which are provided on both signal poles, are currently disconnected.

The signals are normally in operation during times of school traffic (approximately 8:15 - 8:45 A.M. and 2:45 - 3:30 P.M.). During these times the signals operate as flashing red, while at other times they are turned off.

Type I

Type II

Type III

Fig. 3-2. Existing School Crossing Signals.

Type II Signals

These signals are located at the intersections of Linn Street and 14th Street, and Story Street and First Street. Each signal installation consists of red-yellow-green indications for traffic on the north and south approaches, and a single red indication for traffic on the east and west approaches. Stop signs and "No Turn on Solid Red" signs are additionally provided on the east and west approaches. At the intersection of Story Street and First Street, mast-arm poles are installed to provide for signals overhanging Story Street, while the remaining signals are pedestal mounted. Each intersection includes a marked east-west crosswalk, with pedestrian WALK and DON'T WALK signals and push-button actuators.

Normal operation of the aforementioned signals includes a green signal indication on the north and south approaches, and a flashing red indication from the east and west. Upon actuation, the signals complete one cycle, as indicated in Table 3-2, and thereafter revert to normal operation until a subsequent pedestrian actuation.

TABLE 3-2

EXISTING SCHOOL CROSSING SIGNAL TIMING

INTERSECTION	SIGNAL TIMING (seconds)				PEDESTRIAN SIGNAL TIMING (seconds)		
	Green	Yellow	Red	Total	Walk	Don't Walk	Total
Story Street & First Street	27.0	4.8	28.2	60.0	25.2	34.8	60.0
Linn Street & 14th Street	29	3.5	25.5	60	10	50	60

Pedestrian clearance intervals for the two signal installations are currently 15½ seconds at Linn Street and 14th Street, and 3.0 seconds at Story Street and 1st Street. Accordingly, a pedestrian legally stepping from the curb at the end of the WALK indication would receive only 3.0 seconds to cross Story Street, or 15½ seconds to cross Linn Street, before opposing traffic received a green signal.

Type III Signals

This type of signal was observed to be located at the intersections of Mamie Eisenhower Avenue with Greene Street and Cedar Street, and were on Mamie Eisenhower Avenue near Lincoln School at the time of the field investigations for this study. Type III signals consist of two 8-inch diameter lenses, one red and one yellow, accompanied by signs reading "No Turn on Red" and "School Crossing." Such signals face eastbound and westbound traffic on Mamie Eisenhower Avenue only. Push-button actuators are provided at these signal locations, and signs reading "Push Button For Walk Signal" are included at Mamie Eisenhower Avenue and Cedar Street. WALK or DON'T WALK signals are not present at these locations.

Normally these signals are in operation only during the hours of school traffic. During these hours, the signals operate as flashing yellow warning beacons, and upon actuation the signals display a red indication. The signals at Lincoln School were out of service at the time of the field investigations, due to an accident.

Evaluation of School Signals:

Existing school crossing signals are not in conformance with the following requirements of the Manual on Uniform Traffic Control Devices:

1. The MUTCD states that "Each signal face, except in pedestrian signals, shall have at least three lenses.....The lenses shall be red, yellow or green in color." Existing signals consist of only one or two lenses at many locations.

2. "A minimum of two signal faces for through traffic shall be provided." At Story Street and First Street, and at Linn Street and 14th Street, only one signal face is provided for eastbound and westbound traffic.

3. "Continuity of Operation: A traffic signal installation.....shall be operated as a stop-and-go device or as a flashing device. When a signal installation is not in operation.....they should be hooded, turned or taken down to clearly indicate that the signal is not in operation." Existing Type I and Type III signals do not comply with this requirement.

4. "Stop signs shall not be used in conjunction with any signal operation, except: 1) When the indication flashes red at all times or 2) When a minor street or driveway is located within or adjacent to the controlled area, but does not warrant separate signal control due to extremely low potential for conflict." Existing Type III installations are in conflict with this requirement.

5. "A pedestrian clearance interval shall always be provided where pedestrian signal indications are used. It shall consist of a flashing DON'T WALK indication." Flashing DON'T WALK indications are not currently provided. In addition, the clearance interval is inadequate in length at the intersection of Story Street and First Street.

It is recommended that a comprehensive "Safe School Route Plan" be undertaken within the City of Boone, to determine pedestrian routes and locations of future school crossings. It is further recommended that traffic movements

be studied at all proposed school crossings to determine the type of signals or other crossing controls to be established at the respective crossings. This type of school route study is provided as part of the Iowa Department of Transportation Traffic Engineering Assistance Program.

RAILROAD CROSSING SIGNALS

Railroad crossing signals are presently installed on Crawford Street, Division Street, Marion Street, Greene Street and Story Street at their crossings with the Chicago and North Western Transportation Company tracks. (See Figure 3-1). Existing signals on Greene Street and Division Street are of an outdated wig-wag design (see Figure 3-3), while the remaining three crossings are provided with standard crossing signals and crossing gates. During the five-year study period, the C.N.W.T. crossing on Division Street has been the scene of four collisions resulting in two fatalities and property damage totalling $8,300. An additional four collisions have occurred at the Greene Street crossing, although no fatalities resulted at that location. Only one accident has been reported at the Story Street crossing, while no accidents have been reported at the crossings on Marion Street and Crawford Street.

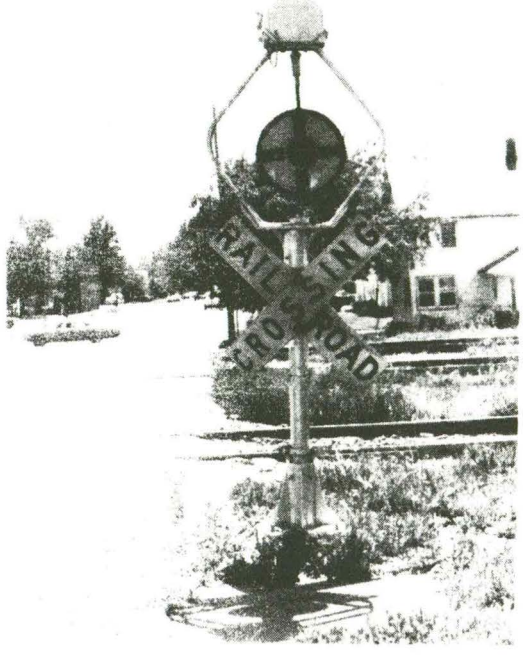


Fig. 3-3. Existing Railroad Crossing Signals on Greene Street.

RAILROAD CROSSING SIGNS

Railroad crossbuck signs are currently provided at most railroad crossings in accordance with MUTCD provisions. No such sign is present for southbound traffic on Story Street at the Fort Dodge, Des Moines and Southern Railroad crossing, or for northbound traffic on Crawford Street, at the crossing north of Eighth Street. It is recommended that crossbuck signs be erected at such locations.

Railroad advance warning signs are not presently implemented at most railroad crossings in Boone, including those crossings on Marion Street, Division Street, Crawford Street, Story Street, Linn Street and other local streets. According to the MUTCD, "A Railroad Advance Warning sign shall be used in advance of every railroad crossing, except at a minor spur or siding which is infrequently used and which is guarded by train crews, or in the business districts of large cities where the crossings are fully protected; or where physical conditions are such that even a partially effective display of the sign is impossible." Accordingly, all railroad crossings in Boone should be preceded by a Railroad Advance Warning sign for each approach.

STOP SIGNS

Stop signs are presently installed at those locations along the arterial street system as shown in Figure 3-1. (Only arterial streets have been included in this evaluation.) Existing stop signs are in general conformance with the requirements of the MUTCD, except that certain signs are mounted too low for effective display. The mounting height of stop signs should be at least seven feet (measured from the pavement to the bottom of the sign), wherever parking is permitted near the respective signs.

The City of Boone is advised to check all stop signs relative to the height and lateral clearance requirements as set forth in the MUTCD and replace or reset posts as necessary.

Stop sign beacons are currently provided for stop signs facing eastbound and westbound traffic on U.S. Highway No. 30 at its intersection with Story Street. These single-eight-inch lens beacons are mounted slightly above the respective stop signs, with the bottom of the signal housing being approximately at the level of the top of the respective stop signs. As specified in the MUTCD, such beacon housings are to be located from 12 inches to 24 inches clear distance above the top of a stop sign. It is therefore, recommended that the existing stop sign beacons be raised to conform with the requirements of the MUTCD.

PORTABLE SIGNS

In addition to normal stop sign installations, there are several locations where portable stop signs are used. According to City ordinances, either stationary or movable signs reading "Stop, School Zone" are to be used at all designated school zones during morning, noon and afternoon school traffic. Portable stop signs are utilized at such locations, with such signs being placed in the center of the designated intersections during periods of school traffic. Additionally, ten intersections have been designated "Sunday stop intersections" by the City ordinances, where stop signs are to be displayed only between the hours of 8:00 A.M. and 1:00 P.M. on any Sunday. Another portable stop sign consists of four stop signs mounted on a rectangular frame and located at the center of the intersection of Eighth Street and Allen Street. This sign supplements four stop signs that are installed at this intersection.

All of the above stop signs are contrary to the provisions of the MUTCD,

which states that "for other than emergency purposes portable or part-time stop signs shall not be used." In addition, "Portable school signs shall not be placed within the roadway at any time."

School crossing signals, crossing guards or permanent stop signs are acceptable according to the aforementioned manual. According to the Iowa Code, however, roll-out stop signs are permitted for school crossings but must meet requirements whereby the vertical clearance from the pavement surface to the center line of the 30" stop sign face be 4.5 feet. (Roll-out stop signs are currently being studied as part of a research project at Iowa State University, Ames, Iowa.)

Crossing guards may be used effectively at the various crossing areas in Boone. The choice of adult or student guards will be dependent upon the nature and volumes of pedestrians to be accommodated and the corresponding vehicular traffic conditions at the respective crossings.

A different type of portable sign is used on Crawford Street between school crossing zones designated according to current City ordinances. A portable "Do Not Enter" sign is located at the center line of Crawford Street at the south side of Seventh Street, facing southbound traffic on Crawford Street. A similar sign is located at the center line of Crawford Street at the north side of Sixth Street, facing northbound traffic on Crawford Street. The obvious purpose of these signs is to close this one block segment of Crawford Street to vehicular traffic during certain periods when school is in session. No provision was noted in the City ordinances for such closing of this street. The ordinances designate the aforesaid intersections of Sixth and Seventh as school zones and specified either stationary or movable signs bearing the words "Stop, School Zone". Portable four-way stop signs were observed to be used at certain times.

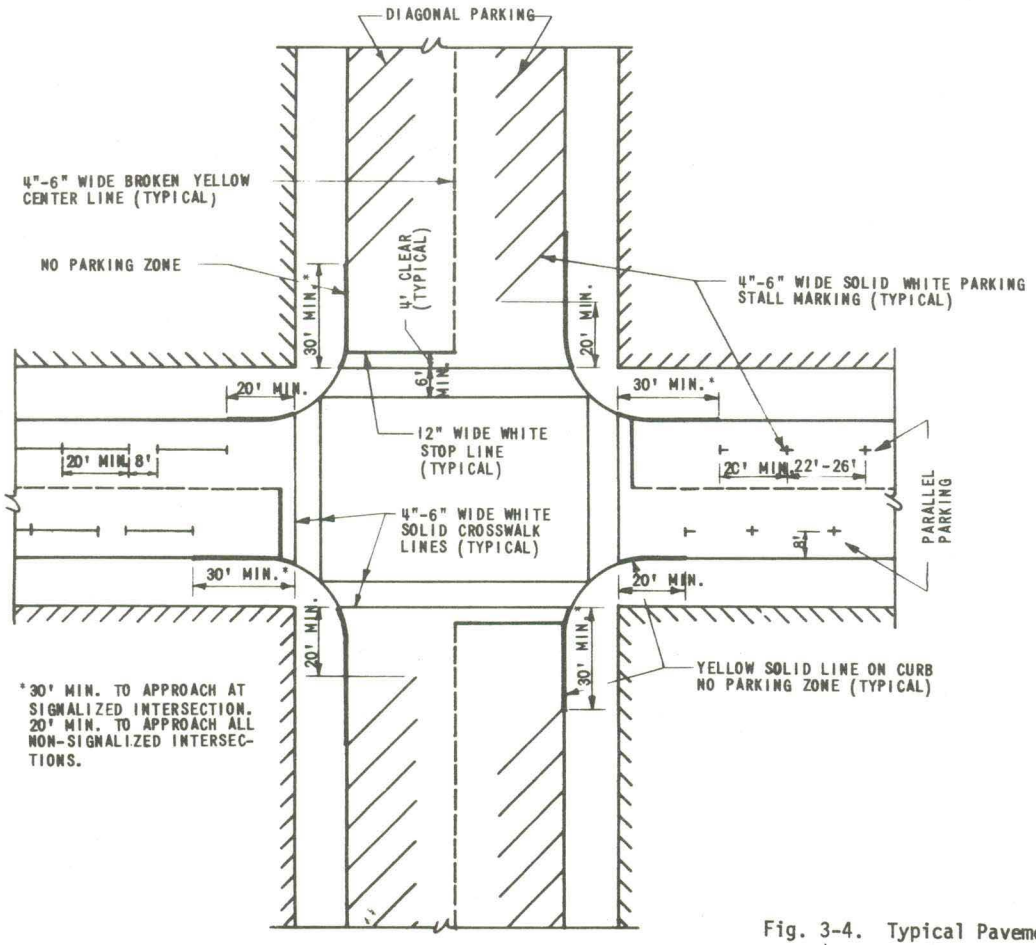
The placement of the existing portable signs is primarily in relation to northbound and southbound traffic on Crawford Street. Eastbound and westbound traffic on Sixth and Seventh Streets with destinations on Crawford Street may partially complete turning movements toward the closed portion of Crawford Street before realizing that the street is closed. In addition, through travel on the closed street is readily accomplished by driving beside the existing signs.

As a more positive means of closing this street, it is recommended that a barricade or barricades, in conformance with provisions of the MUTCD, be placed at each end of the noted block. A sign reading "Street Closed to Through Traffic" should be affixed to each barricade. Such barricades should be located immediately north and south of the curb line extensions on Sixth and Seventh Street, respectively. Although this method of closing the street may be less convenient than the existing procedure, it will provide more effective and safer traffic control at the respective intersections. City ordinances should be updated to provide for the closure of this street.

PAVEMENT MARKINGS

Existing pavement markings on Story Street, Mamie Eisenhower Avenue and other major streets within the corporate limits of Boone, consisting of center lines, lane lines, turn arrows, stop lines and pedestrian crosswalk markings, were observed to be in generally fair to poor condition in the Spring of 1977. Most parking stall markings in the central business district were generally in good condition. A continuing effort should be made to maintain all markings in good condition, as an aid to the safer movement of vehicles and pedestrians.

Typical pavement markings, based on requirements of the MUTCD, are shown in Figure 3-4. The type of pavement markings for parallel parking stalls can vary in regard to extent of the markings. Such markings may extend perpendicularly from the curb. It is important to note the recommended stop lines and the



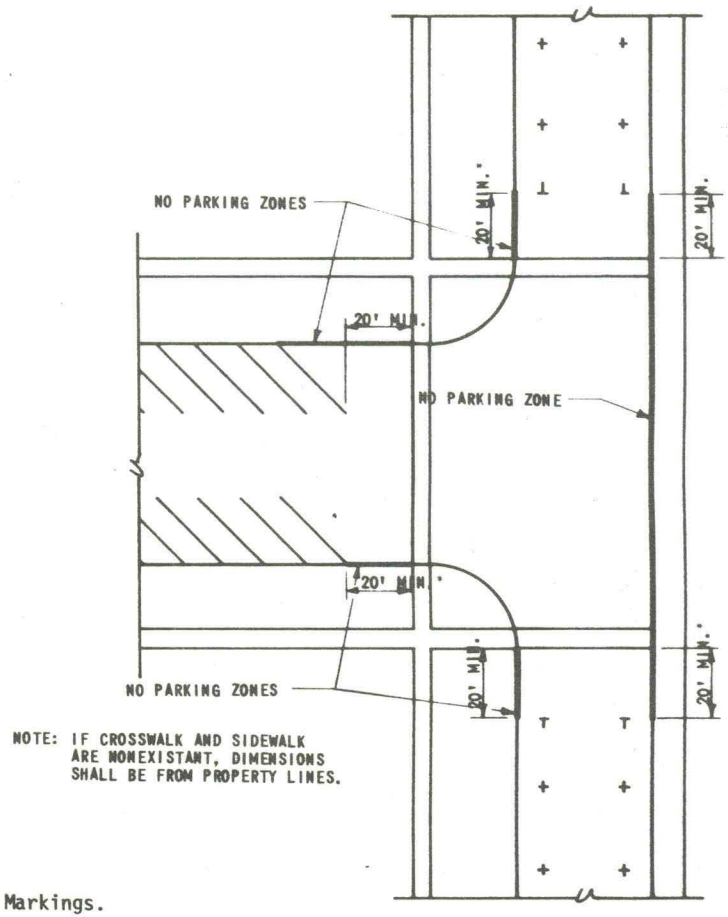


Fig. 3-4. Typical Pavement Markings.

20- and 30-foot no parking zones at the intersections. The no parking zones are so located to prevent obstruction of turning movements and view during such movements and to prevent conflicts with pedestrians. Stop lines define the stop location necessary to maintain adequate crosswalk clearance.

Except for parking stalls and no parking zones, pavement markings were observed to be in general conformance with the MUTCD. Recommendations on pavement markings, relative to parking stall measurements and location, will be presented in Chapter 5 of this report.

SPEED LIMITS

Speed limits within the City of Boone, according to City ordinances, are indicated on the map in Figure 3-5. In addition to the streets indicated, City ordinances specify the following generalized speed limits:

20 m.p.h. in any business district.

25 m.p.h. in any residence or school district.

Speed limits, as signed, are generally in conformance with City ordinances, although the following discrepancies were noted:

Division Street - Ordinances specify 35 m.p.h. between 15th Street and 22nd Street, although no such signing is present for northbound traffic.

Story Street - Ordinances specify 50 m.p.h. south of U.S. Highway 30, although present signing indicates 40 m.p.h.

Eighth Street (Industrial Road) - Ordinances specify 55 m.p.h. east of Argo Street, although no such signing is present for eastbound traffic.

It is recommended that speed limit signing be updated to conform with City ordinances, unless otherwise recommended herein.

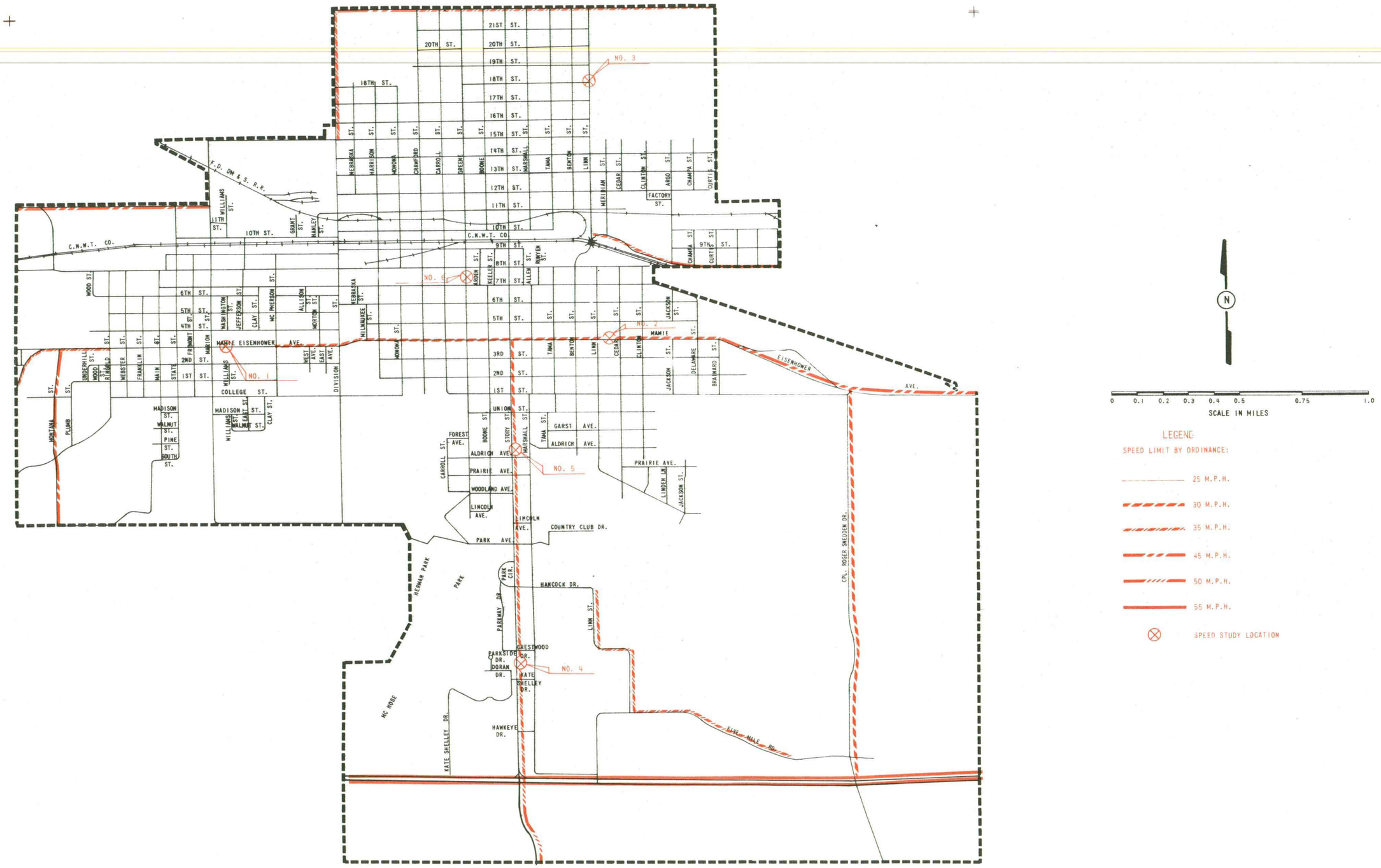


Fig. 3-5. Speed Limits According to City Ordinances.

As part of this study, speed checks were conducted at six locations within the community. Speeds were recorded through the use of radar equipment mounted in an unmarked vehicle. Efforts were made to select inconspicuous observation points in order to avoid any effect on normal driving patterns in the areas. Data was collected during the week of May 9 to May 13, 1977, at the following locations:

Location No. 1: Mamie Eisenhower Avenue, East of Marion Street.

Location No. 2: Mamie Eisenhower Avenue at Cedar Street.

Location No. 3: North Linn Street at 18th Street.

Location No. 4: Story Street at Imperial Inn Entrance.

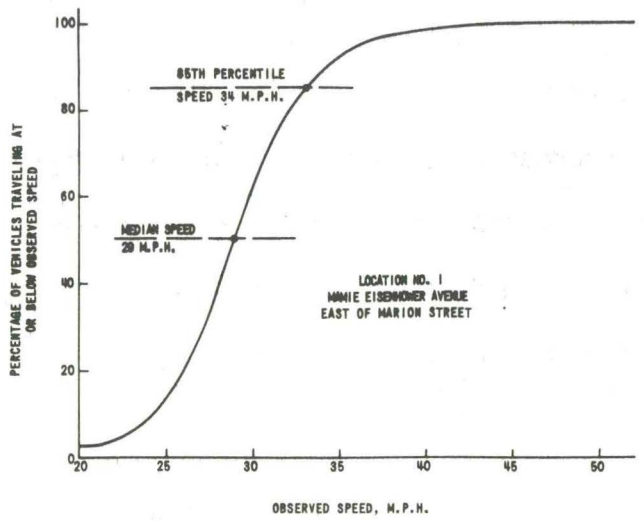
Location No. 5: Story Street, North of Aldrich Avenue.

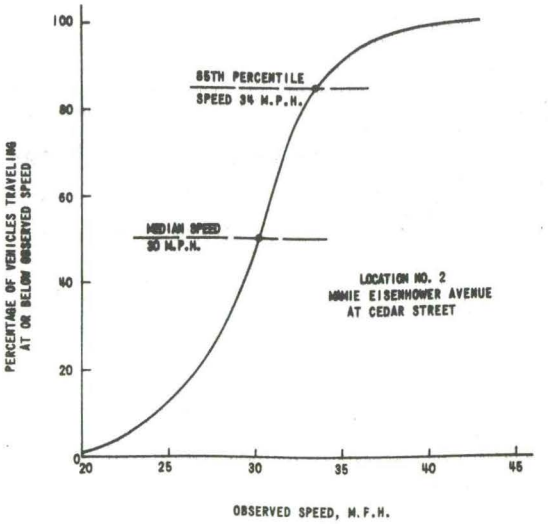
Location No. 6: Greene Street at 7th Street.

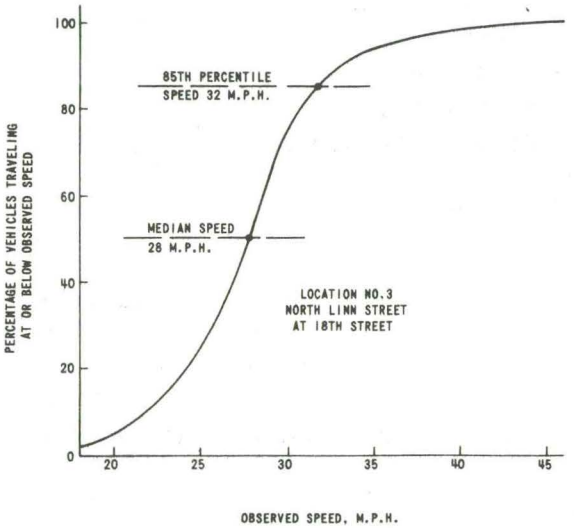
Observed driving speeds at the above locations were recorded separately for each direction of travel, with a sufficient number of readings taken to assure the validity of the results. Readings at each location were taken for both morning and afternoon traffic, and represent traffic conditions during the spring of 1977.

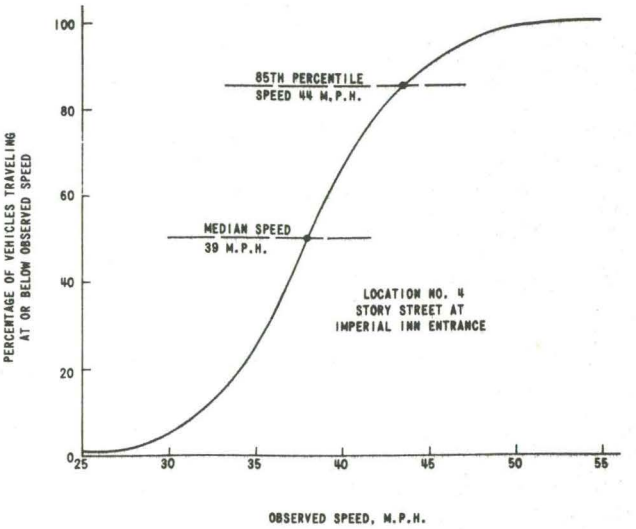
The cumulative speed distribution curves for each of the observed locations are shown in Figure 3-6. These curves represent the percentage of the total vehicles observed that were traveling at or below the indicated speeds.

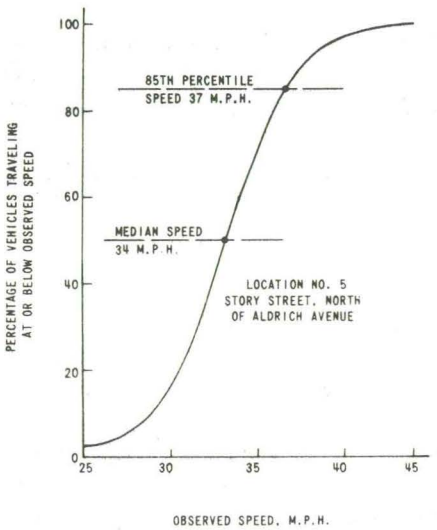
Table 3-3 is a listing of the various speed statistics at each of the six locations. The minimum and maximum observed speeds, as well as the range of speeds, are indicated for traffic in each direction and for total traffic in both directions at the six locations. Some of the categories found in this table are explained as follows:











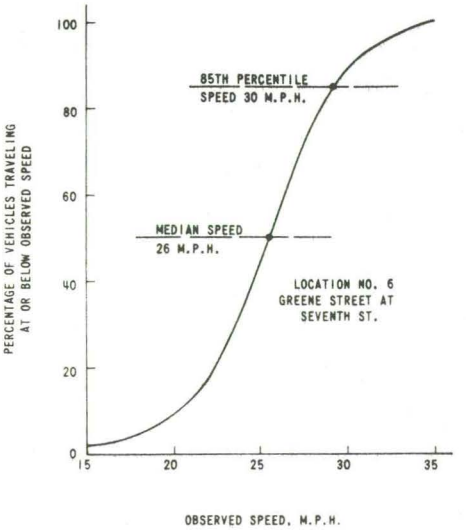


Fig. 3-6. Speed Distribution Curves Resulting from Speed Studies.

TABLE 3-3

OBSERVED SPEED STATISTICS

LOCATION	SPEED OBSERVATIONS (IN MILES PER HOUR) LOCATION	POSTED SPEED LIMIT	MINIMUM OBSERVED SPEED	MAXIMUM OBSERVED SPEED	RANGE OF SPEEDS	AVERAGE SPEED	STANDARD DEVIATION	MEDIAN SPEED	85 PERCENTILE SPEED	RECOMMENDED SPEED
1	Mamie Eisenhower Avenue, East of Marion Street.	25	20	52	32	30	4.3	29	34	25
	Eastbound Traffic		20	52	32	29	4.7	29	33	
	Westbound Traffic		20	40	20	30	3.7	30	34	
2	Mamie Eisenhower Avenue at Cedar Street.	30	20	43	23	30	4.0	30	34	30
	Eastbound Traffic		21	43	22	30	4.2	30	34	
	Westbound Traffic		20	39	19	30	3.9	30	34	
3	N. Linn Street at 18th Street.	25	18	46	28	28	4.8	28	32	30
	Northbound Traffic		18	46	28	29	5.0	29	32	
	Southbound Traffic		18	42	24	28	4.6	28	33	
4	Story Street at Imperial Inn Entrance.	35	25	55	30	39	4.9	39	44	40
	Northbound Traffic		25	49	24	38	4.7	38	43	
	Southbound Traffic		29	55	26	40	5.0	39	45	
5	Story Street, North of Aldrich Avenue.	35	25	44	19	34	3.6	34	37	35
	Northbound Traffic		26	44	18	33	3.6	33	36	
	Southbound Traffic		25	43	18	34	3.6	34	38	
6	Greene Street at Seventh Street.	25	15	35	20	26	4.1	26	30	25
	Northbound Traffic		15	34	19	26	4.1	26	30	
	Southbound Traffic		16	35	19	26	4.1	26	31	

The "average speed" is equal to the arithmetic mean, and is obtained by dividing the sum of all observed speeds by the number of observations.

The "standard deviation" is a measure of the variance of the observed speeds from the average speed. Approximately two-thirds of all vehicles travel within one standard deviation above or below the average speed. For example, at Location No. 1 approximately two-thirds of the observed vehicles were traveling between 24.7 and 33.3 miles per hour.

The "median speed" is that speed which is exceeded by 50 percent of the vehicles. Median speeds are shown in Figure 3-6 and are also listed in Table 3-3.

The "eighty-fifth percentile speed", as shown in Figure 3-6 and Table 3-3 is the speed at or below which 85 percent of the vehicles are traveling. Drivers exceeding the eighty-fifth percentile speed are usually considered as driving faster than is safe under existing conditions. This percentile is an accepted criterion for use in establishing speed limits.

EVALUATION OF SPEED STUDY

Speed data obtained at Location No. 1 indicates that only 13 percent of the drivers are traveling within the posted (25 m.p.h.) speed limit. Observed speeds ranged from 20 m.p.h. to 52 m.p.h., with an average speed of 30 m.p.h. The 85th percentile speed at this location was 34 m.p.h.

Mamie Eisenhower Avenue is the principal east-west route through the City of Boone, and carries a current traffic volume of approximately 5,000 vehicles per day. In the vicinity of Location No. 1, Lincoln School is adjacent to and north of Mamie Eisenhower Avenue, and a residential area is located along the south side of said street. Sight distance is relatively unrestricted in the area, and few traffic accidents have been reported along this section of

Mamie Eisenhower Avenue during the five-year study period.

The presence of the school adjacent to Mamie Eisenhower Avenue necessitates the maintenance of the 25 m.p.h. speed limit between Marion Street and McPherson Street. An outlying business district is located west of Marion Street. Based on the nature of the existing land use adjacent to Mamie Eisenhower Avenue, it is recommended that the speed limit be raised to 30 m.p.h. from Ringold Street to Main Street and remain at the existing 25 m.p.h. speed limit from Main Street to McPherson Street. In addition, it is recommended that law enforcement efforts be increased in an effort to reduce speeding in this area.

Observed driving speeds at Location No. 2 were generally near the speed limit, with an 85th percentile speed of 34 m.p.h. in both directions. No change in the current speed limit is recommended at this location.

At Location No. 3, approximately three-fourths of the observed drivers were traveling in excess of the current 25 m.p.h. speed limit. North Linn Street is classified as a minor arterial street, and passes through a residential area of Boone. Traffic accidents have been infrequent on North Linn Avenue, with the following numbers of accidents reported during the five-year study period:

North Linn and 21st Street - 0 accidents.
North Linn and 20th Street - 2 accidents.
North Linn and 19th Street - 2 accidents.
North Linn and 18th Street - 4 accidents.
North Linn and 17th Street - 1 accident.
North Linn and 16th Street - 1 accident.
North Linn and 15th Street - 2 accidents.

In addition, North Linn Street currently operates as a through street south of 22nd Street, with stop signs on all approaching streets. Based on the above factors, and in consideration of the school located near 14th Street, it is recommended that the speed limit on North Linn Street be increased to 30 m.p.h. between 15th Street and 22nd Street.

Speed observations at Location No. 4 again indicate that approximately three-fourths of the drivers were exceeding the posted 35 m.p.h. speed limit, with speeds ranging from 25 to 55 m.p.h. The 85th percentile speed at this location was 43 m.p.h. for northbound traffic and 45 m.p.h. for southbound traffic.

Story Street near Location No. 4 is a four-lane divided highway with relatively uninterrupted traffic between U.S. Highway 30 and Hancock Drive. This street is classified as a minor arterial, and functions as a limited access highway, with only three access points provided in the aforementioned section. Sight distance along this street is relatively unrestricted. Accordingly, it is recommended that the speed limit along Story Street be increased to 40 m.p.h. between U.S. Highway 30 and Hancock Drive.

Driving speeds at Location No. 5 were somewhat lower than those at Location No. 4, with a median speed of 34 m.p.h. and an 85th percentile speed of 37 m.p.h. This portion of Story Street is undivided, and experiences considerably more friction to traffic flow from intersecting streets and abutting properties. No change in the speed limit is recommended at this location.

At Location No. 6, observed speeds ranged from 15 m.p.h. to 35 m.p.h. with an 85th percentile speed of 30 m.p.h. This portion of Greene Street is located near the central business district, with accompanying turning movements, parking maneuvers and truck traffic. It is recommended that the existing speed limits remain unchanged at this location.

CHAPTER 4
TRAFFIC OPERATIONS

SCOPE

The purpose of this chapter is to present findings relative to traffic operations, exclusive of those previously discussed in other chapters of this report. Among the subjects to be considered in this chapter are the following: physical layout of existing intersections, street widths, obstructions, traffic volumes, pedestrian volumes, intersection capacity analysis, traffic control devices and lighting.

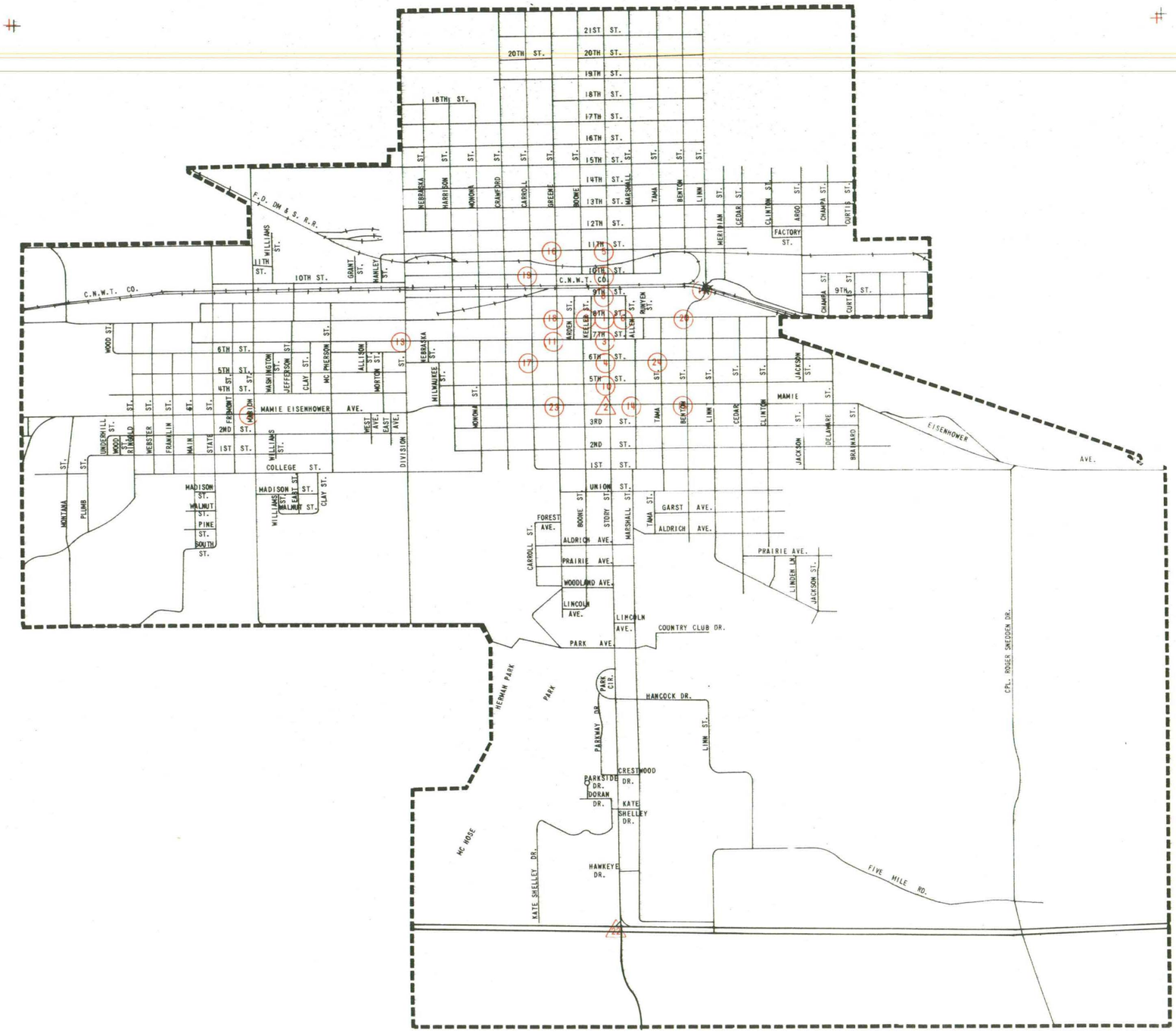
INTERSECTION LAYOUTS

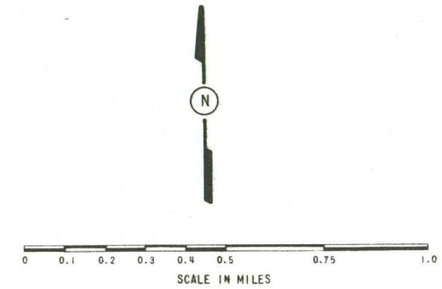
On-site surveys were conducted at each of the 24 intersections studies, to determine the physical and geometric characteristics of the intersections. Among the features located were pavement widths and corner radii, traffic signals, stop signs, utility poles, street lights, buildings, parking areas, sidewalks and driveways. The intersections so measured are identified on the index map in Figure 4-1.

The existing features of each intersection are shown in black on the intersection diagrams in Figures 4-2 through 4-13. A legend for symbols used and an index of intersections studied in detail appears on the fold-out page following Figure 4-13.

PAVEMENT RADII AND PAVEMENT WIDTH TRANSITIONS

On-site measurements were made of the radii of curbs at the corners of intersections. Several such corners in the central business district and elsewhere have a curb radius of less than ten feet. It is difficult





INTERSECTIONS AT WHICH ANALYSIS OF GEOMETRIC AND TRAFFIC CONDITIONS WERE CONDUCTED

LEGEND

△ INTERSECTION TRAFFIC VOLUMES COUNTED BY I.D.O.T.

○ OTHER STUDIED INTERSECTIONS

1. 8TH STREET & STORY STREET
2. MAMIE EISENHOWER AVE. & STORY STREET
3. 7TH STREET & STORY STREET
4. 6TH STREET & STORY STREET
5. 11TH STREET & STORY STREET
6. 8TH STREET & ALLEN STREET
7. 10TH STREET & STORY STREET
8. 9TH STREET & STORY STREET
9. 8TH STREET & KEELER STREET
10. 5TH STREET & STORY STREET
11. 7TH STREET & GREENE STREET
12. LINN STREET & 9TH STREET - UNDERPASS
13. 7TH STREET & DIVISION STREET
14. MAMIE EISENHOWER AVE. & MARSHALL STREET
15. MAMIE EISENHOWER AVE. & BENTON STREET
16. 11TH STREET & GREENE STREET
17. 6TH STREET & CARROLL STREET
18. 8TH STREET & GREENE STREET
19. 10TH STREET & CARROLL STREET
20. 8TH STREET & BENTON STREET
21. MAMIE EISENHOWER AVE. & MARION STREET
22. U.S. 30 & STORY STREET
23. MAMIE EISENHOWER AVE. & GREENE STREET
24. 6TH STREET & TAMA STREET

Fig. 4-1. Map Showing Intersections Studied in Detail.

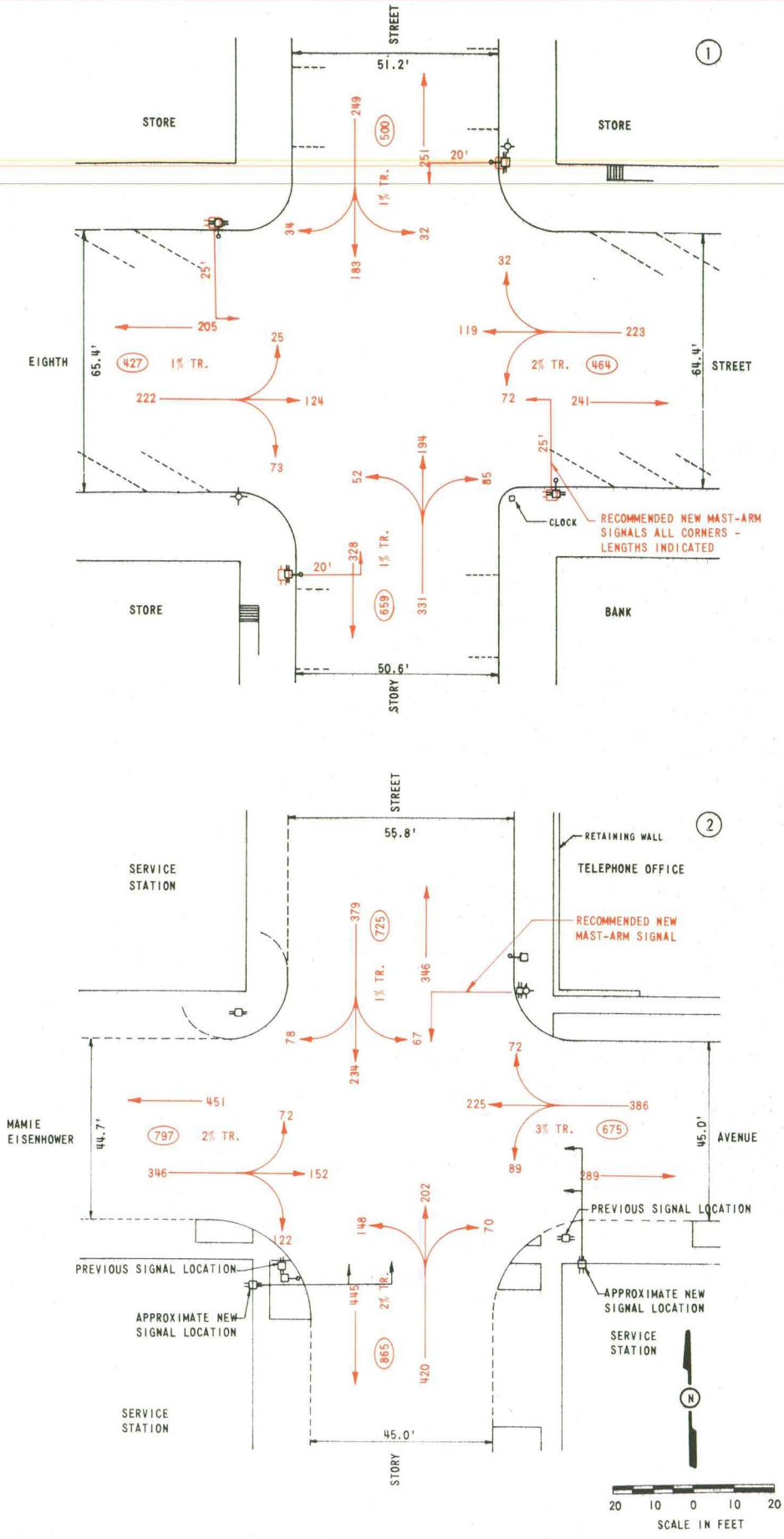


Fig. 4 2. Intersection Geometrics and Traffic Volumes for Intersection Nos. 1 and 2.

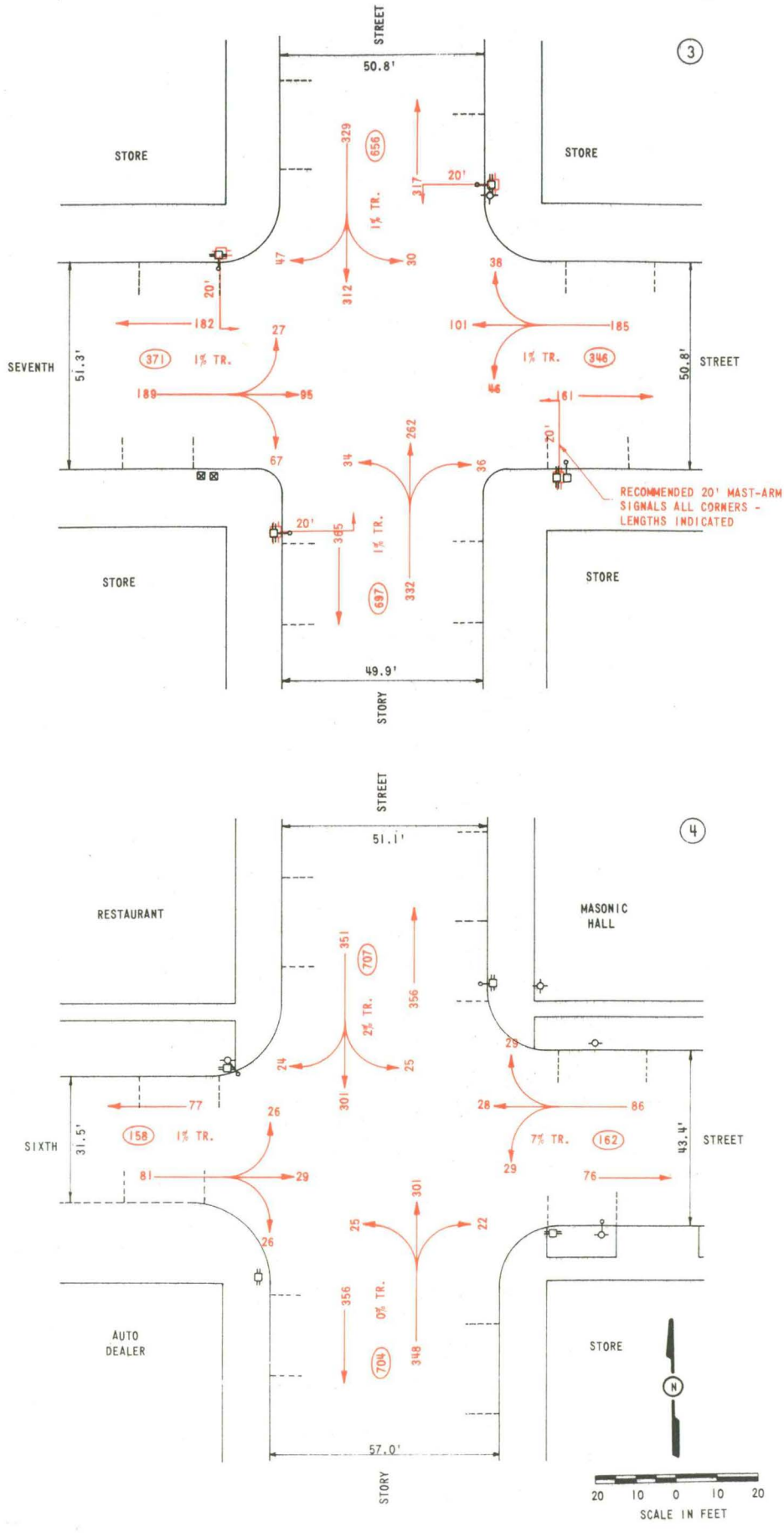


Fig. 4-3. Intersection Geometrics and Traffic Volumes for Intersection Nos. 3 and 4.

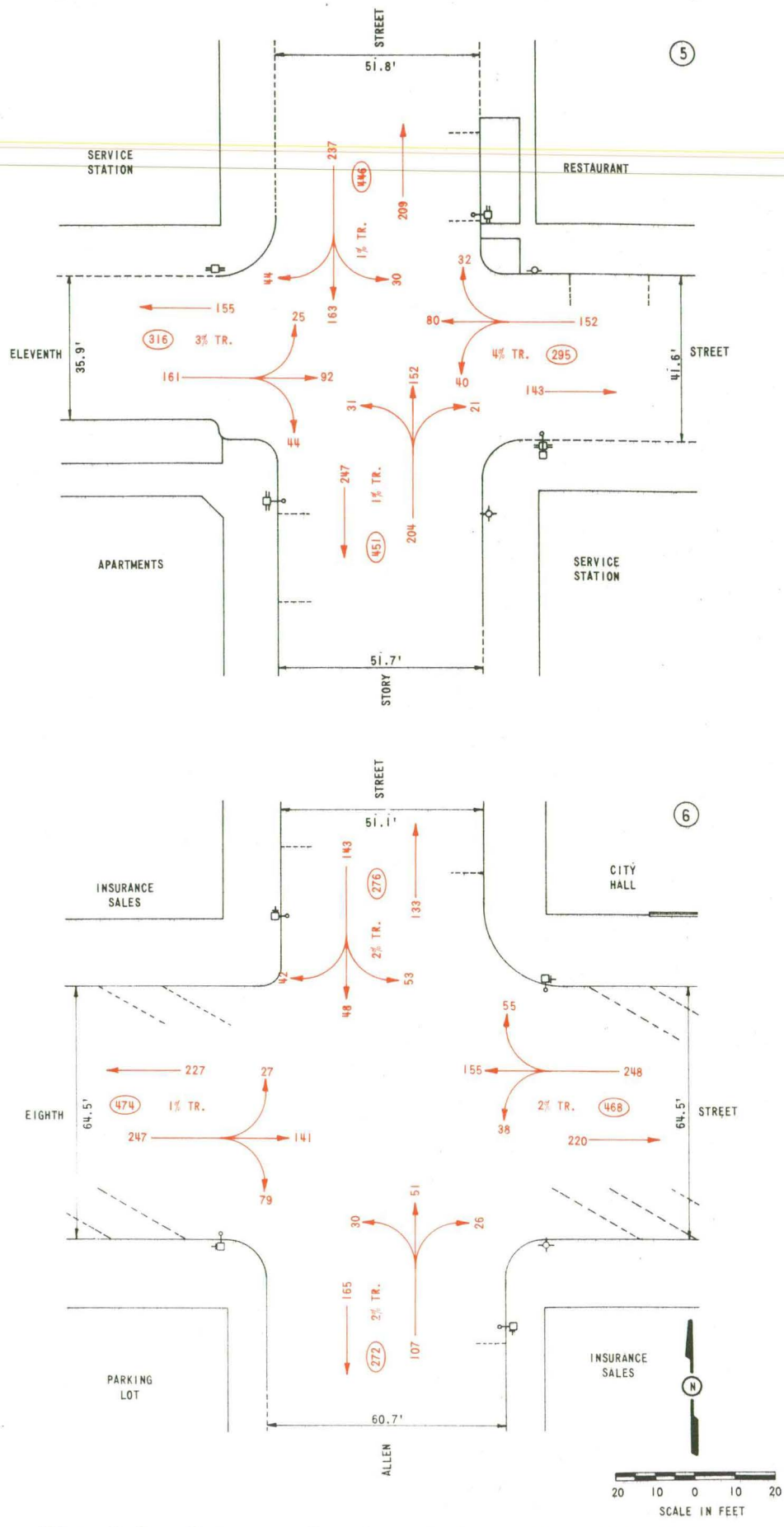


Fig. 4-4. Intersection Geometrics and Traffic Volumes for Intersection Nos. 5 and 6.

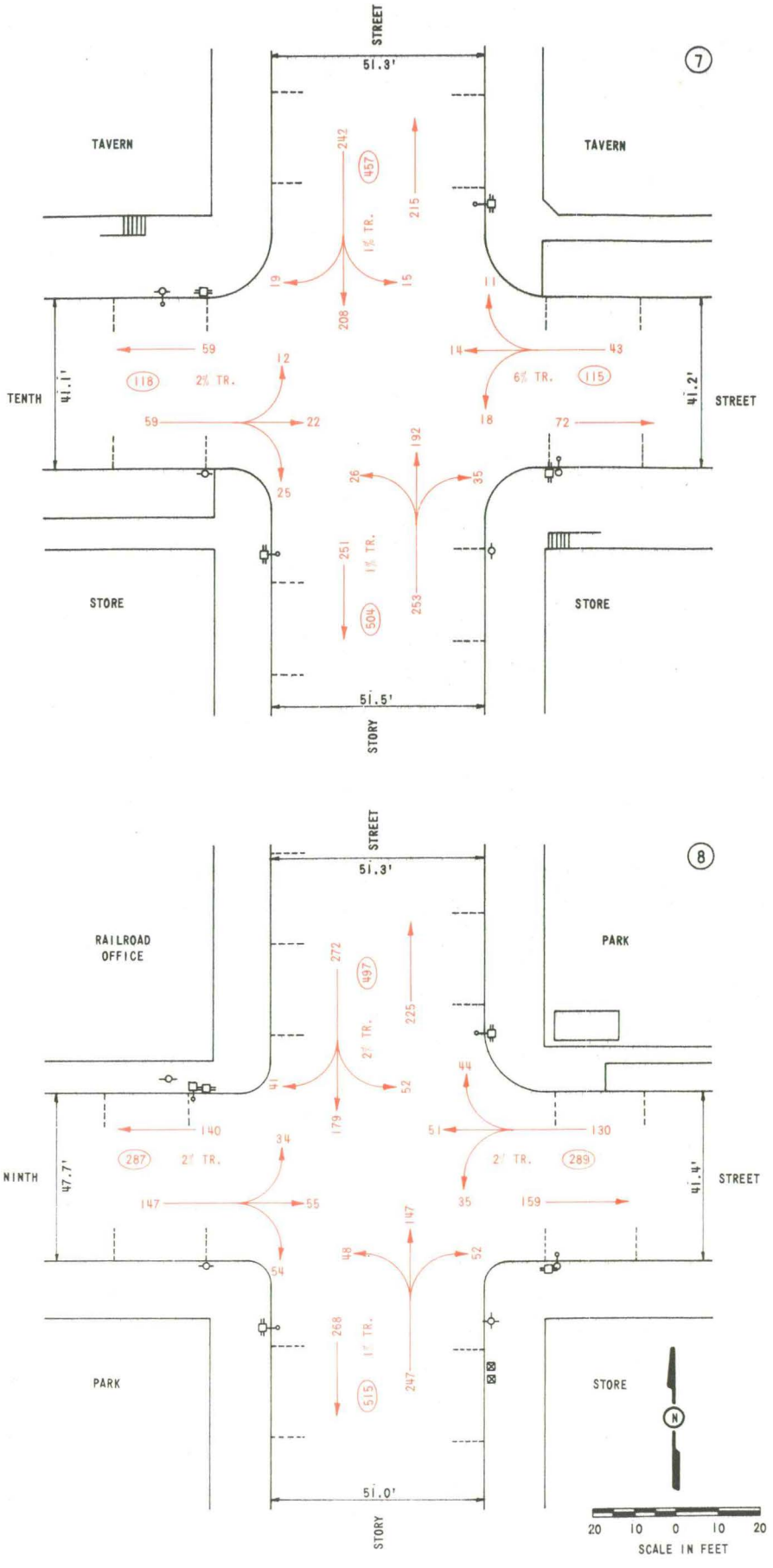


Fig. 4-5. Intersection Geometrics and Traffic Volumes for Intersection Nos. 7 and 8.

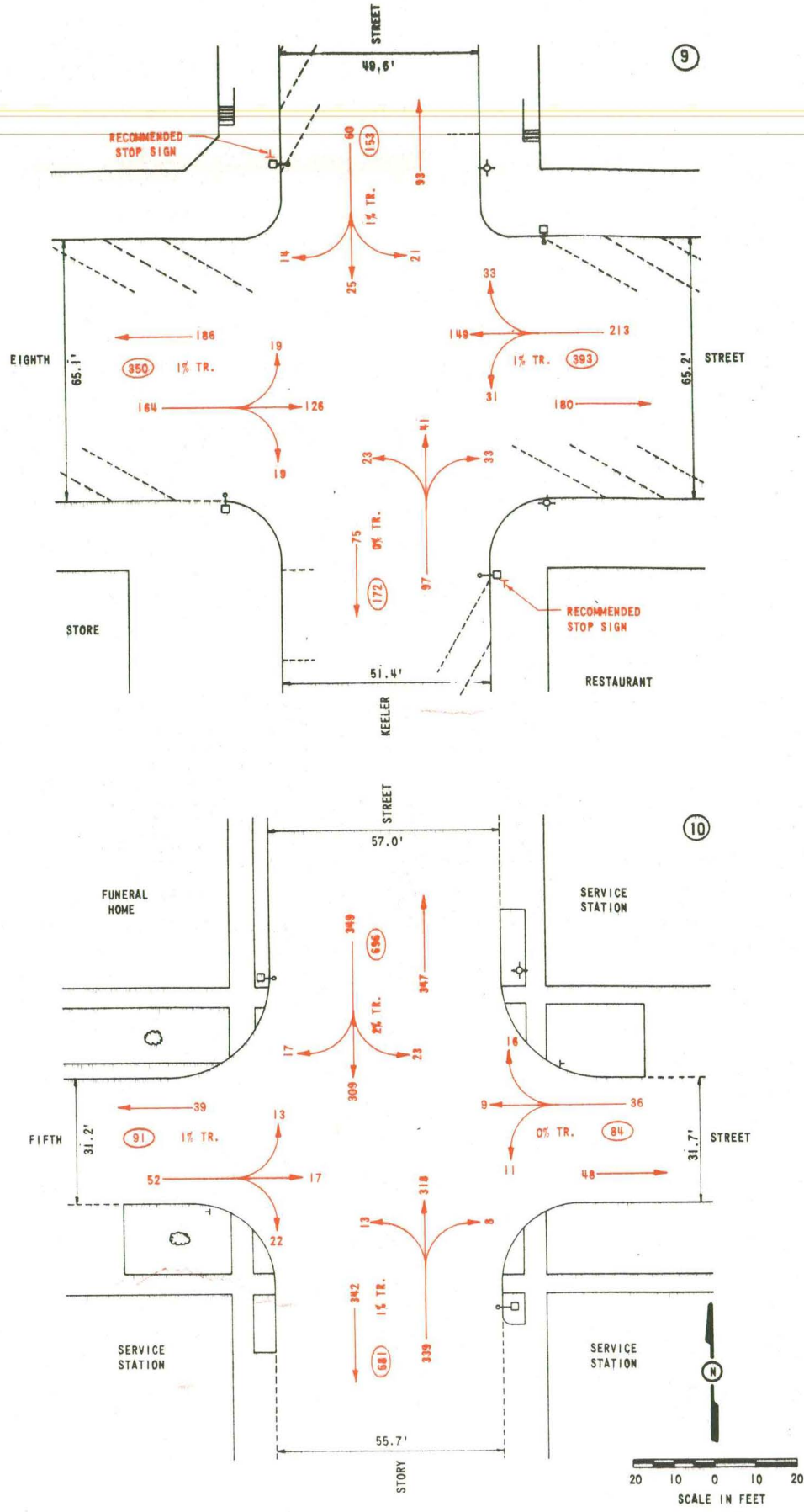


Fig. 4-6. Intersection Geometrics and Traffic Volumes for Intersection Nos. 9 and 10.

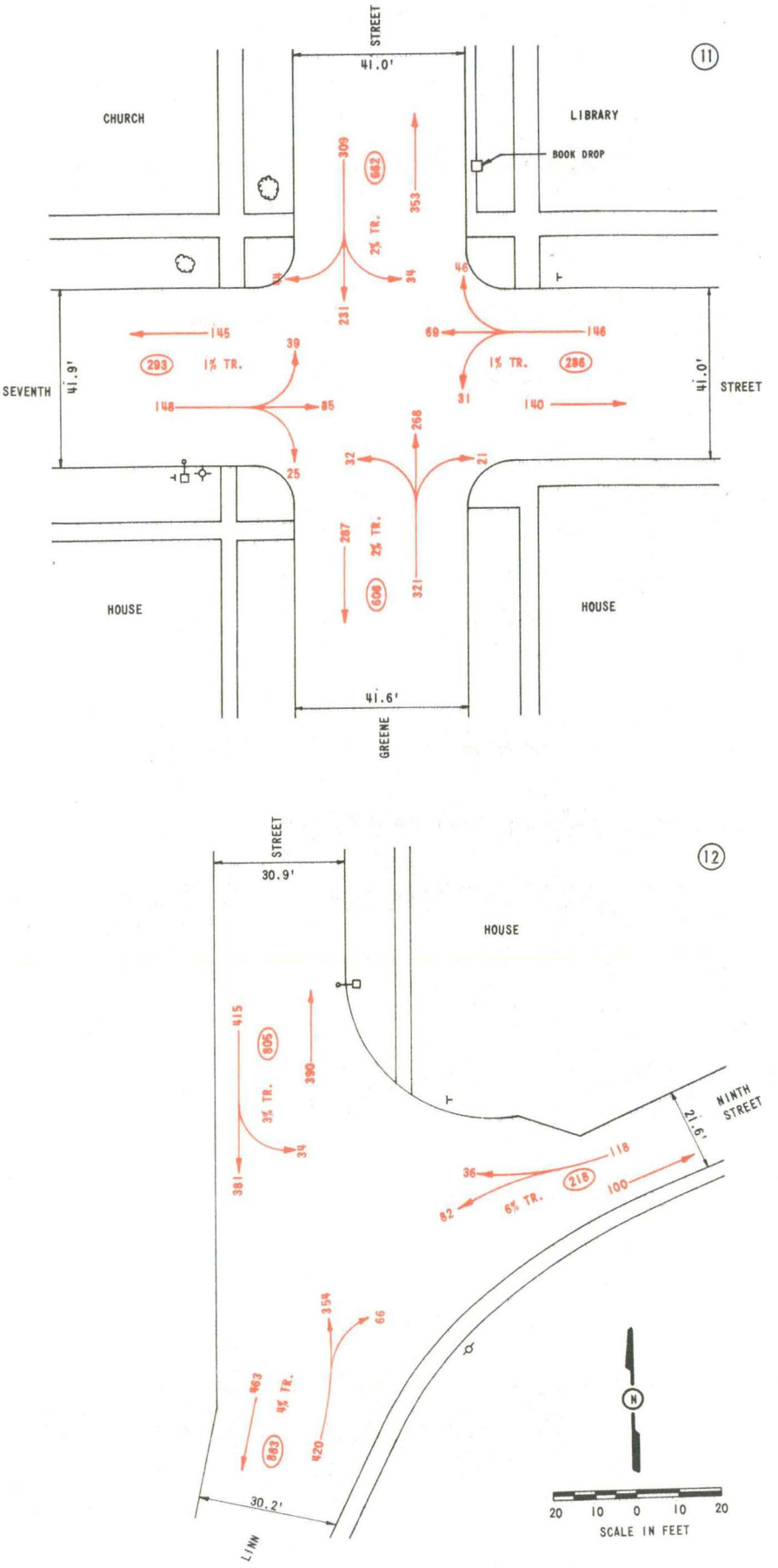


Fig. 4-7. Intersection Geometrics and Traffic Volumes for Intersection Nos. 11 and 12.

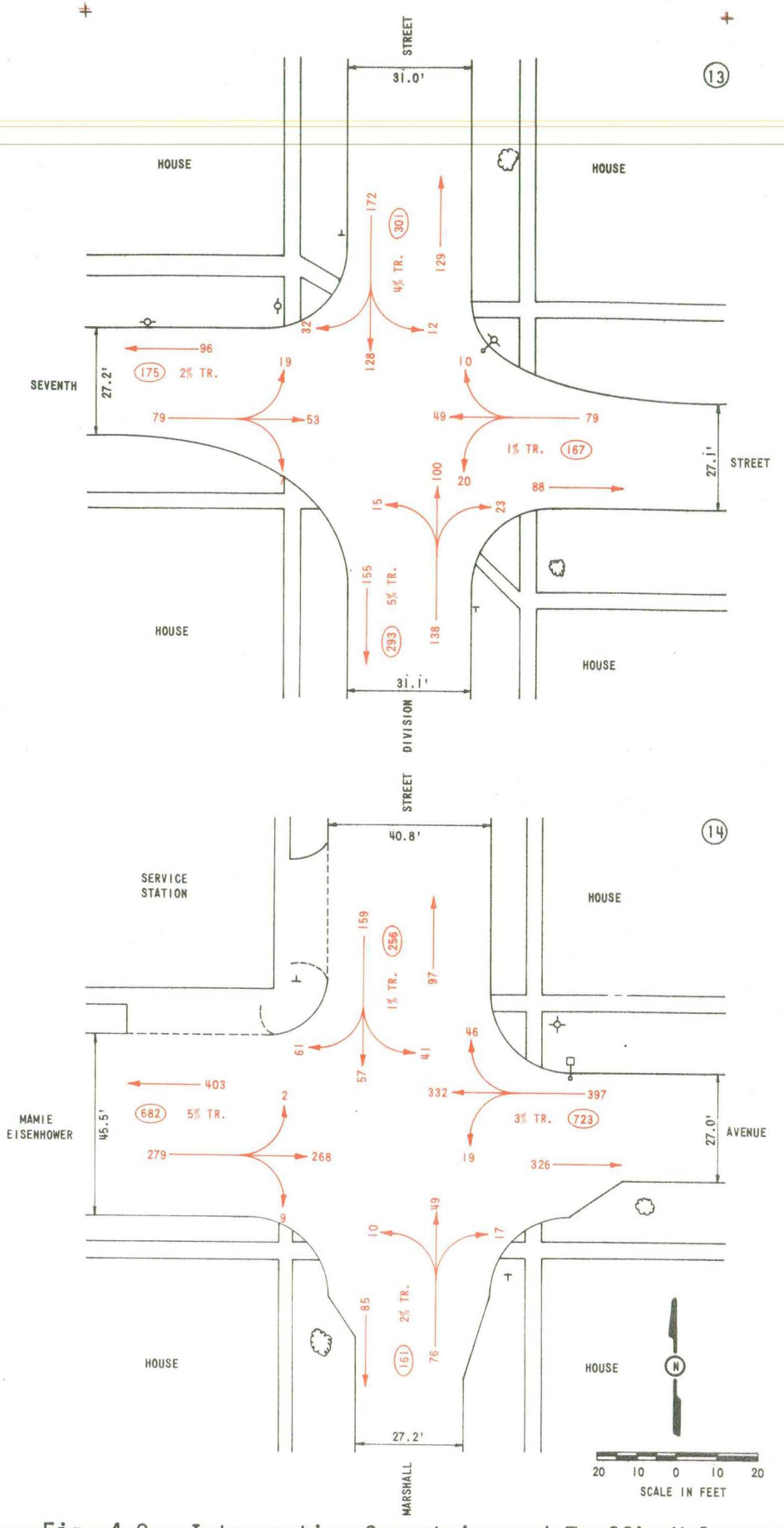


Fig. 4-8. Intersection Geometrics and Traffic Volumes for Intersection Nos. 13 and 14.

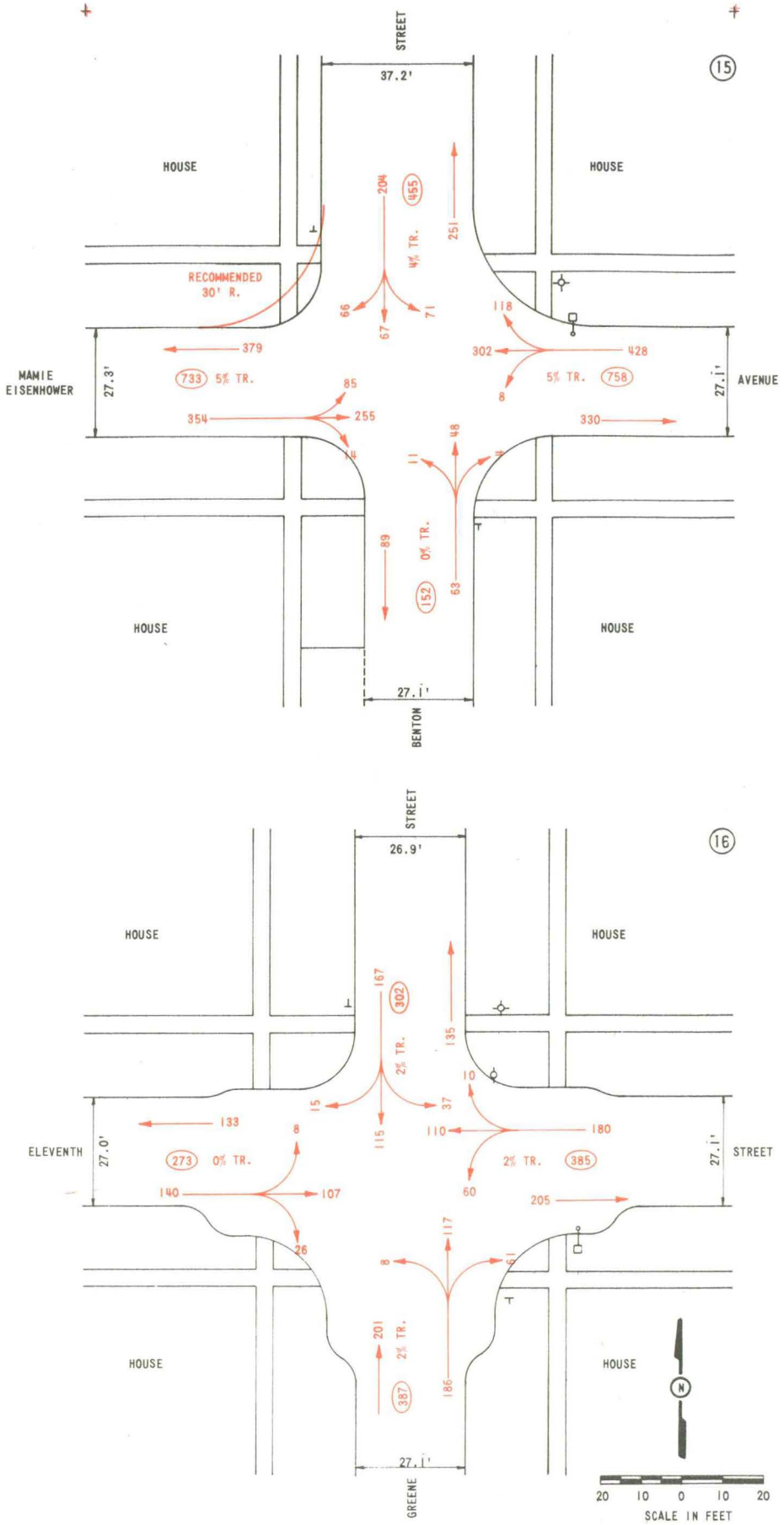


Fig. 4-9. Intersection Geometrics and Traffic Volumes for Intersection Nos. 15 and 16.

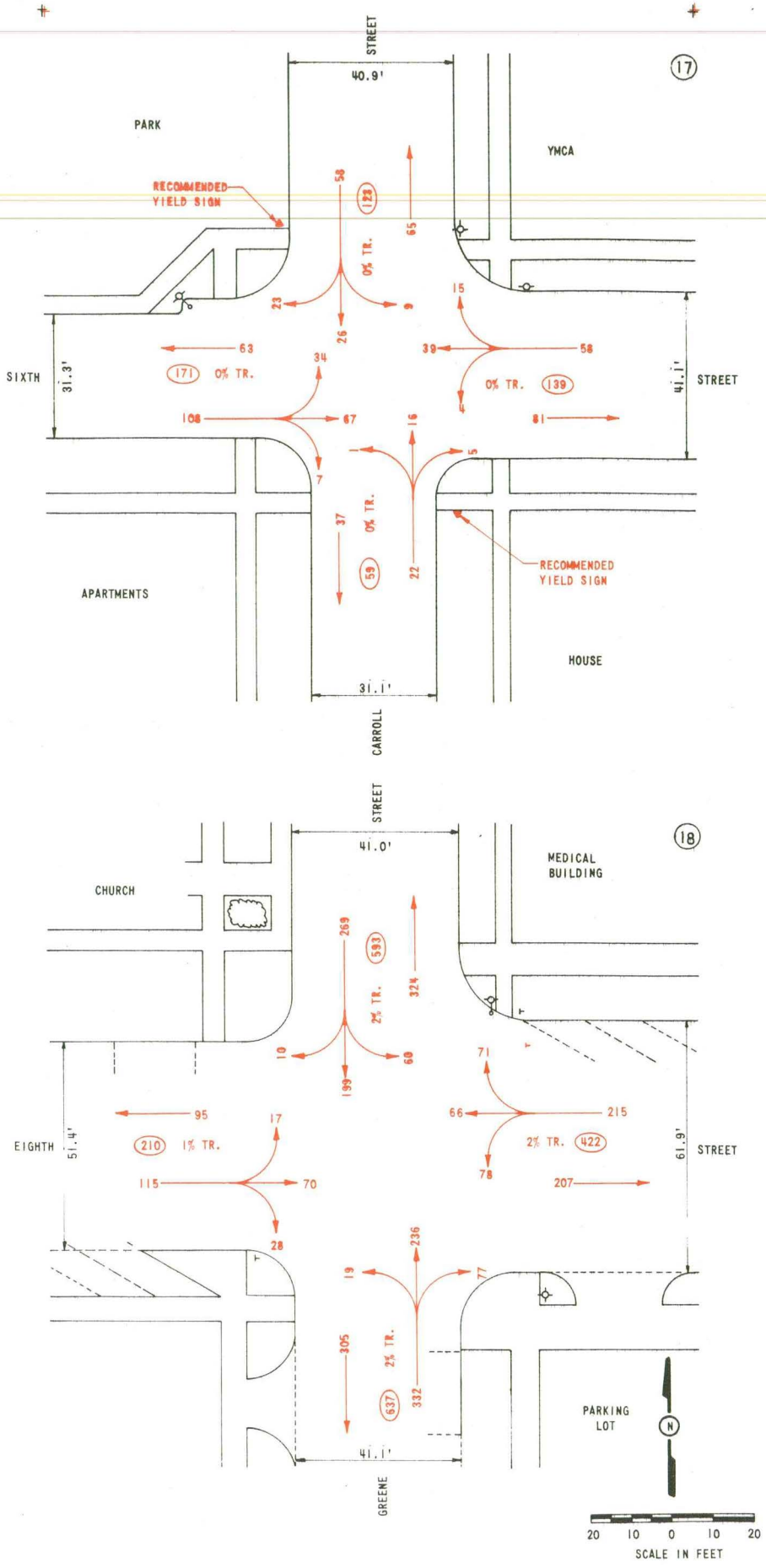


Fig. 4-10. Intersection Geometrics and Traffic Volumes for Intersection Nos. 17 and 18.

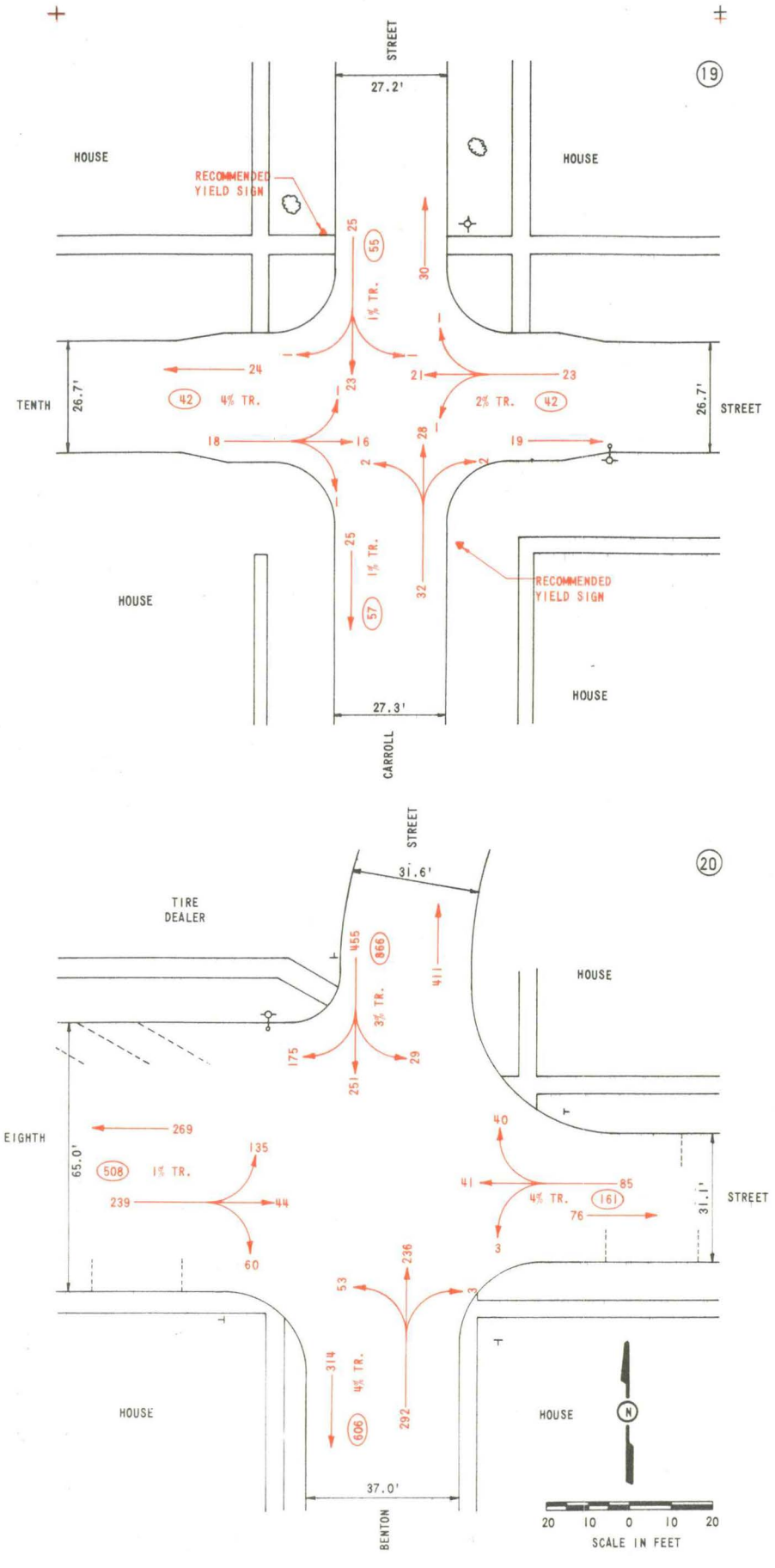


Fig. 4-11. Intersection Geometrics and Traffic Volumes for Intersection Nos. 19 and 20.

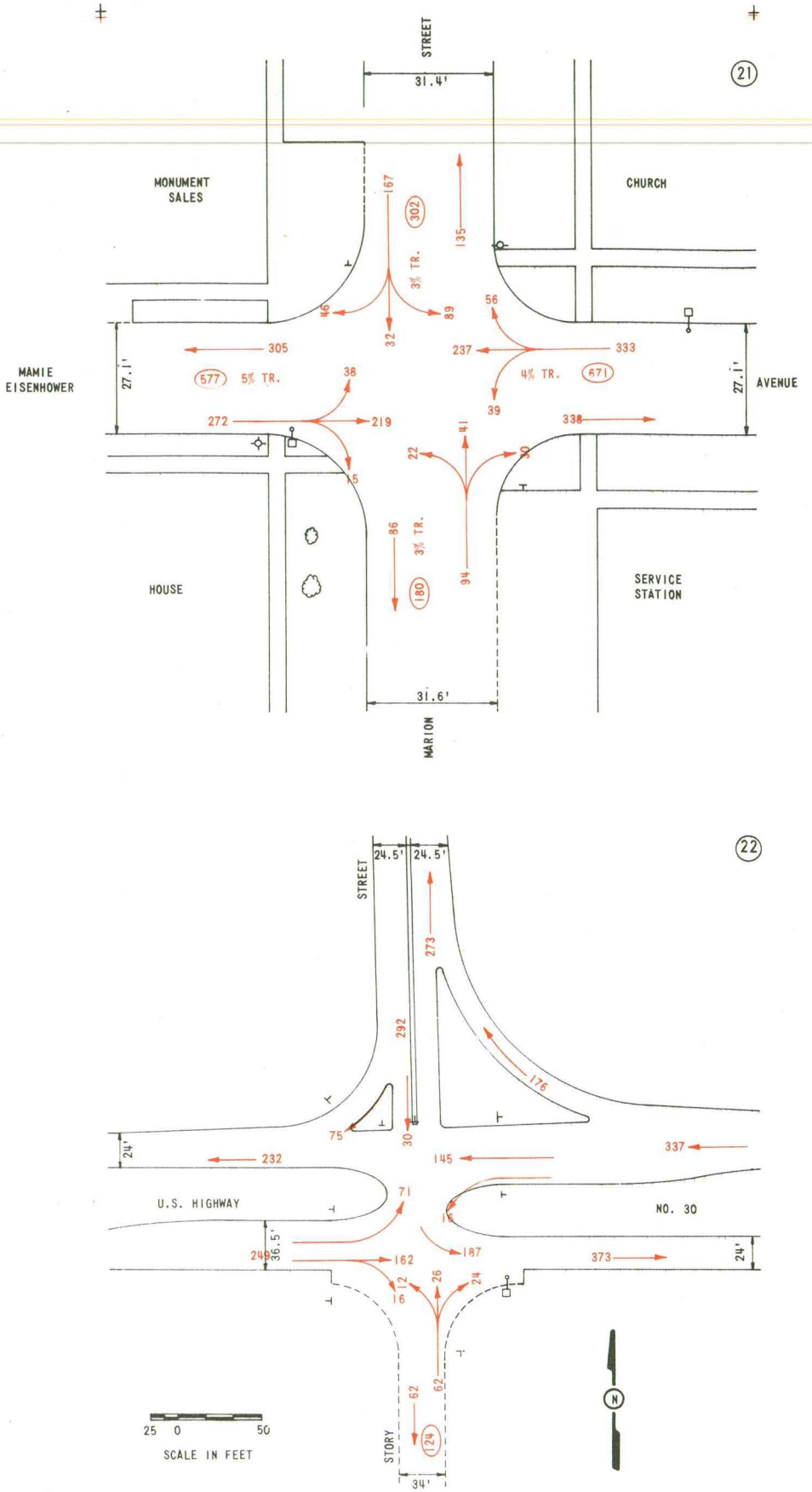


Fig. 4-12. Intersection Geometrics and Traffic Volumes for Intersection Nos. 21 and 22.

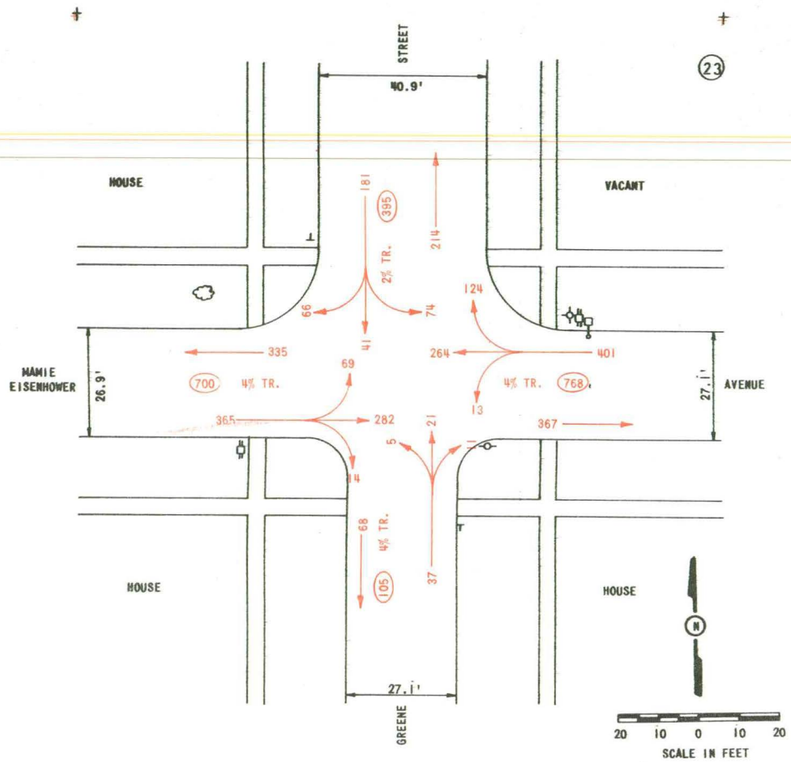
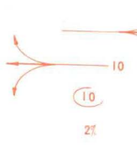


Fig. 4-13. Intersection Geometrics and Traffic Volumes for Intersection Nos. 23 and 24.

LEGEND

- UTILITY POLE
- FIRE HYDRANT
- MAIL BOX
- TRAFFIC SIGNAL
- STOP SIGN
- STREET LIGHT ON POWER POLE
- STREET LUMINAIRE
- TREE
- (5) COUNTING STATION
- 5 INTERSECTION IDENTIFICATION NUMBER



DESIGN HOURLY TRAFFIC VOLUME (ONE MOVEMENT)

DESIGN HOURLY TRAFFIC VOLUME (ONE DIRECTION)

TOTAL DESIGN TRAFFIC VOLUME (ONE INTERSECTION APPROACH)

PERCENTAGE OF TRUCKS PER APPROACH

INDEX OF INTERSECTION DIAGRAMS

FIGURE NUMBER FOR COLLISION DIAGRAM	FIGURE NUMBER FOR GEOMETRICS AND TRAFFIC VOLUMES	INTERSECTION IDENTIFICATION NUMBER	INTERSECTIONS
2-2	4-2	1	8TH STREET & STORY STREET
2-3		2	MAMIE EISENHOWER AVE. & STORY STREET
2-4	4-3	3	7TH STREET & STORY STREET
		4	6TH STREET & STORY STREET
2-5	4-4	5	11TH STREET & STORY STREET
		6	8TH STREET & ALLEN STREET
2-6	4-5	7	10TH STREET & STORY STREET
		8	9TH STREET & STORY STREET
2-7	4-6	9	8TH STREET & KEELER STREET
		10	5TH STREET & STORY STREET
2-8	4-7	11	7TH STREET & GREENE STREET
		12	LINN STREET & 9TH STREET - UNDERPASS
2-9	4-8	13	7TH STREET & DIVISION STREET
		14	MAMIE EISENHOWER AVE. & MARSHALL STREET
2-10	4-9	15	MAMIE EISENHOWER AVE. & BENTON STREET
		16	11TH STREET & GREENE STREET
2-11	4-10	17	6TH STREET & CARROLL STREET
		18	8TH STREET & GREENE STREET
2-12	4-11	19	10TH STREET & CARROLL STREET
		20	8TH STREET & BENTON STREET
2-13	4-12	21	MAMIE EISENHOWER AVE. & MARION STREET
		22	U.S. 30 & STORY STREET
2-14	4-13	23	MAMIE EISENHOWER AVE. & GREENE STREET
		24	6TH STREET & TAMA STREET

to turn a vehicle this sharply. The presence of parking near such corners will cause vehicular traffic to remain from 10 to 20 feet from the curbs, dependent upon whether parallel or diagonal parking is present and thus, in effect, will provide for an additional 10 feet in the turning radius with parallel parking and 20 feet for diagonal parking. The curved dashed lines shown in Figure 4-14 indicate the minimum 20-foot radius and the possible turning radius available at such intersections, using several combinations of parking and no parking as examples.

There are several locations where paving widths change at intersections. Such changes are many times accompanied by similar changes in parking lanes. Figure 4-14 shows several generalized examples of such. In this sketch, the increase in width from the centerline to the curb on the right for westbound traffic is offset by the amount of width required for diagonal parking. Such width is decreased for southbound traffic involving a change from diagonal to parallel parking. In cases as such examples shown in Figure 4-14, through traffic movements experience no significant change in lane width. At the majority of the 24 intersections studied, changes in paving widths are offset by changes in parking arrangements, so that "pavement width transition" signs are not required.

A different type of pavement transition exists, however, at the intersection of Mamie Eisenhower Avenue and Marshall Street (See Figure 4-8).

The outside, or right, lane for eastbound traffic on Mamie Eisenhower Avenue ends at Marshall Street, with a short recovery-lane taper being provided just east of Marshall Street. A vehicle in the right lane

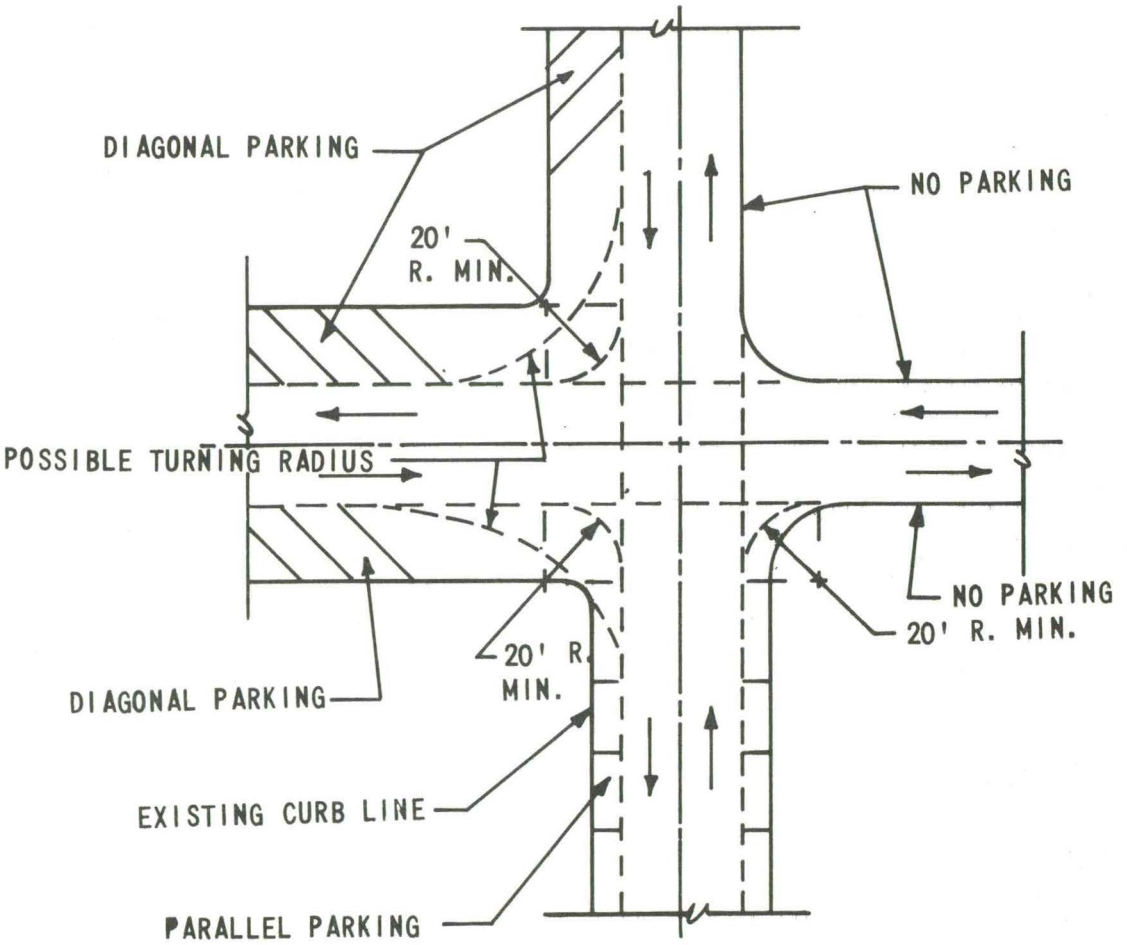


Fig. 4-14. Examples of Changes in Pavement Widths with Accompanying Changes in Parking Arrangements.

but wishing to continue east would presently be required to yield to traffic in the left or inside lane of Mamie Eisenhower Avenue. If such a motorist could not shift from the right lane to the inside lane prior to the intersection, only the width of the intersection would be available in which to shift to the left before reaching the single eastbound lane east of Marshall Street. Existing signing west of Marshall Street, reading "Pavement Narrows Right Vehicle Yield," precedes the intersection relative to such eastbound traffic. This signing is not in conformance with the requirements of the MUTCD.

It is recommended the existing signing be replaced by a "Pavement Width Transition" sign and a "Right Lane Must Turn Right," sign and that right-turn arrow pavement markings accompanied by the word "Only" be used to supplement the signing.

A similar situation currently exists relative to westbound traffic on Mamie Eisenhower Avenue at its intersection with Boone Street and similar recommendations are applicable thereto.

Table 4-1 is a listing of curb radii for each respective intersection measured. Additional data is provided to indicate those sides of the respective approaches on which parking is presently permitted by signing. Signing was found not to be in accordance with City Ordinance requirements in several locations. As discussed in previous paragraphs, the presence of parking on one or both approaches determines, to a large extent, the permissible curb radii. Present standards for curb radii call for minimum radii of 25 to 30 feet and are most applicable to major streets. Minimum curb radii for residential streets are 15 to 20 feet.

TABLE 4-1

EXISTING CURB RADII AND PARKING CONDITIONS

	INTERSECTION	EXISTING CURB RADIUS (FT.)				EXISTING PARKING ON APPROACH TO INTERSECTION			
		NW	NE	SE	SW	N	E	S	W
1.	8th Street and Story Street	12.0	15.0	5.0	15.0	E-W	N-S	E-W	N-S
2.	Mamie Eisenhower Avenue and Story Street	15.0	15.0	25.0	25.0	E	NP	NP	NP
3.	7th Street and Story Street	15.0	15.0	6.0	6.0	E-W	N-S	E-W	N-S
4.	6th Street and Story Street	18.0	15.0	15.0	19.0	E-W	N-S	E-W	N-S
5.	11th Street and Story Street	15.0	5.0	10.0	5.0	E-W	N	E-W	S
6.	8th Street and Allen Street	5.0	20.0	10.0	10.0	E-W	N-S	E-W	N-S
7.	10th Street and Story Street	15.0	15.0	12.5	10.0	E-W	N-S	E-W	N-S
8.	9th Street and Story Street	7.0	15.0	6.0	6.0	E-W	N-S	E-W	N-S
9.	8th Street and Keeler Street	10.0	7.5	15.0	17.2	E-W	N-S	E-W	N-S
10.	5th Street and Story Street	25.0	25.0	20.0	20.0	E-W	N-S	E	N-S
11.	7th Street and Greene Street	9.0	9.0	9.0	9.0	E-W	N-S	E-W*	N-S
12.	Linn Street and 9th Street - Underpass	(See Figure 4-7)				NP	NP	NP*	---
13.	7th Street and Division Street	20.0	27.0	20.0	31.0	E-W	N	E	N
14.	Mamie Eisenhower Avenue and Marshall Street	13.5	20.0	20.0	20.0	E	NP	E	NP
15.	Mamie Eisenhower Avenue and Benton Street	13.0	30.0	20.0	15.0	E**	NP	E-W	NP
16.	11th Street and Greene Street	13.0	13.0	20.0	20.0	W	N-S	ALT	N-S
17.	6th Street and Carroll Street	15.0	16.5	10.0	12.0	E-W	N-S	E-W	S
18.	8th Street and Greene Street	11.0	18.0	13.0	12.0	W	N-S	E-W	N-S
19.	10th Street and Carroll Street	15.0	15.0	15.0	15.0	E-W	N-S	E-W	N-S
20.	8th Street and Benton Street	17.5	35.0	20.0	20.0	E	N-S	E**	N-S
21.	Mamie Eisenhower Avenue and Marion Street	25.0	20.0	20.0	25.0	W	NP	E-W	N-S
22.	U.S. 30 and Story Street	(See Figure 4-12)				NP	NP	NP	NP
23.	Mamie Eisenhower Avenue and Greene Street	20.0	20.0	10.0	10.0	E	NP	W	NP
24.	6th Street and Tama Street	10.0	20.0	25.0	10.0	E-W	N-S	E-W	N

* City Ordinance Provides for No Parking on West Side of Street.
**City Ordinance Provides for No Parking on Either Side of Street.
ALT = Alternate Side Parking.

At most of the intersections studied in detail, the presence of parking on the respective streets in conjunction with existing corner radii results in satisfactory turning radii. The prohibition of truck traffic along portions of Story Street additionally allows sharper corner radii to function adequately.

It is recommended that the northwest corner of the intersection of Mamie Eisenhower Avenue and Benton Street be reconstructed to provide a 30-foot radius, as shown in Figure 4-9. The occurrence of truck turning movements at this location requires such an improvement in order to limit the encroachment of truck traffic into the opposing traffic lanes.

Relative to parking, it is recommended that on-street parking be prohibited on one side of narrow streets where such streets approach a stop sign. Such parking restrictions will provide an unobstructed approach for the stopping motorist as well as prevent the street from being occasionally blocked by a vehicle waiting at the stop sign. Additional parking modifications will be discussed in latter sections of this report.

OBSTRUCTIONS TO VIEW

Buildings, signs, trees, fences, railroads and parked vehicles near intersections are examples of those things that can obstruct the motorist's view at or around the corner and thus contribute to intersection accidents. Further, the view of a stop sign or yield sign, obscured by presence of trees or parked cars, can have tragic consequences.

As indicated in Figures 4-2 through 4-13, parking is presently permitted near many of the studied intersections, in some cases immediately behind the

respective crosswalks. Such parking arrangements can result in serious visual obstructions for approaching traffic, especially when diagonal parking is present. At other times, with less parking occurring or when parking is prohibited near the intersection, no obstruction to view may be present. An example of restricted sight distance caused by diagonal parking is shown in Figure 4-15.

Fig. 4-15. Visual Obstruction Caused by Parked Vehicles.

The prohibition of parking within 20 to 30 feet of the various crosswalks, as recommended in Chapter 3, will substantially improve sight distances at intersections.

Significant visual obstructions were not observed at the majority of the studied intersections, except for the aforementioned sight restrictions caused by parked vehicles. At some approaches to the signalized intersections

on Story Street, the view of traffic signals was sometimes obscured by street light poles, although at least one signal was visible from any point on the approach.

Stop signs at several locations throughout the City were observed to be mounted too low, and could potentially be hidden behind parked vehicles.

TRAFFIC VOLUMES

Vehicular Traffic Volumes

The type of vehicles and the quantity or volume of vehicles traveling on a given roadway are the primary features upon which many elements of highway design are based. The design of such features as pavement width, pavement thickness, turning lanes, roadway lighting, traffic signal installations and timing, signing and pavement markings are based on existing or anticipated traffic volumes to be accommodated by the highway or street.

The basic traffic volume normally used for design of the various streets and intersections is the thirtieth highest hourly volume of the year on any such intersection or approach to an intersection. In other words, the design hourly volume is that hourly volume which will be exceeded only 29 times a year.

Existing traffic volumes were observed at the intersections identified in Figure 4-1. As part of this study, current traffic counts were conducted at 22 of the 24 numbered intersections during May of 1977. Similar traffic counts were conducted by the Iowa Department of Transportation in August of 1976 at the two remaining intersections. (Mamie Eisenhower Avenue and Story Street, and U.S. Highway 30 and Story Street.) Such traffic counts were

made on weekdays between the hours of 7:00 and 11:00 A.M. and between 2:00 and 6:00 P.M., and included the number of vehicles traveling straight ahead, turning right and turning left on each approach to the respective intersections. Vehicles were further classified according to type. One classification included passenger cars, pick-up trucks and motorcycles. Other categories included single-unit trucks, buses and tractor-trailer truck combinations. All buses and single-unit or larger trucks were included in the percentage of trucks using the respective streets.

Average daily traffic volumes (abbreviated A.D.T.) and design hourly volumes of traffic (30th highest hour) were computed for all counted intersections. These values were based on the results of the eight-hour traffic counts conducted and on traffic count information furnished by the Iowa Department of Transportation, Highway Division.

The map in Figure 4-16 indicates the average daily traffic volumes for the various streets. The respective band widths are to scale, proportional to the number of vehicles using such streets on an average day. A band-width scale is included in the upper right-hand portion of this figure. Mid-block features, such as parking lots or alleys into which traffic may turn, account for the imbalance in traffic volumes at adjacent intersections.

Design hourly traffic volumes for all movements within each counted intersection are shown in Figures 4-2 through 4-13. Traffic volume data included in these figures includes the following hourly volumes: for each movement, totals for each direction of traffic entering or leaving

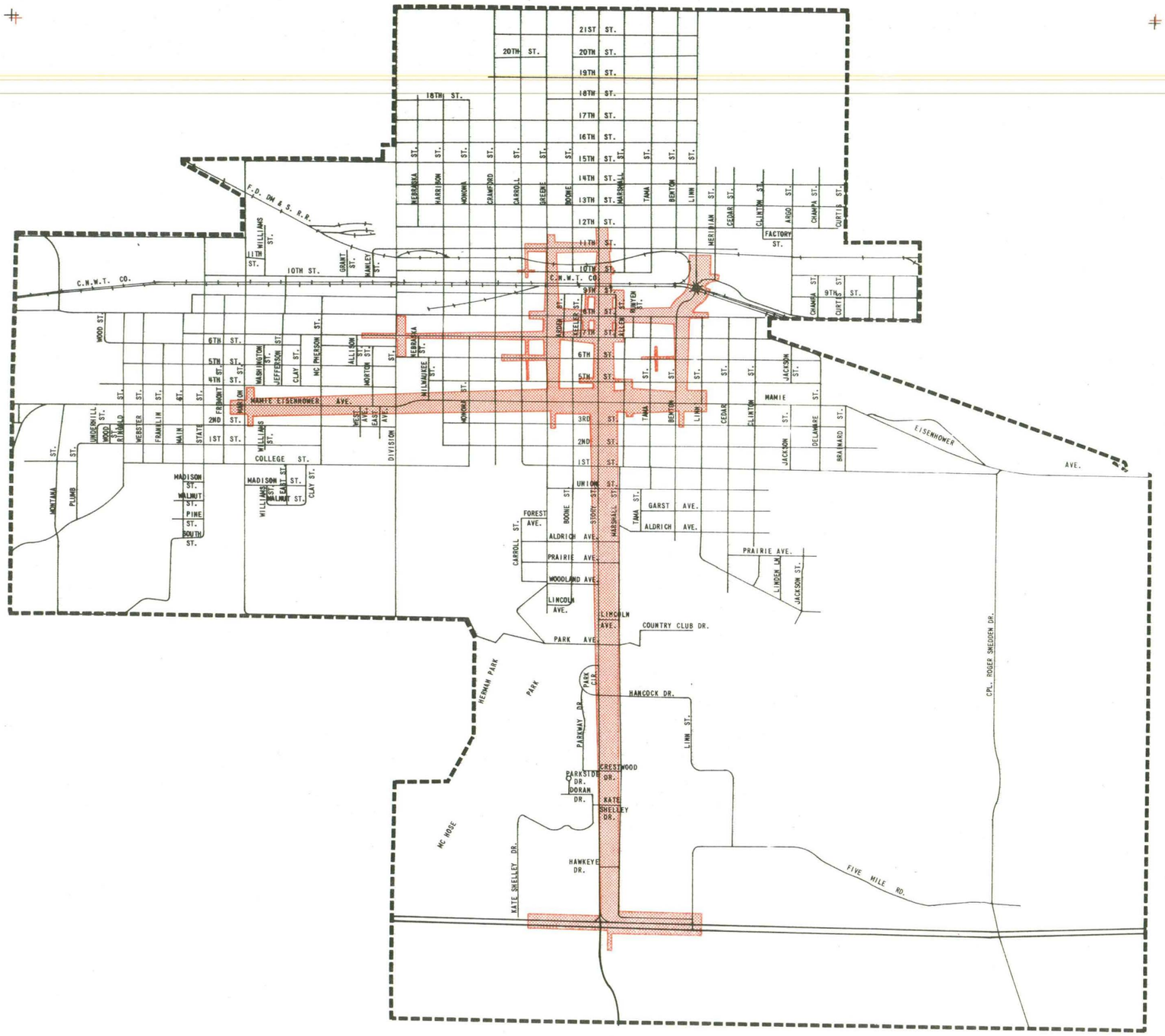


Fig. 4-16. Average Daily Traffic Flow Map.

intersection (per approach), total traffic per approach (both directions of traffic), and the percentage of trucks (per approach). The legend pertaining to hourly traffic volumes and an index for such intersections is included on the fold-out sheet that follows Figure 4-13.

Pedestrian Volumes

Pedestrians are often in conflict with vehicular traffic, particularly at intersections and other crosswalk locations. The amount of pedestrian traffic is an important consideration in the design of such features as sidewalks, drainage and traffic control devices.

Pedestrian counts were conducted concurrently with vehicular counts at each of the 24 intersections studied. The observed pedestrian volumes are shown for intersections within the central business district in Figure 4-17. These values represent the highest hourly volumes observed for each of the respective crosswalks. They are not necessarily the peak pedestrian volumes that might occur within the year, as seasonal variations may produce peak volumes considerably higher than those observed during this study. Pedestrian peak volumes shown in Figure 4-17 generally occurred during the 3:00 to 4:00 P.M. hour after the dismissal of nearby schools.

INTERSECTION CAPACITY ANALYSIS AND LEVELS OF SERVICE

Each intersection for which traffic counts were made was analyzed according to its respective features, including pavement widths, location within the community, traffic volumes, left-turning volumes, right-turning volumes, truck volumes, parking conditions and existing traffic signal

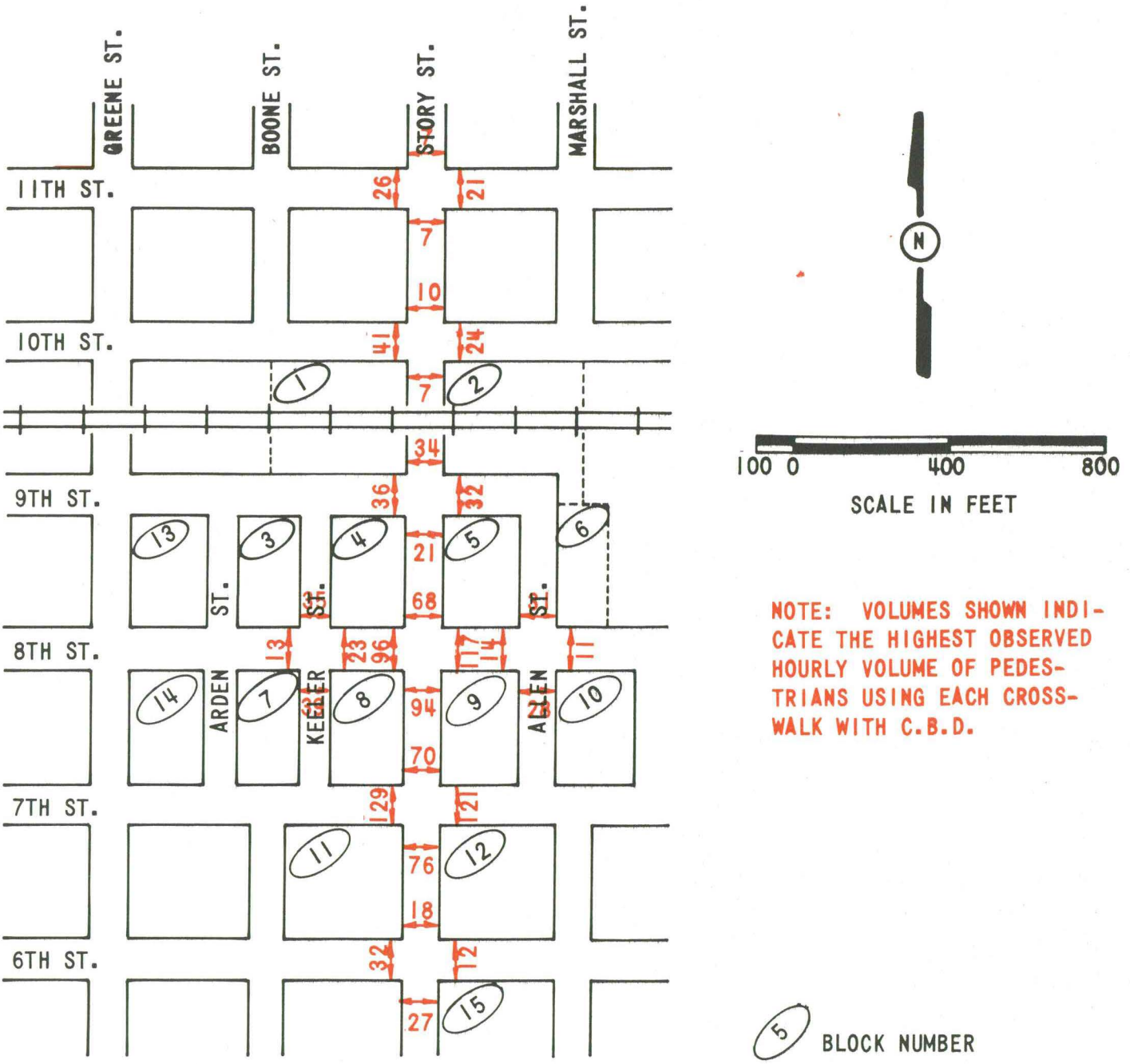


Fig. 4-17. Observed Pedestrian Volumes in Vicinity of Central Business District.

timing. The level of service was determined for each intersection approach. The level of service is an index for rating the operational characteristics of each intersection or roadway, which include the following: safety, driving comfort and convenience, freedom to maneuver, speed and travel time, traffic interruptions and restrictions and economy. Levels of service are designated A, B, C, D, E and F, with operating conditions progressing from most satisfactory to least satisfactory, respectively. Table 4-2 indicates the characteristics of each respective level of service.

TABLE 4-2

LEVELS OF SERVICE CHARACTERISTICS

LEVEL OF SERVICE	DESCRIPTION OF OPERATING CONDITIONS
A	Free flow, low density, little restriction of maneuverability, driver may select desired lane with comfort, little or no delays.
B	Stable flow, minor restrictions in operation, driver has reasonable freedom in selecting desired land of operation.
C	Lesser stable flow, most drivers are restricted in changing lanes or passing, relatively satisfactory operating speed.
D	Approaching unstable flow, low operating speed, little freedom to maneuver, comfort and degree of convenience low, condition tolerable for short periods only.
E	Unstable flow, lower operating speeds, some momentary stoppages, volumes at or near capacity.
F	Forced flow, operations at low speeds, highway acts as a storage area, many stoppages.

As was previously noted in this chapter, several streets in Boone are presently too narrow to accommodate two lanes of traffic and the present parking arrangements. A pavement width of less than 40 feet is considered too narrow to permit parallel parking on both sides and paving widths of

less than 32 feet are too narrow to accommodate two lanes of traffic and one lane of parallel parking. It is desirable that widths of 48 and 36 feet, respectively, be provided for such conditions.

The width of existing pavements for many streets outside of the central business district is 31 feet, although some streets are as narrow as 24 feet. Parking is not presently prohibited on either side of many such streets. These streets are too narrow to accommodate parking on both sides while maintaining two lanes of traffic. However, traffic volumes and parking demand on most residential streets are small enough that parking prohibitions are not often warranted. For the occasional event when two vehicles are parked opposite each other on such streets, the street is essentially reduced to one lane of traffic in that area. It is recommended that parking on one or both sides of such narrow streets be prohibited if the streets are to function as through streets. On-street parking modifications are further discussed in Chapter 5.

The aforementioned recommendations, relative to prohibition of parking on existing narrow streets, were included in calculations to determine the levels of service for the various intersections that were studied in detail. Existing traffic signal timings were used to analyze the signalized intersections along Story Street. The results of the level of service determinations indicated that, with the recommended changes in parking, 21 of the 24 intersections studied would operate at a level of service "A". The intersection of Story Street with Mamie Eisenhower Avenue operates at a level of service "C", while the intersections of Story Street with Sixth Street and Mamie Eisenhower Avenue with Greene Street each have a level of service "B".

The aforementioned levels of service are based on existing traffic volumes at the 24 studied intersections. It is anticipated that somewhat lower levels of service may be experienced at times due to fluctuations in pedestrian and vehicular traffic volumes.

Level of Service "C" is an acceptable level for urban facilities. Accordingly, traffic volumes may continue to increase somewhat at most of the studied intersections before such level is reached. At the intersection of Mamie Eisenhower Avenue and Story Street, however, any increase in traffic volumes will result in a Level of Service "D" at that location, with accompanying congestion, lower operating speeds and increased accident potential.

RAILROAD OPERATIONS

The Chicago and North Western Transportation Company (C.N.W.) currently operates a major east-west freight route through the City of Boone, along trackage generally located between Ninth and Tenth Streets. In addition, the Fort Dodge, Des Moines and Southern Railroad line passes through the City, generally located between Tenth and Eleventh Streets.

Railroad operations along the C.N.W. trackage are frequent, averaging approximately 20 to 30 trains per day. During the traffic counting phase of this study, approximately 1.3 trains per hour were observed using the C.N.W. tracks. The observed duration of the respective train crossings ranged from 3 minutes to 20 minutes, with an average duration of 6.6 minutes per train crossing. During the eight-hour period of traffic counting, the C.N.W. grade crossings within the City of Boone were observed to be blocked for approximately 8.3 minutes during an average hour.

Presently there is one railroad viaduct within the City of Boone, being located on an extension of Benton Street and Linn Street. During times when the remaining grade crossings are blocked by railroad operations, this viaduct spans the only unblocked roadway connecting the north and south portions of the City. Traffic volumes along Benton Street and Linn Street near the railroad viaduct were observed to increase during such times when trains were present.

The effects of railroad operations could be a detriment to emergency vehicle operations, especially when responding to emergencies in the northwest portion of the City. For example, during a train crossing a fire truck dispatched from the fire station on Allen Street north of Eighth Street would be required to travel east to Benton Street, then north under the viaduct, and then west to reach any point in the northwest portion of Boone. This distance is approximately 3,000 feet farther than that required when the railroad crossings are not blocked. A similar delay would be experienced by emergency vehicles traveling to and from the hospital near the intersection of First Street and Marshall Street. In addition to the increased travel distance, the increase in traffic volumes utilizing the railroad underpass during train crossings would further retard the response time for emergency vehicles.

According to City ordinances, "Whenever Greene Street or Story Street in said city is blocked by any railroad company's train, locomotive or car and it is necessary for the fire equipment to pass in order to respond to a fire alarm given, any such railroad company shall immediately, upon orders from the fire chief or his assistant, cause said train, locomotive or car to be removed or the train broken so that the fire equipment may pass."

Dependent upon traffic conditions, such action could reduce the response time of fire vehicles, compared to using the railroad underpass, although a delay in the fire response time would be likely in either case, as a train cannot instantaneously be removed from the required crossing.

In consideration of the frequency of railroad operations, the locations of emergency facilities, and the high volume of traffic currently using the railroad underpass, it appears that an additional grade separation across the C.N.W. railroad would be desirable. It is recommended that a detailed study of traffic and other conditions precede the selection of a location for such a grade separation. Among factors recommended to be considered are traffic volume, travel distances to emergency facilities, existing topography, land use and buildings near the respective crossing, right-of-way available, existing utilities, projected growth patterns of the City, estimated cost of the grade separation and other related factors.

STORY STREET TRAFFIC OPERATIONS

Existing traffic lanes along Story Street from Sixth Street to Eleventh Street include two parallel parking lanes, two lanes for through and right-turning traffic and one left-turn lane. This arrangement, which is typical on Story Street between said streets, is depicted in Figure 4-18.

As indicated in Figure 4-18, the existing lanes are narrow in width, with little clearance being provided between the traveled lanes and the parking lanes. As a result, drivers attempting to park their vehicles, or attempting to enter the traveled lanes from a parked position, encounter a relatively restricted area in which to accomplish such maneuvers. Parking-related accidents such as improper backing and failure to yield right-of-way

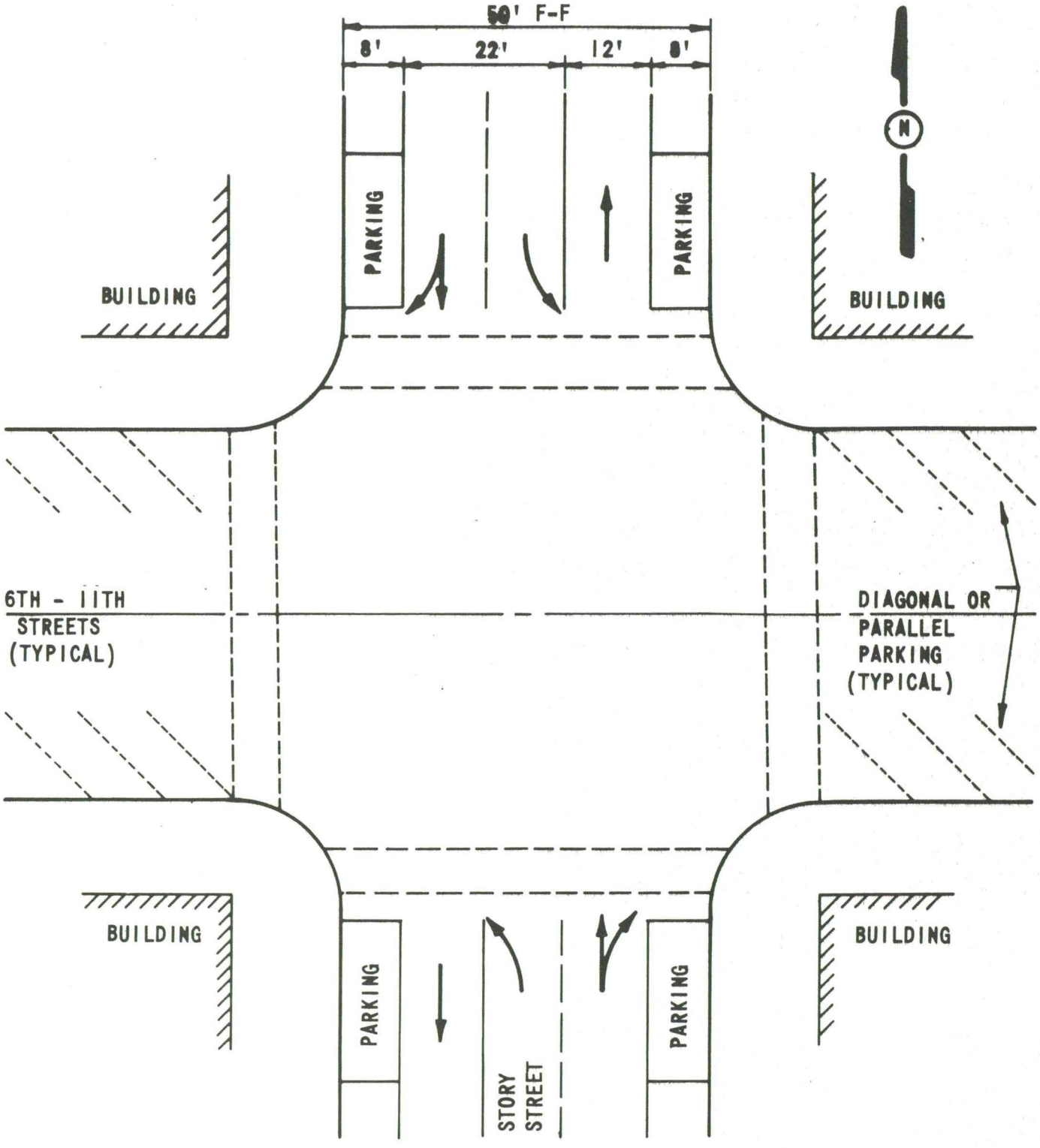


Fig. 4-18. Typical Layout of Story Street Intersection Within Central Business District.

from the curb have been frequent along Story Street, with 114 such accidents being reported between Sixth and Eleventh Streets.

Traffic volumes for each left-turning movement along Story Street are summarized in Table 4-3. These figures represent the 30th highest hour, or design hour traffic volumes as previously discussed. The need for exclusive left-turn lanes is related to the volume of left-turning traffic at each of the respective intersections listed, as well as the volume of oncoming or opposing vehicles. As indicated, several exclusive left-turn lanes, which are presently provided, carry relatively light volumes of left-turning traffic.

TABLE 4-3

DESIGN HOURLY TURNING VOLUMES ALONG STORY STREET

INTERSECTION	LEFT-TURNS FROM			
	North	South	East	West
Story Street and 5th Street	23	13	11	13
Story Street and 6th Street	25	25	29	26
Story Street and 7th Street	30	34	46	27
Story Street and 8th Street	32	52	72	25
Story Street and 9th Street	52	48	35	34
Story Street and 10th Street	15	26	18	12
Story Street and 11th Street	30	31	40	25

It is recommended that existing left-turn lanes at the intersections of Story Street with 6th, 7th, 8th, 9th, 10th and 11th Streets be removed. With parallel parking on both sides of Story Street, traveled lane widths of approximately 17 feet in each direction will result, which will increase the space available for parallel parking maneuvers. Such an arrangement should reduce the incidence of parking-related accidents without significantly disrupting traffic operations.

As previously indicated in Chapter 3, it is recommended that on-street parking be prohibited within 30 feet of the crosswalk at signalized intersections. Such parking restrictions, in addition to providing improved sight distance at intersections will allow traffic to move around a vehicle waiting to turn left at the intersection. Accordingly, small volumes of left-turning traffic will not significantly disrupt the through-traffic movements at such intersections.

The effects of the above-recommended improvements on parking supply and demand will be addressed in Chapter 5.

TRAFFIC CONTROL DEVICES

Traffic Signals

Traffic signals should not be installed or remain in operation (if already installed) unless one or more of the signal warrants, as set forth in the Manual on Uniform Traffic Control Devices for Streets and Highways, are met. Such warrants are, however, advisory rather than mandatory in nature. Table 4-4 describes briefly the various warrants for installation of traffic signals. As indicated, minimum vehicular and/or pedestrian traffic volume criteria are to be met to satisfy the respective warrants. The MUTCD differentiates between communities with less than 10,000 population by reducing by approximately 30 percent the minimum traffic volume criteria. The latter is in recognition of differences in the nature and operational characteristics of traffic in smaller communities.

TABLE 4-4

DESCRIPTION OF TRAFFIC SIGNAL WARRANTS

WARRANT NO.	DESCRIPTION OF APPLICATION
1 Minimum Vehicular Volume	Where the volume of intersecting traffic is the principal reason for consideration of the signal installation.
2 Interruption of Continuous Traffic	Where the volume of traffic on the major street is so heavy that traffic on a minor intersecting street suffers excessive delay or hazard in entering or crossing the major street.
3 Minimum Pedestrian Volume	Where the volume of pedestrian traffic desiring to cross the major street is in conflict with heavy volumes of vehicular traffic.
4 School Crossing	Where a traffic engineering study of the frequency and adequacy of gaps in the vehicular traffic stream as related to the number and size of groups of school children at the school crossing shows that the number of adequate gaps in the traffic stream during the period when children are using the crossing is less than the number of minutes in the same period.
5 Progressive Movement	Where progressive movement control necessitates traffic signal installations, that might not otherwise be warranted, in order to maintain proper grouping of vehicles and effectively regulate group speed.
6 Accident Experience	Where accident experience has proven that less restrictive remedies have failed; that accidents susceptible to correction by traffic signal control have occurred to a certain extent; that vehicular and pedestrian volumes are at least 80 percent of the requirements in either Warrants 1, 2 or 3; and that such signal installation will not disrupt progressive traffic flow.
7 Systems Warrant	Where traffic signal installation at some intersections may be warranted to encourage concentration and organization of traffic flow networks.
8 Combination of Warrants	In exceptional cases where signals cannot be justified by one single warrant but where two or more of Warrants 1, 2 and 3 are satisfied to the extent of 80 percent or more of the stated values.

Ref. Manual on Uniform Traffic Control Devices for Streets and Highways, U.S. Department of Transportation, Federal Highway Administration, 1971.

All existing signalized intersections and those unsignalized intersections which carry higher volumes of traffic or have a considerable accident history were evaluated regarding the various warrants. Table 4-5 includes the results of the evaluation of the indicated traffic signal warrants for each of the listed intersections. According to the MUTCD, the minimum traffic volumes set forth must be exceeded during each of eight hours of an average day in order for traffic signals to be warranted. Based on existing traffic volumes, traffic signal installations are not warranted at any of the intersections evaluated, with the exception of the Story Street intersections at Eighth Street and Mamie Eisenhower Avenue, when evaluated according to Boone's population being in excess of 10,000.

Although Boone's population of 12,468 is in excess of 10,000 residents, the characteristics of its traffic may possibly be considered as being more like that of a community with a population slightly less than 10,000. Therefore, a further comparison of existing traffic volumes was made relative to traffic criteria for smaller communities (less than 10,000 population) to determine if traffic signals were so warranted. As is indicated in Table 4-5, such an evaluation indicated that traffic signals would be warranted at certain intersections.

It should be noted that Warrant No. 4 for School Signals (see Table 4-4) requires a detailed study of traffic and pedestrian movements which is beyond the scope of this study and thus was not included in this evaluation. As was recommended in the preceding chapter, it is recommended that a comprehensive "Safe School Route Plan" be developed through the Iowa Department of Transportation Department's Traffic Engineering Assistance Program.

TABLE 4-5

EVALUATION OF TRAFFIC SIGNAL WARRANTS

No.	Intersection Street	Intersection Street	Present Type of Control	More Than 10,000 Population Basis: Evaluation of Traffic Signals, Warrant Number 1	2	3	4*	5	6	7	8	Signals Warranted Yes or No	Less Than 10,000 Population Basis: Evaluation of Traffic Signals, Warrant Number 1	2	3	4*	5	6	7	8	Signals Warranted Yes or No
2	Story	Mamie Eisenhower	T.S.	Yes	No	No		No	Yes	Yes	Yes	Yes	Yes	Yes	No		No	Yes	Yes	Yes	Yes
10	Story	Fifth	S.S.	No	No	No		No	No	No	No	No	No	No	No		No	No	No	No	No
4	Story	Sixth	T.S.	No	No	No		No	No	No	No	No	No	No	No		No	No	No	B	No
3	Story	Seventh	T.S.	No	No	No		No	No	No	No	No	B	No	No		No	No	No	Yes	Yes
1	Story	Eighth	T.S.	No	No	No		No	No	Yes	No	Yes	B	No	No		No	No	Yes	B	Yes
8	Story	Ninth	T.S.	No	No	No		No	No	No	No	No	No	No	No		No	No	No	No	No
7	Story	Tenth	T.S.	No	No	No		No	No	No	No	No	No	No	No		No	No	No	No	No
5	Story	Eleventh	T.S.	No	No	No		No	No	No	No	No	No	No	No		No	No	No	No	No
6	Eighth	Allen	4-Way S.S.	No	No	No		No	No	No	No	No	No	No	No		No	No	No	B	No
9	Eighth	Keeler	None	No	No	No		No	No	No	No	No	No	No	No		No	No	No	No	No
18	Eighth	Greene	S.S.	No	No	No		No	No	No	No	No	B	No	No		No	No	No	B	No
20	Eighth	Benton	4-Way S.S.	B	No	No		No	No	No	B	No	Yes	No	No		No	No	No	Yes	Yes
15	Mamie Eisenhower	Benton	S.S.	No	No	No		No	No	No	No	No	Yes	No	No		No	No	No	B	Yes
21	Mamie Eisenhower	Marion	S.S.	No	No	No		No	No	No	No	No	No	No	No		No	No	No	B	No
23	Mamie Eisenhower	Greene	S.S.	No	No	No		No	No	No	No	No	Yes	No	No		No	No	No	B	Yes

B = Borderline Condition
T.S. = Traffic Signal
S.S. = Stop Sign

*Excludes Evaluation of "School Crossing" Warrant.

In consideration of existing traffic conditions and characteristics, accident experience and the various traffic signal warrants, it is recommended that traffic signal installations be provided at the following intersections:

Story Street and Mamie Eisenhower Avenue.

Story Street and Seventh Street.

Story Street and Eighth Street.

It is further recommended that existing Story Street traffic signals at the intersections of Sixth, Ninth, Tenth and Eleventh Streets be removed, as they are not warranted. Traffic signals are not recommended for the Mamie Eisenhower intersections at Benton and Greene Streets due to the fact that 4-way stop signs are not warranted. (See subsequent evaluation relative to 4-way stop signs.) Signals are not recommended at the intersection of Eighth and Benton Streets, as there have been relatively few accidents during the five-year study period and due to its borderline condition relative to satisfying signal warrants.

According to the MUTCD, all traffic signal installations should conform to the following criteria, among others:

1. A minimum of two signal faces for through traffic shall be provided and should be continuously visible from a point at least the following distances in advance of and to the stop line, unless physical obstruction of their visibility exists:

85th Percentile Speed	Minimum Visibility Distance (Ft.)
20	100
25	175
30	250

2. At least one and preferably both of the signal faces shall be located not less than 40 feet nor more than 120 feet beyond the stop line. Where both of the signal faces are post-mounted, they shall both be on the far side of the intersection, one on the right and one on the left. In addition, at least one and preferably both of the signal faces shall be located between two lines intersecting with the center of the approach lanes at the stop line; one making an angle of approximately 20 degrees to the right of center of the approach extended, and the other making a like angle of 20 degrees to the left. These requirements are shown in Figure 4-19.

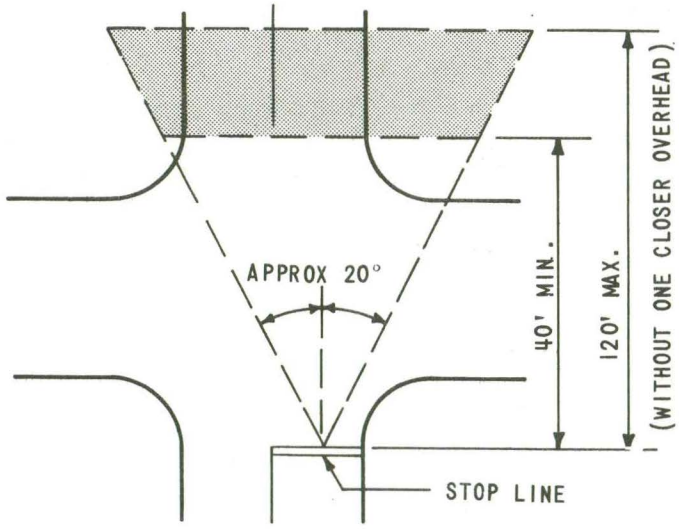


Fig. 4-19. Desirable Location of Traffic Signals.

TABLE 4-6

EXISTING TRAFFIC SIGNAL ANGLES OF VIEW

INTERSECTION	APPROACH	ANGLE OF VIEW OF SIGNAL (DEGREES)			
		LEFT LANE		RIGHT LANE	
		Left	Right	Left	Right
Mamie Eisenhower Avenue and Story Street	S	34	17 (4)*	40 (4)*	10
	N**	35	21 (4)*	43(6 & 13)*	12
	E	29	15	35	8
	W**	30(1)	18 (7)	37 (1 & 8)	11
11th Street and Story Street	S	34	20	31	12
	N	35	21	41	13
	E	30	10	---	---
	W	30	10	---	---
10th Street and Story Street	S	32	17	39	10
	N	32	18	39	10
	E	33	10	---	---
	W	34	10	---	---
9th Street and Story Street	S	35	20	41	13
	N	37	21	39	13
	E	30	10	---	---
	W	30	10	---	---
8th Street and Story Street	S	26	14	32	9
	N	25	14	31	8
	E	37	20	42	14
	W	34	22	40	15
7th Street and Story Street	S	29	17	35	10
	N	31	17	37	10
	E	30	17	36	11
	W	32	18	39	11
6th Street and Story Street	S	34	19	40	12
	N	34	23	41	15
	E	29	13	---	---
	W	33	12	---	---

*Angle of view to Mast-Arm Signal is in parenthesis.
**Signal poles at SW and SE corners of intersection have been relocated and replaced since field surveys were made as part of this study. Indicated angles are approximate for new signals. New mast-arm-mounted signals provide improved angles of view.

Each existing traffic signal installation was compared to the standards as set forth concerning location and angle of view. Table 4-6 is a listing of these comparisons. Mast-arm signal poles are provided at the intersection of Story Street and Mamie Eisenhower Avenue, while the remaining installations each provide two pedestal-mounted signals facing each approach. (School crossing signals were not included in this analysis.)

As shown in Table 4-6, most of the existing traffic signals are within the prescribed limits regarding angle of view relative to existing lane arrangements. For traffic approaching the following intersections in the left lane, neither signal is strictly within the desirable limits:

11th Street and Story Street - North Approach

9th Street and Story Street - North Approach

8th Street and Story Street - West Approach

6th Street and Story Street - North Approach

Angles of view at these locations range from 21^{o} to 23^{o} to the right and 34^{o} to 37^{o} to the left. Angles of view slightly in excess of 20^{o} are deemed to be within the "Approx. 20^{o}" MUTCD criteria. Therefore, existing angles of view from 21^{o} to 23^{o} to the right at these locations are acceptable.

Based on previously recommended elimination of left-turn lanes and provision of traffic signals at the Story Street intersections of Seventh and Eighth Streets, the following angles of view result relative to existing traffic signals:

	Northbound		Southbound	
Intersection	Left	Right	Left	Right
Story Street and Seventh Street	34°50'	12°20'	35°30'	12°50'
Story Street and Eighth Street	30°40'	5°15'	29°00'	10°20'

Angles to the left are considerably in excess of MUTCD guidelines, while angles of view to the right are satisfactory at both intersections.

Traffic accident histories were analyzed for the above intersections, and were compared to the remaining signalized intersections along Story Street. Rear-end collisions and other accidents, which may be attributed to poor signal visibility, occurred frequently at most of the signalized intersections. The four approaches listed above do not appear significantly more dangerous than other similar approaches, indicating that poor signal visibility may be a problem at many locations, in addition to those listed above.

In order to improve the visibility of traffic signals at the Story Street intersections at Seventh and Eighth Streets, it is recommended that mast-arm signal poles be installed at each corner of each of the two intersections. As part of such, it is recommended that 12-inch diameter red-signal lenses be provided for existing signal heads, with one red-yellow-green-signal head being post-mounted and another being mounted overhead on each mast-arm pole. Existing pedestrian WALK-DON'T WALK signals are recommended to be installed on the new posts. It is further recommended that the new mast-arm posts be painted highway yellow and that backplates be installed for all traffic signal heads to improve visibility.

It is recommended that "No Turn on Red" signs be installed at the intersections of Story Street and Seventh and Eighth Streets relative to all approaches.

At the intersection of Story Street and Mamie Eisenhower Avenue, 16 reported accidents have involved left-turn violations, and 12 other accidents have involved right-turn violations. In order to provide for safer traffic operation at this intersection, and in consideration of the heavy turning volumes of traffic, it is recommended that three-phase signalization be provided at this location. Such signalization would provide a separate left-turn signal for the north and south approaches, as discussed under "Traffic Signal Timing."

The following changes in the existing signal installation are recommended at the aforementioned intersection:

1. Provide a new mast-arm pole for northbound traffic, with a signal head overhanging the center of the inside lane.

2. Provide 12-inch diameter signal lenses for all traffic signals to increase visibility of signals.

3. Install green left-arrow indications over the inside lanes on Story Street. Such signals should be accompanied by a sign reading "Left Turn Signal."

4. Install backplates for all signal heads to improve visibility of traffic signals.

5. Provide pavement markings (turning arrows with the word "Only") and "Left Lane Must Turn Left" signs in advance of the intersection for northbound and southbound traffic. An additional such sign is recommended north of Third Street, relative to northbound traffic and south of Fifth Street, relative to southbound traffic on Story Street.

6. Install "No Turn on Red" signs relative to the north and south approaches.

The above-recommended changes will provide a more definite control of left-turning traffic, in addition to improving the overall visibility and effectiveness of the signal installation.

Traffic Signal Timing

The timing of traffic signals is determined in accordance with existing traffic volumes, speed limits, street widths and driver reaction time. Existing traffic signal timing was previously tabulated in Chapter 3 of this report. Present signal timing also allows relatively good progression for northbound traffic, although progression for southbound traffic is restricted by the existing timing. The time-space diagram in Figure 4-20 shows the imbalance in existing signal progression between northbound and southbound traffic.

Current traffic signal timing does not appear to be coordinated with traffic volumes at the various intersections along Story Street. For example, at the intersection of Story Street and Sixth Street, traffic volumes from the south are approximately 400% greater than traffic volumes from the west. Existing signal timing, however, allows equal green time for each of these movements. A similar situation occurs at the intersection of Story Street with 9th Street, 10th Street and 11th Street.

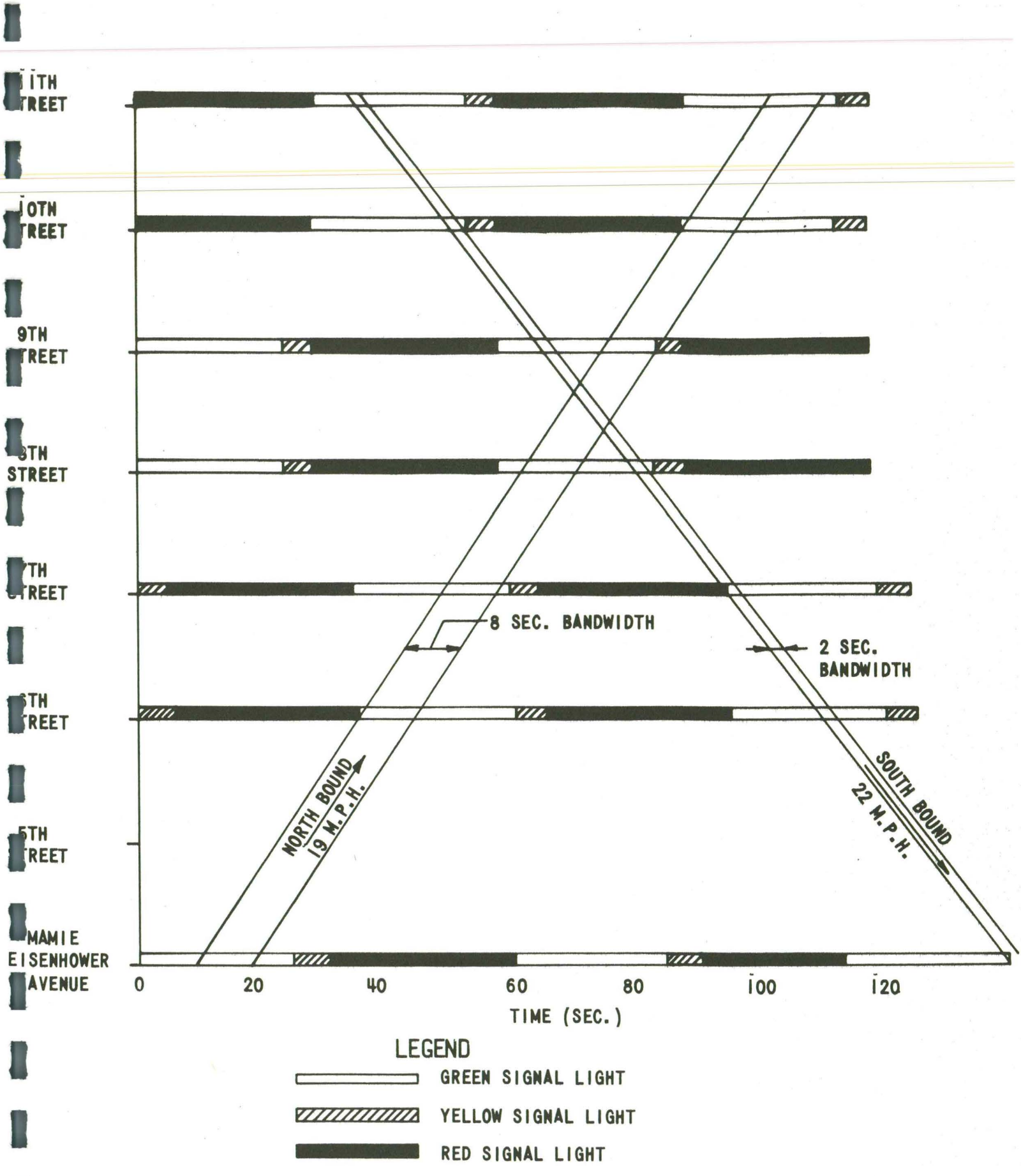


Fig. 4-20. Time-Space Diagram for Existing Signal Timing.

As discussed in the previous section, it is recommended that three-phase signalization be provided at the intersection of Story Street and Mamie Eisenhower Avenue. Upon implementation of such signal improvements, it is recommended that the signal timing at this intersection be revised as follows:

TABLE 4-7

THREE-PHASE SIGNAL TIMING AT STORY STREET AND MAMIE EISENHOWER AVENUE

SIGNAL	PHASE 1 STORY STREET LEFT TURN	PHASE 2 STORY STREET THRU AND RIGHT	PHASE 3 MAMIE EISENHOWER AVENUE
Green	11.9 sec. (Arrow)	22.4 sec.	22.4 sec.
Yellow	3.5 sec.	4.9 sec.	4.9 sec.
Red	54.6 sec.	42.7 sec.	42.7 sec.
Total	70.0 sec.	70.0 sec.	70.0 sec.

It should be noted that the above signal timing requires a cycle length of 70 seconds, and thus there will not be traffic signal progression with the other two signalized intersections on Story Street for which 50-second cycles are recommended (see Table 4-8). Traffic signal progression will still be maintained, however, between Seventh Street and Eighth Street, if the recommended signal timing shown in Table 4-8 is coincidental for the latter two intersections.

Should the City wish to delay the implementation of the three-phase signals with left-turn signals at the intersection of Mamie Eisenhower Avenue and

Story Street until a later time, existing signal timing at the Mamie Eisenhower Avenue, Seventh Street and Eighth Street intersections with Story Street could be re-timed. As part of this alternate staging plan, it is recommended that said signal installations be re-timed and may be adjusted for balanced progression in both directions along Story Street. In order to maintain a progression speed of approximately 20 miles per hour, and to reduce the delays at each respective signal, a 50-second signal cycle is recommended. Table 4-8 shows the recommended cycle splits at each intersection, based on traffic volumes, driving speeds, street widths and other considerations.

TABLE 4-8

RECOMMENDED TRAFFIC SIGNAL TIMING

INTERSECTION	RECOMMENDED TIMING (SECONDS)					
	Story Street			Cross Street		
	GREEN	YELLOW	RED	GREEN	YELLOW	RED
Story Street and Mamie Eisenhower Avenue*	21.5*	5.0*	23.5*	19.0*	4.5*	26.5*
Story Street and 7th Street	24.0	4.5	21.5	17.0	4.5	28.5
Story Street and 8th Street	24.0	4.5	21.5	17.0	4.5	28.5

*Prior to implementation of 3-phase signalization as alternate staging.

Figure 4-21 indicates the recommended sequence of progression along Story Street whereby existing controllers may be used. With such recommended timing, traffic in either direction will progress through the green signals at approximately 20 m.p.h. during a 10.8 second green band. As shown in Figure 4-21, the beginning of the green signal phases at 7th and 8th Streets

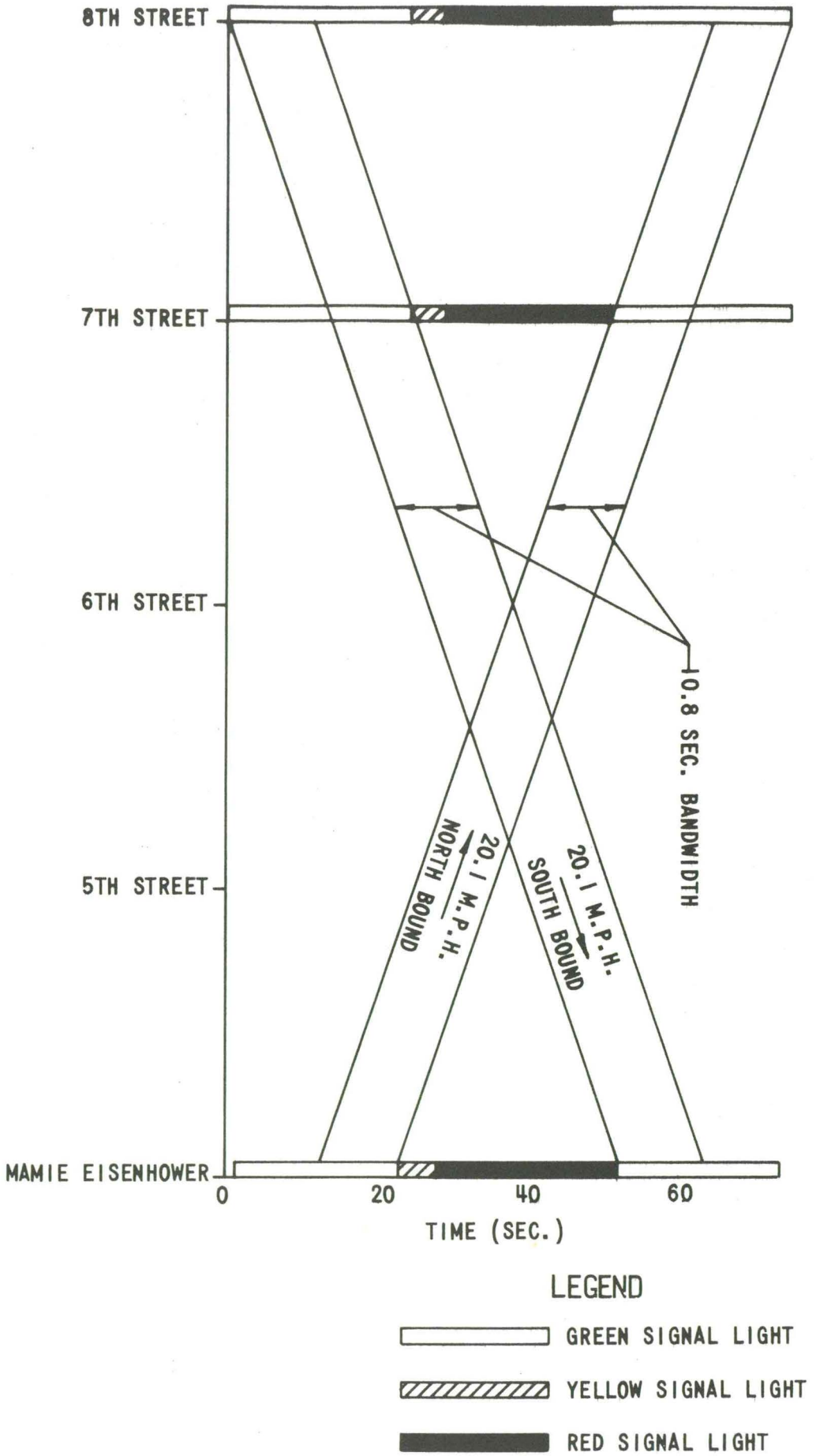


Fig. 4-21. Time-Space Diagram for Recommended Signal Timing (Prior to Installation of 3-phase System at Story Street and Mamie Eisenhower Avenue.)

leads the green phase at Mamie Eisenhower Avenue by 1.25 seconds. With the recommended initial changes in signal timing, approximately 290 to 350 vehicles per hour could travel progressively through the signal system on Story Street in either direction, thereby essentially meeting the existing demand.

Pedestrian Signal Timing

The existing pedestrian signals at Seventh and Eighth Streets do not provide a flashing WALK interval, and the pedestrian clearance intervals are somewhat too short to allow pedestrians to cross the respective streets before opposing traffic receives a green signal.

Pedestrian signal timing is based on walking speeds of pedestrians and includes an allowance for reaction time. Pedestrian walking speeds vary with age and sex. The normal walking speed for persons in the 20-to-25 age group is approximately 4.5 feet per second, while the normal speed for a person in the 81-to-87 age group is approximately 3.5 feet per second. The commonly accepted average walking speed of 4.0 feet per second was used as a basis for pedestrian crosswalk signal timing in this study. The resultant pedestrian signal splits for the intersections of Story Street with Seventh and Eighth Streets are listed in Table 4-9.

TABLE 4-9

RECOMMENDED PEDESTRIAN SIGNAL TIMING

INTERSECTION	RECOMMENDED TIMING (SECONDS)		
	FLASHING WALK	FLASHING DON'T WALK	STEADY DON'T WALK
Story Street and Eighth Street	16.5 10.5	12.0 11.0	21.5 28.5
Story Street and Seventh Street	17.5 10.5	11.0 11.0	21.5 28.5

RAILROAD CROSSING SIGNALS

Railroad crossing signals are generally adequate within the City of Boone, except at the Chicago and North Western Transportation Company crossings on Greene Street and Division Street. As previously discussed, these signals are of an outdated design.

Greene Street currently functions as a segment of the designated truck route in Boone, and carries a traffic volume of approximately 3,500 vehicles per day. Division Street is also a major north-south street, and is classified as a minor arterial on the Federal Aid Urban System classification.

Railroad operations along the Chicago and North Western Railroad include frequent high-speed freight train crossings, and the two aforementioned crossings have been the scene of eight collisions including two fatalities during the five-year study period. In consideration of these factors, it is recommended that new railroad crossing signals and crossing gates be installed at the railroad crossings on Division Street and Greene Street.

PAVEMENT MARKINGS AND DELINEATORS

This section considers pavement markings in addition to those previously discussed in Chapter 3 and the present chapter.

It is recommended that center line markings be provided for all through streets within the community, including the following:

Story Street, from U.S. Highway 30 to 22nd Street.

Mamie Eisenhower Avenue, from the West City Limits to the East City Limits.

Marion Street, north of Mamie Eisenhower Avenue.

Division Street, north of Mamie Eisenhower Avenue.

Eleventh Street, from Division Street to Linn Street.

Benton Street, from Mamie Eisenhower Avenue to Industrial Road.

Linn Street, from Industrial Road to 22nd Street.

Industrial Road, east of Linn Street.

In cases where parking is allowed on one side of the street, the center line should be offset to accommodate such parking. These lines will aid the safe flow of traffic on higher volume streets. "Wrong Side of Center" accidents have been especially prevalent near the railroad viaduct on Benton Street.

Two types of center line markings are applicable to various segments of the above-mentioned streets. A normal broken or dashed yellow center line, separating opposing traffic, is provided where passing is permitted in either direction of traffic flow. The second type of center line marking consists of a double yellow line consisting of two solid yellow lines separating opposing traffic, whereby passing is prohibited in both directions. In the case of divided pavements, a solid yellow line is to be provided along the left edge of each pavement or, if curbed, on the left curb of each pavement. For undivided four-lane pavements, a double yellow line is to be provided to separate opposing traffic lanes and prohibit passing.

In consideration of the accident history near the railroad viaduct, the following markings are recommended in addition to center line markings:

1. Reflective yellow curb markings on both sides of pavement, on each approach to the viaduct, as no parking is permitted.

2. Renew reflective markings on each wingwall of the viaduct, to increase visibility to northbound and southbound traffic. Such marking is to include alternating black and reflectorized yellow or white diagonal

stripes, 12 inches or greater in width and sloped down at an angle of 45 degrees toward the side of the bridge abutments. In addition, a hazard marker should be installed in advance of each bridge abutment relative to traffic flow.

3. Provide a series of white post-mounted delineators on the east side of the roadway south of the viaduct, to enhance the visibility of the horizontal curve relative to northbound traffic. Such delineators should be spaced in accordance with Table III-1 of the MUTCD.

Turn arrows are recommended to be painted on the pavement for all turning lanes along Story Street and any other mandatory turn lanes. Such arrows should be white in color and accompanied by the word "Only," as required by the MUTCD. (Proper signing must accompany such markings.)

Standard railroad pavement markings are recommended at all paved approaches to railroad grade crossings where automatic signals are in use. Specifications for such markings are listed in the MUTCD.

Stop lines are recommended at all stop sign and traffic-signal-controlled intersections where conflicts with pedestrian or vehicular traffic would otherwise be likely. Pedestrian crosswalk markings should be provided at all designated crosswalks.

White lane lines are recommended to separate lanes of traffic traveling in the same direction. When crossing of such lines is permissible, the lane line should be a broken line. Where lane changing is to be discouraged, such as for a left or right turning lane, the lane line should consist of a solid white line.

STOP SIGNS

Existing stop sign locations have previously been discussed in Chapter 3. It is recommended that all stop signs be checked relative to height and lateral clearance requirements specified by the MUTCD and that such signs be relocated wherever necessary. Many existing stop signs were observed to be mounted lower than the required height of seven feet, measured from the top of pavement to the bottom of sign. Such mounting heights are required whenever parking or pedestrians are likely to obscure the respective signs.

No stop signs or other regulatory signing or signals are currently installed at the intersection of Eighth Street and Keeler Street. A similar condition exists at the intersections of Keeler Street and Seventh Street, Arden Street and Eighth Street, and Arden Street and Seventh Street. During the five-year study period, a total of eight accidents were caused by right-of-way violations at these locations. Although such accidents were relatively infrequent, it is recommended that stop signs be installed at each of the four intersections, to more definitely assign the right-of-way. The MUTCD provides that stop signs may be warranted for such unsignalized intersections in a signalized area, or at the "intersection of a less important road with a main road where application of the normal right-of-way rule is unduly hazardous."

In consideration of existing traffic volumes, it is recommended that northbound and southbound traffic be required to stop at each of the aforementioned intersections.

The temporary stop signs presently used at school crossings and Sunday stop locations have been discussed in Chapter 3. In accordance with the provisions of the MUTCD, it is recommended that these signs be removed.

Crossing guards may be employed at the respective intersections during periods of heavy pedestrian traffic.

In lieu of the traffic signals that were heretofore recommended to be removed at the Story Street intersections of Sixth, Ninth, Tenth and Eleventh Streets, stop sign installations are recommended. It is recommended that stop signs be installed on Sixth, Ninth, Tenth and Eleventh Streets to require traffic on such streets to stop before entering or crossing Story Street.

Four-Way Stop Signs

Several high-volume-traffic intersections, including present four-way stop installations were analyzed relative to warrants established in the MUTCD, such warrants including accident history and vehicular and pedestrian traffic. The following is a list of those intersections analyzed according to this warrant and the results of such analyses:

Intersection	4-Way Stop Warranted Yes or No
Story Street and 5th Street	No
Story Street and 6th Street	No
Story Street and 9th Street	No
Story Street and 10th Street	No
Story Street and 11th Street	No
Allen Street and 8th Street (existing 4-way stop)	Yes
Keeler Street and 8th Street	No
Greene Street and 8th Street	No
Benton Street and 8th Street (existing 4-way stop)	Yes
Mamie Eisenhower Avenue and Benton Street	No

Intersection	4-Way Stop Warranted Yes or No
Mamie Eisenhower Avenue and Marion Street	No
Mamie Eisenhower Avenue and Greene Street	No
Story Street and U.S. Highway 30 (existing 4-way stop)	Yes

Existing four-way stop sign installations within the City of Boone include the intersections of Eighth Street and Allen Street, Eighth Street and Benton Street, and U.S. Highway 30 and Story Street. It is recommended that white-on-red "4-Way" plates be mounted below each stop sign at any of these intersections, where such plates do not presently exist.

YIELD SIGNS

Presently there are no yield signs installed along the arterial street system in Boone, or at any of the 24 studied intersections. Such signs may be warranted at locations where "right-of-way to right" violations are frequent. According to the MUTCD, yield signs may be applicable "where it is necessary to assign the right-of-way to the major road, but where a stop is not required at all times, and where the safe approach speed on the minor road exceeds ten miles per hour."

Failure to yield right-of-way to a vehicle on the right has been the cause of a substantial number of accidents at three of the studied intersections. No traffic control devices are currently in use at any of these intersections. Table 4-10 shows the accident histories of the respective intersections.

TABLE 4-10

RIGHT-OF-WAY ACCIDENTS AT UNCONTROLLED INTERSECTIONS

Intersection	Total Accidents	Right-of-Way to Right Accidents	Injuries Caused by R-O-W Accidents
Sixth Street and Carroll Street	18	9	6
Tenth Street and Carroll Street	16	11	9
Sixth Street and Tama Street	15	13	5
Totals	49	33	20

In consideration of the current light traffic volumes and the high incidence of accidents, it is recommended that Yield signs be installed at each of the aforementioned intersections for the following traffic movements:

Sixth Street and Carroll Street: Eastbound and Westbound traffic to yield.

Tenth Street and Carroll Street: Eastbound and Westbound traffic to yield.

Sixth Street and Tama Street: Northbound and Southbound traffic to yield.

SCHOOL CROSSING AND SCHOOL ADVANCE SIGNS

"School Crossing" signs in conformance with the MUTCD are recommended at all designated school crossings. "School Advance" signs are recommended to be installed in advance of all school crossings and school grounds. In many locations in the City of Boone, "School Advance" signs are presently erected at the school crossing, and no "School Crossing" signs are present. At other locations "School Signal Ahead" or "School Stop Ahead" signs are currently used in place of standard school crossing signs. "School Advance" signs are mandated by the MUTCD to be installed in advance of all "School Crossing" signs.

LOW CLEARANCE SIGNS

The existing railroad bridge over Benton Street in the vicinity of Ninth Street (Industrial Road) is posted as having a 13-foot clearance over Benton Street. Old-style, post-mounted, diamond-shaped signs reading "Low Clearance 13 FT.," are located in front of each bridge wingwall to the approaching motorists' right. An additional old-style, post-mounted, diamond-shaped sign reading "Low Clearance, 13 Feet" was observed to be placed relative to northbound motorists on Benton Street and is located just north of Eighth Street. Northbound motorists on Benton Street, upon crossing Eighth Street, would have no alternate means other than backing up and turning onto Eighth Street, if their vehicle height was too much. Southbound motorists, if overheight, could turn east onto Ninth Street (Industrial Road). Likewise, westbound traffic on Ninth Street could turn north onto Linn Street.

It is recommended that a two-piece low clearance sign, in accordance with the MUTCD, be placed on the east side of Benton Street between Seventh and Eighth Streets to warn northbound motorists of the low clearance condition ahead. Other such signs are recommended to be placed on the west side of Linn Street, between Ninth Street and Tenth Street and on the north side of Ninth Street east of Linn Street. In addition, it is recommended that the above-mentioned low clearance signs be replaced by new-style signs conforming to the requirements of the MUTCD.

MISCELLANEOUS TRAFFIC SIGNS

Figure 4-22 shows several examples where existing signing is somewhat inadequate. In addition to those signs previously noted, the following signs are recommended to be installed at the locations indicated:

No "Curve" Sign

No "Turn" Sign or "Large Arrow" Sign
to Precede Right-Angle Turn

Outdated "Do Not Enter" Sign;
No Accompanying "One Way" Signs

No Delineators or Pavement Markings
to Define Curve or Approaching Underpass

Fig. 4-22. Examples of Inadequate Signing.

1. "No Parking" signs - for all sides of streets on which parking is to be eliminated. Such signs should be red-on-white in color. Locations of recommended parking restrictions will be discussed in Chapter 5.

2. "Speed Limit" signs - for all changes in speed limits, and to revise existing signing to conform with City ordinances.

3. "Signal Ahead" signs - prior to first traffic signal installation on Story Street.

4. "No Parking From Here To Corner" signs - in those areas where emphasis on such prohibition is needed.

5. "Double Arrow" signs - for all T-intersections where it is not visually obvious whether or not the roadway continues beyond the intersection. "Large Arrow" signs for all abrupt changes in alignment of a roadway. Several locations where such signs would be appropriate are present along Linn Street south of Hancock Street and portions of Five-Mile Road. (See Figure 4-22).

6. "Turn" signs - in advance of all right-angle turns, including those on the previously-mentioned portions of Linn Street and Five-Mile Road. It is further recommended that these signs be supplemented by an appropriate "Advisory Speed Plate."

7. "Curve" signs - in advance of the curves on Mamie Eisenhower Avenue near Division Street. (See Figure 4-22).

8. "One Way" signs - to be installed at one-way alleys where traffic is not permitted to enter.

9. "Do Not Enter" signs - of standard red-on-white design to replace outdated Do Not Enter signs. (See Figure 4-22).

10. "T-Symbol" signs - be erected in advance of all T-intersections not protected by other traffic control devices.

LIGHTING

A limited review of existing street lighting intensities was made throughout the City. Such intensities were then compared with current illumination standards.

Streets within the central business district, including Keeler Street, Allen Street and portions of Story Street, were observed to have the highest street lighting intensities. Existing street lights in that area consist of four mercury vapor luminaires at each intersection, and two additional luminaires at each mid-block location. Street lighting along Story Street between U.S. Highway 30 and Fifth Street consists of approximately three mercury vapor luminaires per block, located on alternate sides of Story Street. Typical residential street lighting in Boone includes one mercury vapor luminaire at each intersection.

Lighting intensities were observed at three representative intersections in Boone, with readings taken at the center of the intersection, at each crosswalk, and at mid-block each direction. Results of the lighting survey are shown in Table 4-11.

According to the IES Lighting Handbook, published by the Illumination Engineering Society, the recommended average intensities for streets in Boone will range from 0.40 footcandles for local residential streets to 1.20 footcandles for commercial streets. Occasional readings which are below

TABLE 4-11

EXISTING STREET LIGHTING INTENSITIES

Intersection	Observed Illumination (Footcandles)		
	Center of Intersection	Crosswalk	Mid-Block
Story Street and Eighth Street	6.17	6.17	1.70
Story Street and Woodland Avenue	0.93	0.31 - 1.24	0.03 (Woodland) 1.24 (Story)
Linn Street and Third Street	0.54	0.17 - 0.62	0.03

these averages do not necessarily indicate a deficiency in the lighting system. Generally, however, the lowest reading at any point should not be below one-third of the average value, except on residential streets where occasional readings of one-sixth of the average value can be accepted.

According to the above requirements, existing street lighting is more than adequate within the central business district. Lighting along Story Street between U.S. Highway 30 and Fifth Street appears to be nearly equal to the required 1.0 footcandles for major residential streets. Existing lighting in residential areas is somewhat deficient, especially at mid-block locations where the shading effect of trees affects the dispersion of light.

Accident statistics for the five-year period of 1972 through 1976 indicate that street lighting conditions did not significantly affect the incidence of accidents. Of those on-street accidents occurring in the aforementioned five-year period, 64.7 percent occurred during daylight. Of the remaining accidents, 22.6 percent occurred during darkness with street lights present, 3.5 percent during darkness without street lights present, 4.9 percent at dusk or dawn, and an additional 4.4 percent for which no data was available

relative to light conditions. Good quality street lighting accompanied by a reasonable lumen maintenance level helps prevent accidents by providing better visibility and longer sight distances, thereby allowing the driver or pedestrian more reaction time. Poor lighting conditions, rather than being a direct cause of accidents, have an indirect effect by accentuating the primary cause, i.e., driver or pedestrian error, mechanical failure, existing road condition and so forth.

In consideration of the efficient utilization of energy, it is suggested that a portion of the existing street lights in the central business district be turned off, especially during nights when businesses are not open. It is recommended that any future street lighting programs be concentrated in residential districts, where existing street lighting intensities are somewhat deficient. Existing street lighting should be maintained through regular cleaning and replacement of depreciated lamps. Additionally, Federal funds are available for construction of or conversion to more energy-efficient forms of lighting (such as high-pressure sodium).

CHAPTER 5
PARKING

SCOPE

An inventory was made of existing parking facilities, parking restrictions and enforcement, with primary emphasis in the vicinity of the central business district.

INVENTORY OF PARKING

The map in Figure 5-1 is a representation of the parking restrictions as evidenced by existing signing and curb markings observed during an inventory of the arterial street system. Existing signing is generally in conformance with the City ordinances except for the discrepancies noted in Table 5-1. It is recommended that parking signs be installed where necessary to conform to the respective ordinances.

The map in Figure 5-2 indicates the existing parking facilities in the vicinity of the central business district, with the exception that no off-street private parking areas are shown. The different symbols indicate the location and types of on-street parking and the locations of off-street public parking areas, as well as the number of parking spaces available.

USAGE, TURNOVER AND ENFORCEMENT INVESTIGATION

A study was made to determine the usage and turnover of public parking, both on-street and off-street. To accomplish this, an investigator proceeded around each respective block or lot on a regular basis for a period of several hours. Records were kept for each parking space of each block or lot so analyzed, including data relative to vehicle license numbers, presence of parking tickets, time left on meters, expired meters and vacant spaces.

The findings of this report pertain to the Spring of 1977. In accordance with the scope of this study, no projections were made for future conditions or for peak demands.

Table 5-2 indicates the results of these investigations for the blocks and municipal lots listed. The figures listed as "Total Space Hours" were obtained by multiplying the total number of parking spaces per block or lot by the duration of the parking turnover study. The cumulative time that the respective parking spaces were vacant within this time period was termed "Space Hours Vacant." The average percentage vacancy was derived by dividing the space hours vacant by the total space hours of the block or lot.

Every vehicle in occupancy of each respective parking space was recorded during the investigation. The turnover rate was then determined by dividing the number of turnovers per block or lot by the corresponding total space hours.

The blocks bordering Story Street between Sixth Street and Ninth Street (Block Nos. 4, 5, 8, 9, 11 and 12) were observed to have the highest turnover rate, with an average of 0.76 turnovers per space hour. The average vacancy rate for the same blocks was observed at 38.5 percent for the 225 public parking spaces included in the study. All of the above parking spaces are metered, with limits ranging from 12 minutes to 2 hours.

The lowest vacancy rate (22.2% vacant) was observed at Municipal Lot No. 10 at the corner of Keeler Street and Seventh Street. Parking turnover was also low in this lot, with a rate of 0.08 turnovers per space hour. Meters in this parking lot allow four-hour parking which encourages its usage for longer-term parking.

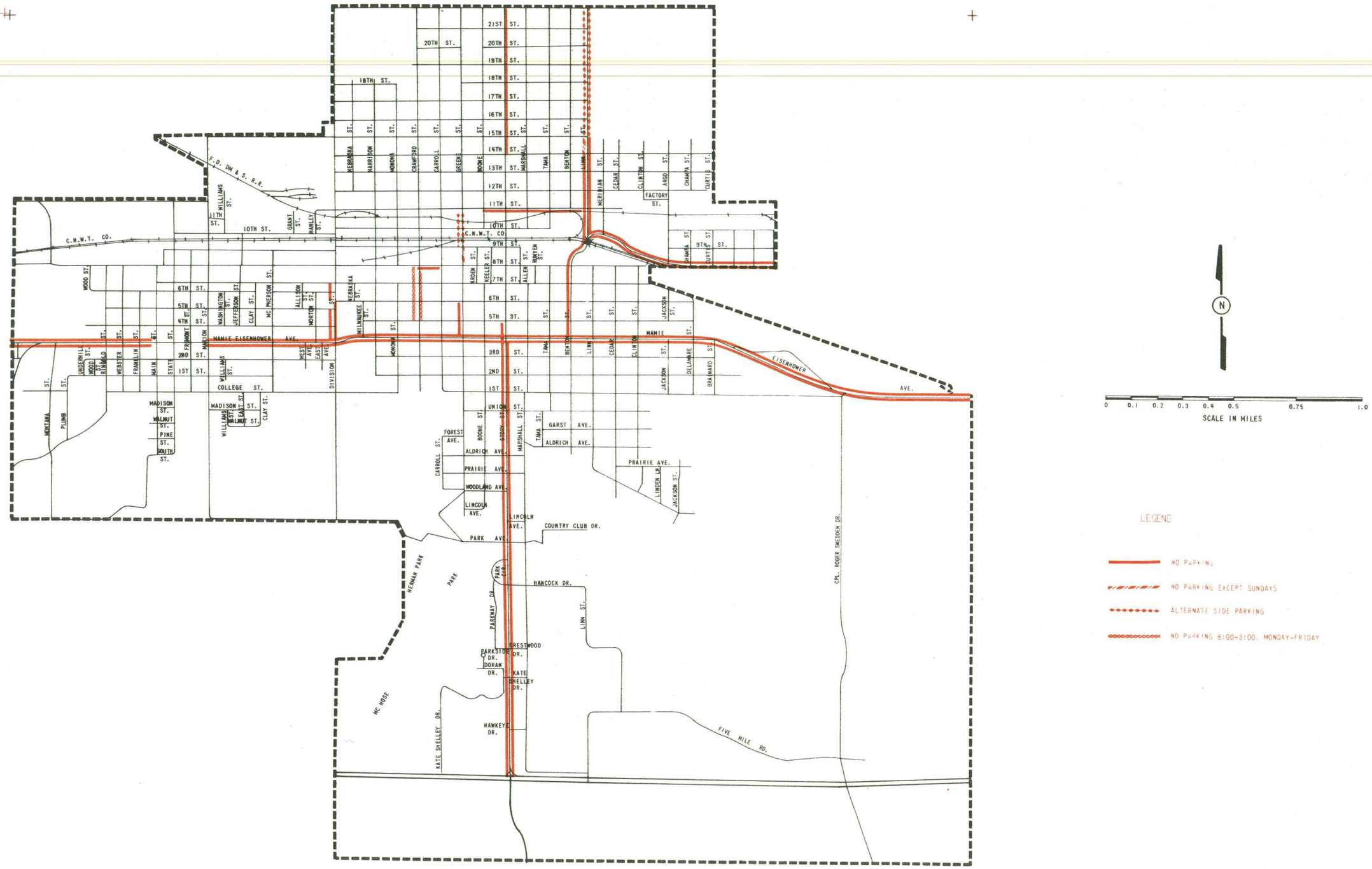


Fig. 5-1. Map Showing Existing Parking Restrictions According to Signing.

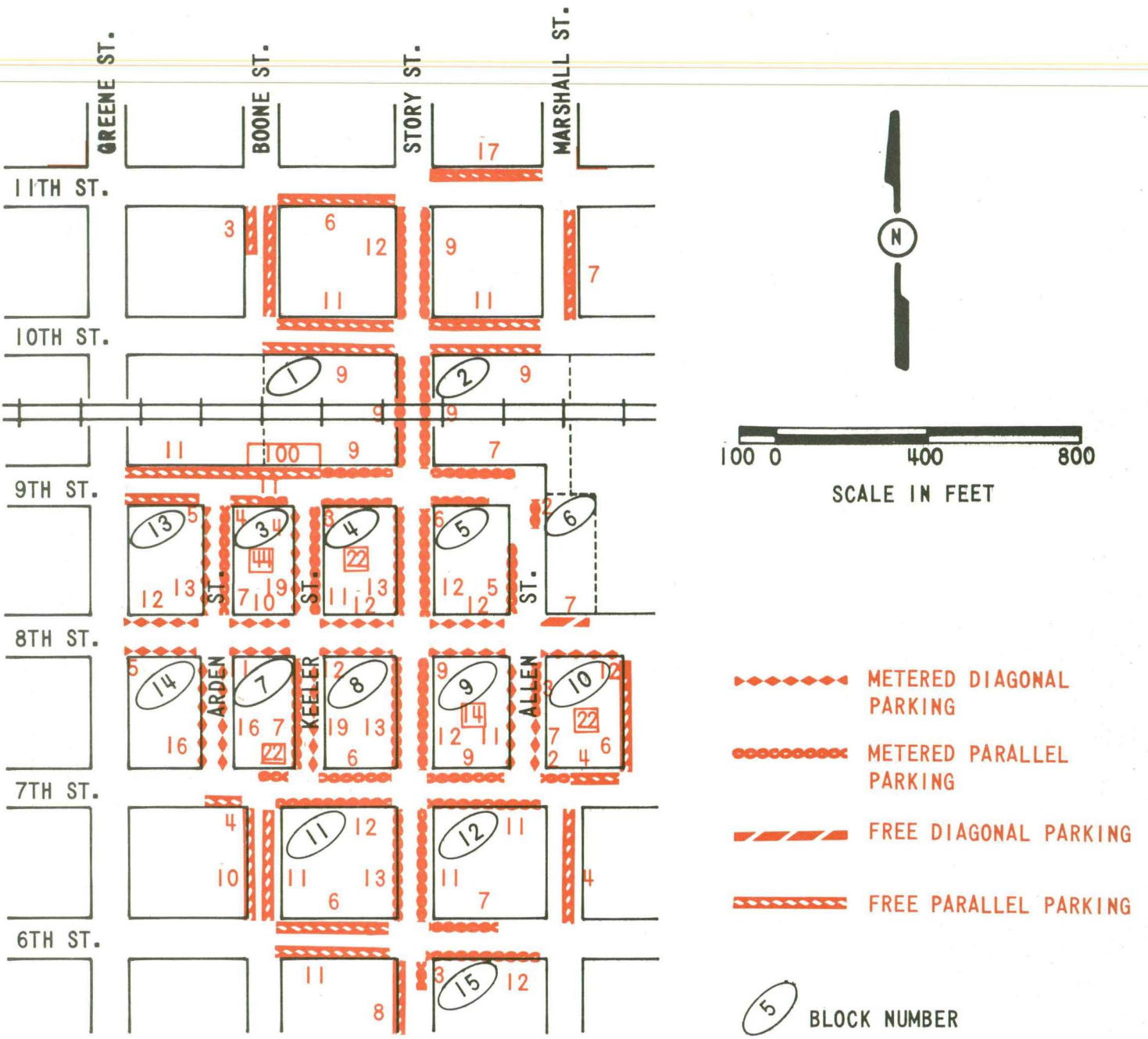


Fig. 5-2. Existing Central Business District Parking Inventory.

TABLE 5-1

CONFLICTS BETWEEN CITY ORDINANCES AND EXISTING SIGNING RELATIVE TO PARKING RESTRICTIONS

STREET	FROM STREET	TO STREET	PARKING RESTRICTIONS ACCORDING TO CITY ORDINANCES	PARKING RESTRICTIONS ACCORDING TO SIGNING
11th	Boone	Story	N.P. North Side	N.P. South Side
9th	Linn	East City Limit	No Restrictions Noted	N.P. Either Side
8th	Crawford	Carroll	No Restrictions Noted	N.P. South Side
Marion	Mamie Eisenhower	7th	No Restrictions Noted	N.P. East Side
Division	4th	5th	N.P. East Side	N.P. East and West Sides
Division	6th	7th	No Restrictions Noted	N.P. West Side
Crawford	5th	6th	No Restrictions Noted	N.P. Alternate Sides/Alternate Days
Crawford	6th	7th	N.P. East Side 8 A.M. - 3 P.M. Mon-Fri	N.P. Alternate Sides/Alternate Days
Crawford	7th	8th	N.P. Either Side 8 A.M. - 3 P.M. Mon-Fri	N.P. Alternate Sides/Alternate Days
Benton	Mamie Eisenhower	5th	N.P. East Side	No Restrictions Observed
Benton	5th	6th	15 min. East Side 8 A.M. - 9 P.M. Secular Days	No Restrictions Observed
Benton	6th	8th	N.P. East Side	No Restrictions Observed
Benton	8th	9th	15 min. East Side 8 A.M. - 9 P.M. Secular Days	No Restrictions Observed Except Yellow Curb East Side North of Railroad
Linn	11th	12th	30 min. West Side North Half of Block	N.P. West Side
Linn	14th	15th	N.P. West Side - Also another reference to N.P. West Side Except Sundays	N.P. West Side Except Sundays
Greene	6th	7th	N.P. West Side Except Sundays	No Restrictions Observed

TABLE 5-2

TABULATION OF PUBLIC PARKING USAGE, TURNOVER, AND ENFORCEMENT IN THE CENTRAL BUSINESS DISTRICT

BLOCK NO.	TOTAL PARKING SPACES	TOTAL SPACE HOURS	PARKING USE		PARKING TURNOVER		VIOLATIONS AND CONTROL		
			SPACE HOURS VACANT	PERCENT VACANT	NUMBER OF TURNOVERS	TURNOVER RATE (TURNOVERS/ SPACE HOUR)	METER VIOLATIONS TICKETED	METER VIOLATIONS OBSERVED	OBSERVED METER ENFORCEMENT PERCENT
3*	36	108	57.7	53.4	34	0.32	5	26	19.2
4	44	132	60.6	45.9	83	0.63	0	35	0.0
5	35	105	34.6	32.9	101	0.96	3	28	10.7
7	38	114	52.1	45.7	36	0.32	1	27	3.7
8	50	150	47.8	31.9	122	0.81	5	61	8.2
9	42	126	44.0	34.9	105	0.83	0	49	0.0
10**	22	66	34.0	51.5	34	0.52	0	24	0.0
11***	25	75	25.4	33.8	47	0.63	0	31	0.0
12	29	87	47.3	54.4	54	0.62	1	27	3.7
Lot No. 7	14	42	17.0	40.5	23	0.55	1	18	5.6
Lot No. 10	22	66	14.6	22.2	5	0.08	4	11	36.4
TOTAL	357	1,071	435.1	40.6	644	0.60	20	337	5.9

* Excluding North Side.

** Excluding South and East Sides.

***Excluding South and West Sides.

Block No. 8, which includes the greatest number of public parking spaces (150), also showed one of the lowest vacancy rates, with an average of 31.9 percent vacancy.

Block No. 12 was observed to have the highest parking vacancy rate of any block within the study area. This block additionally contains large private parking facilities for 166 cars and a free municipal lot for 45 cars, both of which account for the lesser usage of metered parking.

Table 5-3 is a further breakdown of the vacancy and turnover rates for the respective sides of the blocks included in the study. As indicated in Table 5-3, parking turnover rates are generally higher along Story Street between 6th Street and 9th Street, where one-hour meters are in use. Vacancy rates are generally lowest along Story Street and are higher along the perimeter of the central business district.

Several municipal parking lots which were not included in the turnover study were observed periodically during the study to determine their overall usage. Table 5-4 summarizes the parking supply and vacancy rates for these lots. As shown, the vacancy rate for the free parking lots averaged only 25.4 percent, while the metered lot was significantly less utilized.

The degree of law enforcement relative to parking meters was determined by comparing the number of expired meters with the issuance of parking tickets. The percentage enforcement of parking meters, shown in Table 5-2, was determined by dividing the total observed numbers of meter violations ticketed by the total observed numbers of parking meter violations. Throughout the course of the parking study, 337 meter violations were observed, of which 20 were ticketed.

TABLE 5-3

PARKING VACANCY AND TURNOVER RATE BREAKDOWN
ACCORDING TO SIDE OF BLOCK

BLOCK NO.	NORTH SIDE			WEST SIDE			SOUTH SIDE			EAST SIDE		
	NO. SPACES	% VACANCY	TURNOVER RATE*	NO. SPACES	% VACANCY	TURNOVER RATE*	NO. SPACES	% VACANCY	TURNOVER RATE*	NO. SPACES	% VACANCY	TURNOVER RATE*
1	**	---	---	---	---	---	8	91.7	0.21	9	70.8	0.37
2	**	---	---	9	69.4	0.37	7	81.0	0.19	---	---	---
3	**	---	---	7	81.0	0.05	10	72.2	0.30	19	33.0	0.42
4	8	75.0	0.25	11	54.5	0.42	12	40.6	0.69	13	25.6	0.97
5	6	33.3	0.44	12	26.9	1.22	12	22.9	1.25	5	71.1	0.27
6	**	---	---	4	91.7	0.08	5	82.5	0.20	---	---	---
7	11	39.4	0.30	16	47.9	0.17	4	81.3	0.08	7	30.4	0.81
8	12	29.2	0.92	19	31.6	0.56	6	57.4	0.83	13	23.1	1.08
9	9	34.7	1.00	12	22.9	1.03	9	42.0	0.78	11	45.5	0.61
10	12	49.0	0.64	10	54.4	0.37	**	---	---	**	---	---
11	12	53.8	0.42	**	---	---	**	---	---	13	47.9	0.82
12	11	41.4	0.70	11	49.5	0.88	7	82.5	0.10	0	---	---
13	**	---	---	**	---	---	**	---	---	13	73.5	0.44
14	**	---	---	**	---	---	**	---	---	16	86.1	0.08
15	12	64.8	0.28	3	40.7	1.00	**	---	---	**	---	---

* Turnovers Per Space Hour.

**Not Included In Turnover Study

TABLE 5-4

OBSERVED PARKING LOT USAGE AND VACANCY

Location	Free or Metered	No. Spaces	Average Occupancy (No. Vehicles)	Percent Vacant
Lot No. 2 (6th St. & Marshall St.)	Free	45	40.8	9.4%
Lot No. 5 (9th St. & Arden St.)	Free	44	35.0	20.5%
Lot No. 11 (9th St. & Keeler St.)	Meter (2 hr)	22	11.1	49.5%
Lot No. 9 (9th St. & Keeler St.)	Free	100	65.1	34.9%

Although meter enforcement was observed to be quite low during the parking survey, police department records show an average of 547 courtesy parking tickets and 2,354 overtime and illegal parking tickets issued per month during recent years. It appears that overall parking meter enforcement has been adequate. It is recommended that such enforcement efforts continue to encourage parking turnover in the business district.

RELATIONSHIP OF ACCIDENTS TO PARKING

On-street parking facilities have a definite relationship to traffic operations, especially within the central business district. Many accidents that have occurred have been closely associated with parking operations. The types of accidents so associated are as follows: improper backing (during parallel parking operations or in leaving diagonal parking stalls), failure to yield right-of-way from the curb (caused by vehicle proceeding from parallel parking space into the path of a vehicle in the adjacent traffic lane),

opening door to traffic (process of opening car door on traffic side while vehicle parked parallel to curb, with resulting conflict with adjacent lane of traffic), improper parking and sideswiping-type collisions between moving and parked vehicles. Numerous other accidents have occurred as a result of deficient sight distances or restrictive radii caused by parking being permitted too close to an intersection.

During the five-year study period, 23 on-street accidents were caused by unattended vehicles. An additional 376 accidents (13.6% of all accidents) occurred in parking lots and accounted for property damages of $55,182.00 (4.5% of the total estimated property damage for all accidents). A total of 520 vehicles, legally parked on the street, were hit by moving vehicles.

As has been previously noted, the parking of automobiles too close to certain intersections has resulted in deficiencies regarding sight distances and turning movements. Existing parking arrangements in the vicinity of intersections are indicated in Figure Nos. 4-2 through 4-13. In many instances parking spaces are located directly behind the crosswalks of the respective intersections or within a short distance thereof.

As discussed in Chapter 3 (See Figure 3-4), it is recommended that all on-street parking be prohibited within 30 feet of the crosswalk line at approaches to signalized intersections, and within 20 feet of the crosswalk or sidewalk line at other intersections.

SIZE AND TYPE OF PARKING STALLS

Existing parking stalls along various streets within the central business district are somewhat too small for efficient and safe parking maneuvers. Parallel parking stalls are presently 19½ feet long and 8 feet wide, and are

separated by approximately 5½ feet between each pair of stalls. According to the MUTCD, such stalls should be a minimum of 20 feet in length, and separated by 8 feet between each pair of stalls. (See Figure 3-4). Individual parallel parking stalls, not marked in pairs, can be a minimum of 22 feet in length, according to the MUTCD.

Existing diagonal parking spaces vary somewhat in dimensions. Present stalls range from approximately nine feet to less than eight feet in width between center of painted lines, and parking angles are between 31^{o} and 34^{o}, as observed along the various streets in Boone.

It is recommended that parking stalls along each street be marked uniformly relative to dimension and parking angle. Parallel parking stalls are recommended to be marked individually rather than in pairs, to conform with dimensional guidelines of the MUTCD. It is also recommended that diagonal parking stalls be increased to nine feet in width, measured perpendicularly between the lines. The accomplishment of such parking modifications will result in the necessity of relocating parking meters where such are present.

ARTERIAL STREET PARKING

Existing parking conditions along arterial streets in Boone have been mapped in Figure 5-1. As indicated, parking is currently prohibited along one or both sides of many arterial streets. Other arterial streets, some of which are too narrow to accommodate two lanes of traffic in addition to parking, currently have no parking restrictions.

It is recommended that parking be prohibited on sides of arterial streets where such parking interferes with the movement of traffic. Existing street widths were measured for each of the arterial streets in Boone, and compared with current parking conditions. The recommended changes in parking restrictions resulting from this comparison are shown in Figure 5-3. In general,

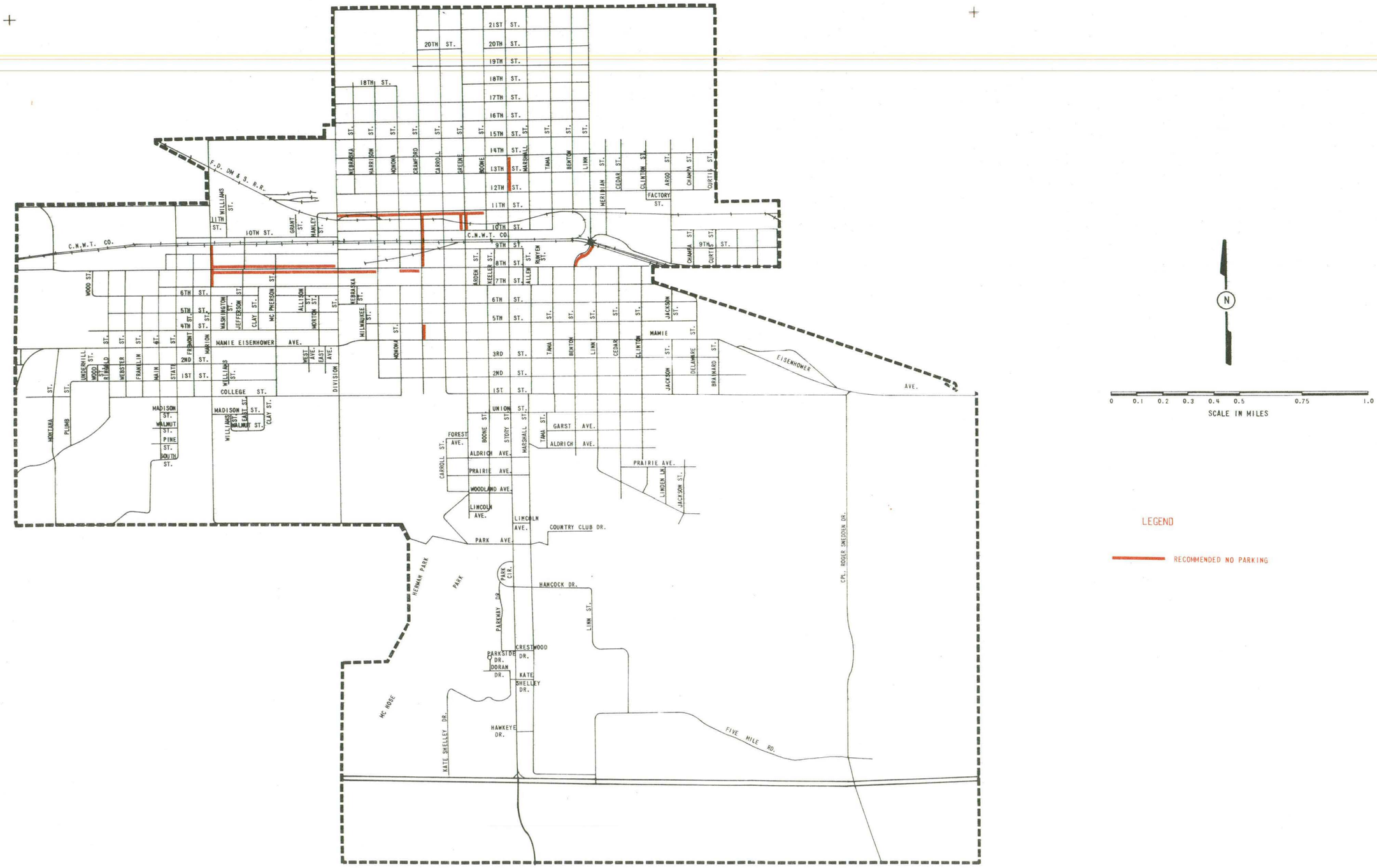


Fig. 5-3. Recommended On-Street Parking Modifications.

parking is recommended to be removed from portions of Eleventh Street, Marion Street, Eighth Street, Crawford Street, Benton Street, Greene Street, and North Story Street. Other parking modifications previously recommended are also shown in Figure 5-3.

All parking restrictions are recommended to be designated by signing, as required by the MUTCD. Curb markings may be used to supplement the no-parking signs.

SUPPLY AND DEMAND FOR PARKING

Table 5-5 summarizes the number of parking spaces presently available within each block in the central business district. This inventory includes all public and private parking areas, both on-street and off-street, with the exception that residential parking is excluded.

Recommended modifications and parking removals to improve sight distance will result in the loss of a number of parking spaces. The approximate number of parking spaces to be removed in each respective block are shown in Table 5-5. The final column in this table indicates the remaining supply of parking spaces, after all recommended changes are implemented.

As indicated in Table 5-5, approximately 92 parking spaces within the 12-block area will be eliminated by the various recommended changes. This reduction represents approximately 8.5 percent of the total parking spaces available.

During the parking turnover study, overall parking vacancy within the study area was observed at 40.6 percent vacant, considering only metered public parking. Parking along individual sides of blocks ranged from 22.9 percent to 91.7 percent vacant during the study period. In addition to public parking spaces, a considerable number of private parking spaces were observed to be vacant throughout the study area. It appears that a reduction

of parking spaces within the central business district, resulting from the changes recommended in this report, will not cause the average demand to exceed the remaining supply.

While the overall parking supply in the downtown area appears to be adequate, some individual blocks may experience parking deficiencies at certain times. Also, private parking areas vary regarding usability, from spacious private parking facilities to congested off-alley parking spaces. These factors will cause parking problems to arise in certain areas during periods of high parking demand, and will make it necessary for some drivers to park their vehicles in another block, farther from their respective destinations.

It is recommended that off-street parking facilities be encouraged relative to future private or public developments within the community, and especially in the vicinity of the business districts.

TABLE 5-5

SUPPLY OF PARKING SPACES

BLOCK NO.	PUBLIC PARKING AVAILABLE		PRIVATE* OFF-STREET PARKING AVAILABLE	EXISTING SUPPLY OF PARKING SPACES	PARKING SPACES RECOMMENDED TO BE ELIMINATED	FUTURE SUPPLY OF PARKING SPACES
	ON-STREET	OFF-STREET				
1	26	100	22	148	4	144
2	25	0	27	52	5	47
3	44	44	12	100	11	89
4	44	22	0	66	11	55
5	35	0	19	54	9	45
6	9	0	0	9	1	8
7	38	22	27	87	10	77
8	50	0	3	53	12	41
9	42	14	14	70	11	59
10	32	22	38	92	7	85
11	42	0	64	106	6	100
12	29	45	166	240	5	235
TOTAL	416	269	392	1,077	92	985

* Approximate Number of Parking Spaces, Excluding Residential Supply and Demand.

CHAPTER 6
ESTIMATED COST, FUNDING, STAGING AND IMPLEMENTATION

SCOPE

The estimated costs of the recommendations contained in this report are included in this chapter along with sources of funding, staging of improvements and implementation.

ESTIMATED COSTS OF RECOMMENDED IMPROVEMENTS

Some of the recommendations made within this report are not included in the cost estimate, as such costs are not readily ascertained or no significant cost is involved. Among such items are revisions of ordinances, increased law enforcement operations and the like. The estimated cost of other improvements relative to the arterial street system are shown on Table 6-1 and as follows:

SIGNALIZATION IMPROVEMENTS

Traffic Signals

1. Intersection of Story Street and Mamie Eisenhower Avenue

1 Installation with 25' Mast-Arm Pole, Overhead Signals, Post-Mounted Signals and Backplates.	$6,000.00
3 Installations with Existing Mast-Arm Poles, New Overhead and Post-Mounted Signals and Backplates.	4,000.00
Controller (3-phase) and incidentals.	6,000.00
Total Estimated Cost of Signals at Intersection.	$16,000.00

2. Story Street Intersections, Seventh Street and Eighth Streets

Remove Existing Traffic Signals and Deliver to City.	$1,200.00

6 Installations with 20' Mast-Arm Poles; modify existing signal heads to provide 12-inch diameter red lenses; install modified signal heads overhead on mast-arms and on vertical posts; install backplates and reinstall existing pedestrian signals.	$24,500.00
2 Installations with 25' Mast-Arm Poles for eastbound and westbound traffic on Eighth Street; modify existing signal heads to provide 12-inch diameter red lenses; install modified signal heads overhead on mast-arms and on vertical posts; install backplates and reinstall existing pedestrian signals.	8,600.00
Modification of existing controllers.	1,000.00
Total Estimated Cost for Intersections.	$35,300.00

3. Story Street Intersections, Sixth, Ninth, Tenth and Eleventh Streets

Remove Existing Traffic Signals and Deliver to City.	$4,000.00

4. Intersection of Story Street and U. S. Highway No. 30

4 Installations - Raise Stop Sign Beacons.	$ 400.00
TOTAL ESTIMATED COST FOR TRAFFIC SIGNALS.	$55,700.00

Railroad Crossing Signals

1. C.N.W. Railroad Crossing on Greene Street

Remove old railroad crossing signals.	$500.00
New railroad crossing signals with crossing gates.	31,000.00
Total Estimated Cost for Crossing.	$31,500.00

2. C.N.W. Railroad Crossing on Division Street

Remove old railroad crossing signals.	$500.00
New railroad crossing signals with crossing gates.	31,000.00
Total Estimated Cost for Crossing.	$31,500.00
TOTAL ESTIMATED COST FOR RAILROAD CROSSING SIGNALS.	$63,000.00

TABLE 6-1

ESTIMATED COST OF NEW SIGNS AND DELINEATORS

TYPE OF SIGN OR DELINEATOR	ESTIMATED NUMBER	ESTIMATED UNIT COST	ESTIMATED COST
Stop	14	$45.00	$ 630.00
4-Way Plates	11	10.00	110.00
Raise Existing Stop Sign	20	25.00	500.00
Yield	6	45.00	270.00
Speed Limit	14	45.00	630.00
Low Clearance	5	55.00	275.00
Railroad Crossbuck	2	45.00	90.00
Railroad Advance Warning	16	55.00	880.00
Pavement Width Transition	2	45.00	90.00
Right Lane Must Turn Right	2	45.00	90.00
Left Lane Must Turn Left	4	45.00	180.00
No Parking	90	40.00	3,600.00
School Advance	10	55.00	550.00
School Crossing	6	55.00	330.00
Street Closed to Through Traffic*	2	75.00	150.00
Signal Ahead	6	55.00	330.00
One Way	10	45.00	450.00
Double Arrow	2	70.00	140.00
Large Arrow	5	70.00	350.00
Turn	6	50.00	300.00
Advisory Speed Plate	6	15.00	90.00
Curve	2	50.00	100.00
Do Not Enter	10	45.00	450.00
Left Turn Signal	2	25.00	50.00
T-Symbol	1	50.00	50.00
No Turn On Red	10	25.00	250.00
Hazard Marker	2	25.00	50.00
Post-Mounted Delineators	8	10.00	80.00
Totals	274		$11,065.00

*Includes barricade.

Pavement Markings and Striping* and Parking Meter Relocations

Stop Lines - 12" Solid White	900 sq. ft.	@ $0.25=	$ 225.00
Crosswalk Lines - 6" Solid White	1,400 sq. ft.	@ $0.25=	350.00
Center Lines - 4" Broken Yellow	2,000 sq. ft.	@ $0.25=	500.00
No Parking Lines - Solid Yellow Curb Markings	7,000 sq. ft.	@ $0.25=	1,750.00
Turn Only Markings	12	@ $10.00=	120.00
Railroad Crossing Markings	12	@ $30.00=	360.00
Parking Stall Markings - 6" Solid White	2,900 sq. ft.	@ $0.25=	725.00
Reflective Markings on Viaduct			320.00
Parking Meter Relocations			4,000.00
Total Estimated Cost			$8,350.00

Radii and Other Pavement Modifications at Measured Intersections

The costs of radii changes and other pavement revisions for the measured intersections were estimated individually per return. Such cost estimates included removal of existing returns or pavement, storm drainage revisions, new concrete returns, traffic islands, pavement replacement and sidewalk adjustments. The estimated costs per intersection are as follows:

1. Intersection of Mamie Eisenhower Avenue and Benton Street

Pavement Removal	16.7 sq. yd. @ $ 6.00 =	$100.00
New Pavement	34 sq. yd. @ $20.00 =	680.00
Sidewalk Adjustments	8 sq. yd. @ $20.00 =	160.00
Total Estimated Cost for Intersection		$940.00

Summary of Estimated Costs

New Signs and Delineators		$ 11,065.00
Traffic Signalization		
Traffic Signals	$55,700.00	

*Excludes existing markings on Story Street and Mamie Eisenhower Avenue.

Summary of Estimated Costs (Continued)

Railroad Crossing Signals	$63,000.00	
Total Estimated Cost of Traffic Signalization		$118,700.00
Pavement Marking and Striping and Parking Meter Relocations		8,350.00
Radii and Pavement Modifications		940.00
Total Estimated Cost of Improvements		$139,055.00

FUNDING

Funding for the previously-mentioned improvements may be obtained from sources such as Revenue Sharing, Road Use to Cities, State and Federal Funds, General Obligation Bonds, or a combination of these or other funds. In addition, funds authorized by the Highway Safety Act may be available for projects of this nature. The following is a list of current Federal-Aid Safety Programs and State Programs which might be used to implement the respective projects:

1. Pavement Marking Demonstration Program (23 USC 151).

   The objective of this program is to "demonstrate the value of pavement markings in providing greater vehicle and pedestrian safety." This program may be applicable for improvements in pavement striping, markings, stop lines and crosswalk lines as recommended by this study. Funding under this program consists of 100 percent federal funds.

2. Safer Off-System Funds (SOS).

   The objective of this program is the "correction of safety hazards not on the Federal-Aid system." This program may be applicable for any of the recommended improvements, except those on Federal-Aid routes. Funding under this program includes 70 percent federal and 30 percent local funds.

3. Federal-Aid Secondary Funds (FAS).

   This program applies to any project on the secondary road system. Funding under this program includes 70 percent federal funds.

4. Federal-Aid Urban Funds (FAUS).

   This program applies to any project on the urban (FAUS) system in cities with a population over 5,000 persons. (Figure 3-1 indicates those streets within the City Limits of Boone which are included in the FAUS system.) Funding under this program includes 70 percent federal funds.

5. Federal-Aid Highway Safety Funds.

   Other federal-aid funds may be available under the Highway Safety Act or State funding programs to finance railroad crossing improvements. The two recommended railroad signalization projects on Greene Street and Division Street may be eligible for funding under these programs, which include 90 percent federal funds.

6. Urban-State Traffic Engineering Program (U-STEP).

   This program is applicable to projects implementing improvements identified by traffic engineering analysis of problem areas on Primary Road Urban Extensions. As part of this program, 50 percent of the cost of such traffic engineering improvements are funded by the State, with the remaining amount being financed by the City.

The street budget for the City of Boone shows a total expenditure of $2,699,370.00 for the period July 1, 1975, through June 30, 1976. Table 6-2 lists the itemized expenditures for street purposes.

Table 6-3 is a summary of receipts and disbursements relative to the Federal Revenue Sharing Fund for the period July 1, 1975, through June 30, 1976.

TABLE 6-2

STREET EXPENDITURES FOR THE CITY OF BOONE

JULY 1, 1975 THROUGH JUNE 30, 1976

STREET EXPENDITURES JULY 1, 1975 THROUGH JUNE 30, 1976	ROAD USE TAX FUNDS ONLY	STREET ACCOUNT	OTHER FUNDS	TOTAL
Maintenance				
Roadway Maintenance	$215,526.00	$ ---	$ 36,081.00	$ 251,607.00
Snow and Ice Removal	14,687.00	---	---	14,687.00
Storm Sewers	7,562.00	---	---	7,562.00
Traffic Services	---	---	19,006.00	19,006.00
Street Cleaning	10,013.00	---	---	10,013.00
Construction or Reconstruction				
Engineering	---	120,562.00	58,415.00	178,977.00
Roadway Construction	---	1,723,707.00	---	1,723,707.00
Storm Sewers	13,398.00	---	---	13,398.00
Administration	5,671.00	---	27,597.00	33,268.00
Street Lighting	---	---	67,726.00	67,726.00
Equipment	45,642.00	---	35,508.00	81,150.00
Miscellaneous	---	---	87,493.00	87,493.00
Bonds and Interest Paid				
Paid on Bonds Retired	---	---	164,000.00	164.000.00
Interest Paid on Bonds	---	---	46,776.00	46,776.00
Total Expenditures	$312,499.00	$1,844,269.00	$542,602.00	$2,699 370.00

TABLE 6-3

REVENUE SHARING FOR THE CITY OF BOONE
JULY 1, 1975 THROUGH JUNE 30, 1976

ITEM	AMOUNT	TOTALS
Fund Balance July 1, 1975		$ 6,295.39
Receipts		
Federal Government	$132,099.00	
Interest	4,656.26	
Sales Tax Refund	2,627.77	
Bonds Redeemed	150,000.00	289,383.03
Disbursements		
Police Department	5,042.93	
Fire Department	13,388.80	
Garage	164,986.38	
Airport Road	30,985.13	
Sweeper	30,000.00	
Saw	2,754.23	
Mowers	1,900.00	
Hose	450.00	
Radios	404.00	
Transportation	1,135.97	
Generator	5,575.00	
Legal Aid	150.00	256,772.44
Balance on Hand June 30, 1976		$ 38,905.98

TABLE 6-4

BONDED INDEBTEDNESS OF BOONE AS OF JUNE 30, 1976

TYPE	YEAR ISSUED	AMOUNT
General Obligation Bonds		
Sanitary Sewer	1966	$ 15,000.00
Street Improvement	1970	10,000.00
Fire Equipment	1970	15,000.00
Tree Sanitation	1970	10,000.00
Street Improvement	1972	25,000.00
Sanitary Sewer	1972	280,000.00
1973 Street Improvement	1974	125,000.00
1974 Sewer Improvement	1974	320,000.00
1974 Street Improvement I-IV	1975	335,000.00
Essential Corporation	1975	445,000.00
Total General Obligation Bonds		$1,580,000.00
Revenue Bonds		
Sewer	1958	$ 5,000.00
Water	1972	180,000.00
Total Revenue Bonds		$ 185,000.00
Special Assessment Bonds		
1973 Street Improvement	1974	$ 108,000.00
1974 Street Improvement I-IV	1975	91,000.00
1974 Street Improvement II-III	1975	39,000.00
Total Special Assessment Bonds		$ 238,000.00
Total Bonding Obligation		$2,003,000.00

The general obligation bonded indebtedness of the City of Boone as of June 30, 1976, was $1,580,000.00. Revenue and special bonds totalled $423,000.00, as of the same date. The total outstanding bonded indebtedness of the City of Boone was $2,003,000.00, as shown in Table 6-4. The legal limit of bonded indebtedness for Boone was $4,427,719.00, as of June 30, 1976.

The preceding data and remarks relative to funding have been provided as general information for the City officials of Boone. Such information has been offered to aid the City officials in their decision-making process, rather than as recommendations regarding funding.

STAGING OF IMPROVEMENTS

When reviewing staging, it is desirable to accomplish first those items of relatively low cost and high benefits (safety, traffic movements and the like) that can be realized in relatively short periods of time.

Also, certain deadlines have been established by law relative to compliance with provisions of the Manual on Uniform Traffic Control Devices. All signing was to be in compliance with the MUTCD by December, 1976, while the deadline for compliance for all traffic signals is December, 1977.

Based on the previous criteria and compliance dates, the following is the recommended time sequence for the various categories of work:

1. a. Signing (including sign relocations and all new signs).
   b. Parking changes, including removal of parking near intersections.
   c. Pavement marking and striping, including changes in parking and turning lanes.
   d. Radii and other paving modifications.

Estimated cost of Item 1 = $20,355.00.

2. Traffic Signal Improvements

   a. Traffic signals at intersection of Story Street and Mamie Eisenhower Avenue.

   b. Traffic signals at intersections of Story Street and Seventh and Eighth Streets.

   c. Removal of existing traffic signals at intersections of Story Street and Sixth, Ninth, Tenth and Eleventh Streets.

   d. Raise stop sign beacons at intersection of Story Street and U.S. Highway 30.

Estimated cost of Item 2 = $55,700.00.

3. New Railroad Crossing Signals and Gates on Division Street and Greene Street at the C.N.W. Crossings.

Estimated cost of Item 3 = $63,000.00.

The revision of City ordinances, and other items for which no cost estimates were made, are not included in the time schedule. City ordinances should be revised prior to the actual implementation of improvements.

It will not be possible to make the necessary improvements or modifications in signing and signalization before the aforementioned deadlines, but such improvements should be completed as soon as possible. Accordingly, Items No. 1 and 2 in the above schedule should be completed first. It is recommended that these projects be implemented as quickly as funding permits. It is also recommended that a feasibility study on railroad grade separations in the west portion of Boone proceed as quickly as possible, to avoid unnecessary expenditures for railroad signalization. Item No. 3 in the above schedule should be implemented as soon as future locations for grade separations are finalized. It appears that a two-or-three-year program would be necessary to complete all of the recommended improvements.

IMPLEMENTATION

In terminating this report, it is the desire of the writer to mention and emphasize that people in general have the tendency to drive in accordance with their personal established habits. Changes in traffic signalization, signing, pavement marking, parking and the like should be and must be well publicized to avoid regrettable accidents caused by drivers being unaware of modified conditions and continuing to drive as previously accustomed.

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