IOWA STATE UNIVERSITY

TRAFFIC ENGINEERING STUDY

IOWA STATE UNIVERSITY ★ OF SCIENCE AND TECHNOLOGY ★
SCIENCE with PRACTICE

Prepared By

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Mr. William W. Whitman
Director
Physical Plant
Iowa State University
Ames, Iowa 50011

Dear Mr. Whitman:

We are pleased to present herewith this Traffic Engineering Study for Iowa State University.

This report makes recommendations relative to improving traffic control devices, street geometrics and pedestrian and bicycle facilities in order to provide a safer flow of the various modes of travel along the peripheral streets adjacent to the central campus area. These recommendations are based on existing and anticipated future traffic conditions.

The results of this report, when implemented, will provide improved flow and safety of pedestrian, bicycle and vehicle traffic and upgrading and uniformity of traffic control devices.

We would like to express our appreciation to the staff and members of the Iowa State University Physical Plant, the University Traffic Committee, the University Facilities Committee and the Safety Education Department for providing assistance, comments and documentation in the accomplishment of this report.

Respectfully Submitted,

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CHAPTER 1
INTRODUCTION

SCOPE

The scope of this traffic engineering study is to analyze the existing network of peripheral streets adjacent to the central campus area of Iowa State University, with major emphasis being directed toward improvement of traffic flow and safety relative to the movement of vehicular, pedestrian and bicycle traffic. In addition, the proposed future developments and expansion of the present roadway network are to be evaluated relative to their effect on traffic circulation and congestion.

The present system of traffic control devices, including traffic signals, was implemented in the early 1960's to provide primarily for the flow of vehicular traffic on the respective streets and intersections on the campus. The subsequent closure of the central campus to through vehicular traffic forced traffic to use the peripheral streets exclusively with resultant increases of traffic volumes on such streets. In addition, increased volumes of vehicular and pedestrian traffic associated with increased enrollment and the rising popularity of travel by bicycle have compounded the problems at several of the peripheral intersections.

Future developments on and in the vicinity of the Iowa State University campus relative to building construction and the expansion of the present roadway system will produce significant changes in travel patterns relative to the present roadway network.

METHODOLOGY

The first step in the development of the study was to obtain data and input from Iowa State University Physical Plant officials, which data included available mapping, current traffic and parking regulations, previous campus master plan studies and data relative to existing traffic signalization. In addition, the Consultant was requested to analyze and make recommendations relative to the improvement of traffic flow and safety at the following locations:

1. Intersection of Stange Road and Thirteenth Street
2. Intersection of Stange Road and South Drive-East Road
3. Intersection of Stange Road and Pammel Drive
4. Intersection of Bissell Road and Pammel Drive
5. Intersection of Bissell Road and Union Drive
6. Intersection of Wallace Road and Union Drive
7. Intersection of Wallace Road and North Richardson Court
8. Intersection of Wallace Road and South Richardson Court
9. Intersection of Wallace Road and Osborn Drive-Sixth Street
10. Intersection of Sixth Street and Physical Plant Entrance
11. Intersection of Sixth Street and Haber Road
12. Pammel Drive from Bissell Road to Stange Road
13. Morrill Road in the vicinity of the Memorial Union

The next phase of the study included traffic counts and geometric survey at the eleven aforementioned intersections.

The counting of vehicular, pedestrian and bicycle traffic was accomplished through the Safety Education branch of the Industrial Education Department of Iowa State University. Traffic counting personnel were hired, scheduled and paid by the University and the Consultant assisted in briefing the personnel and in providing limited supervision.

Although the study was initiated in February, 1975, traffic counting operations were scheduled for the Spring of 1975, so that pedestrian and bicycle movements could be accurately documented. The arrival of favorable spring weather, conducive to such pedestrian and bicycle movements, was later than was originally anticipated. The counts were therefore accomplished on April 25 and April 28, 1975.

These dates were so established to avoid traffic disruptions or irregularities associated with Veishea festivities, the closing of Thirteenth Street west of Grand Avenue, "dead week" and "final-exam" week. In addition, these dates were virtually the only ones that could be scheduled by the personnel who were employed by the University. Although Wednesdays were originally determined to be most favorable for the counting operations and Fridays and Mondays were to be avoided due to weekend migration of students, the counts were conducted on Friday morning, April 25 and Monday afternoon, April 28, 1975. The Friday afternoon and the Monday morning were avoided due to the aforementioned effects of weekend migration.

Traffic counts were accomplished in a period of ten hours. The Friday morning counts began at 7:30 A.M. and ended at 1:30 P.M. The Monday afternoon counts covered the period from 1:30 P.M. to 5:30 P.M. Hourly counts were obtained for each intersection and included observations of numbers and types of vehicles turning right, turning left or proceeding straight, the numbers of pedestrians using each respective crosswalk and the numbers of bicycles using the respective sidewalks, bikeways and roadways. Each hourly count was, in addition, broken down to include a 15-minute period at the time classes terminated. Such "class change" periods generally produced heavier pedestrian and bicycle traffic than the remaining 45 minutes of the one-hour counting periods.

During the course of the traffic counting phase of the study, each selected intersection was measured to establish its physical layout regarding pavement, traffic control devices, utility poles, sidewalks, parking areas and street lights.

Subsequent investigations were made relative to existing traffic signal timing, existing traffic signing and pavement marking and speed of existing traffic at selected locations.

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

The second chapter of the report, entitled "Existing Traffic Conditions", presents findings relative to existing traffic conditions and includes considerations pertaining to existing traffic control devices, traffic circulation, traffic volumes, comparison of existing traffic control devices with recognized standards, and provides analyses relative to existing deficiencies.

The third chapter, entitled "Future Developments", includes discussion relative to proposed future roadway extensions and the effects of such on traffic conditions on the campus.

The fourth chapter, "Traffic Operations", presents considerations and analysis relative to pedestrian, bicycle and vehicular traffic movements and makes recommendations for improvements.

The fifth chapter of the report, "Summary of Recommendations", provides a summary of data and recommendations previously included in prior chapters of the report.

The sixth and final chapter of the report, entitled "Estimated Cost and Staging of Improvements", includes the estimated costs of recommended improvements and suggested staging of such improvements.

The Appendix of the report provides supplemental traffic signal phasing information and includes additional traffic signal phasing information for the condition of constructing traffic signal improvements but not constructing pavement widening improvements.

CHAPTER 2
EXISTING TRAFFIC CONDITIONS

SCOPE

The purpose of this chapter is to present findings relative to existing traffic conditions, and to isolate existing and potential problems within the study area. The study area is generally outside the limits of that portion of the central campus area that is closed to general traffic. Among the subjects considered in this chapter are the following: existing traffic circulation patterns, traffic control devices, geometrics of intersections, existing pedestrian, bicycle and vehicular traffic volumes, existing traffic signalization, levels of service and speed limits.

EXISTING TRAFFIC CIRCULATION PATTERNS AND CONTROLS

Figure 2-1 is a graphical summary of existing vehicular traffic patterns on the Iowa State University campus. Within the general limits of the study area are shown the approximate locations of the gates that limit access of general traffic to the central campus area between the hours of 7:00 A.M. to 5:30 P.M.

Existing streets restricted to one-way operations are also indicated in Figure 2-1. Union Drive is one-way eastbound from Morrill Road to the Memorial Union parking lot entrance and is then a two-way street from

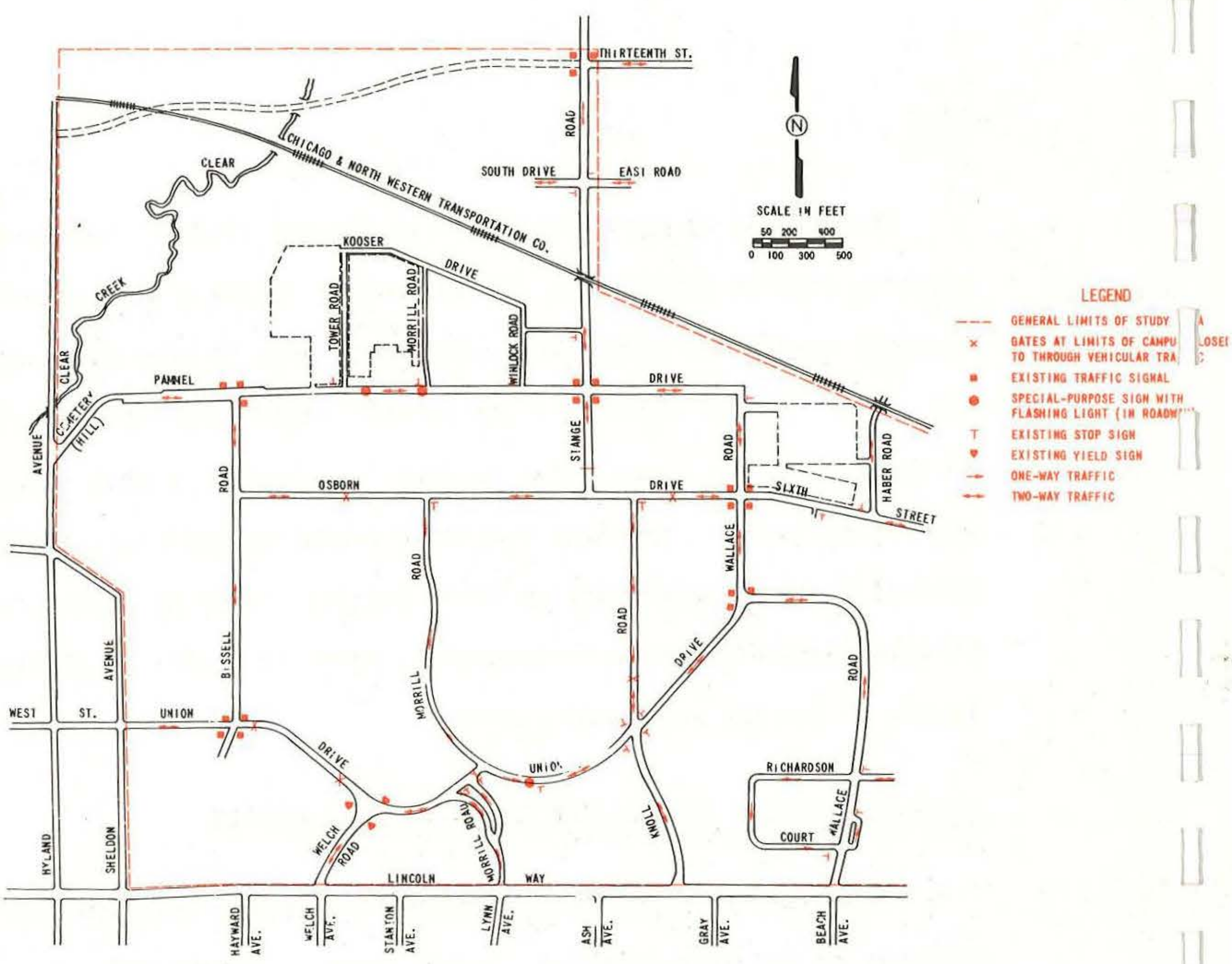


Fig. 2-1. Existing Vehicular Traffic Patterns and Traffic Control Devices.

said entrance to Wallace Road. Knoll Road is presently one-way southbound from Osborn Drive to the Curtis Hall parking lot entrance and thence a two-way facility south to Lincoln Way. Richardson Court is another one-way street, proceeding westbound from the intersection of North Richardson Court and Wallace Road, then southerly and then easterly to the intersection of South Richardson Court and Wallace Road. The drop-off lane adjacent to the west entrance to the Memorial Union is one-way northbound from its connection to Morrill Road to its connection to Union Drive.

Existing traffic control devices, except pavement markings and certain signing, are indicated in Figure 2-1. Traffic signals are present at six intersections, while stop signs or yield signs are located at other indicated locations. In addition, three special-purpose sign installations including flashing lights are present, two on Pammel Drive and one on Union Drive.

Figure 2-2 indicates the present bicycle travel patterns as they appear in the University's Traffic and Parking Regulations. Bikeways on the Iowa State University campus include bike routes in the street. These are often signed but the pavement is not marked to indicate the routes. In other areas, separate bike lanes on the street are identified by pavement lane markings. Additionally, pedestrians and bicycles share many of the sidewalks, which are marked and posted as bicycle routes. The fourth classification of bikeways, of which there is only one in existence on the campus, is the separate bicycle lane.

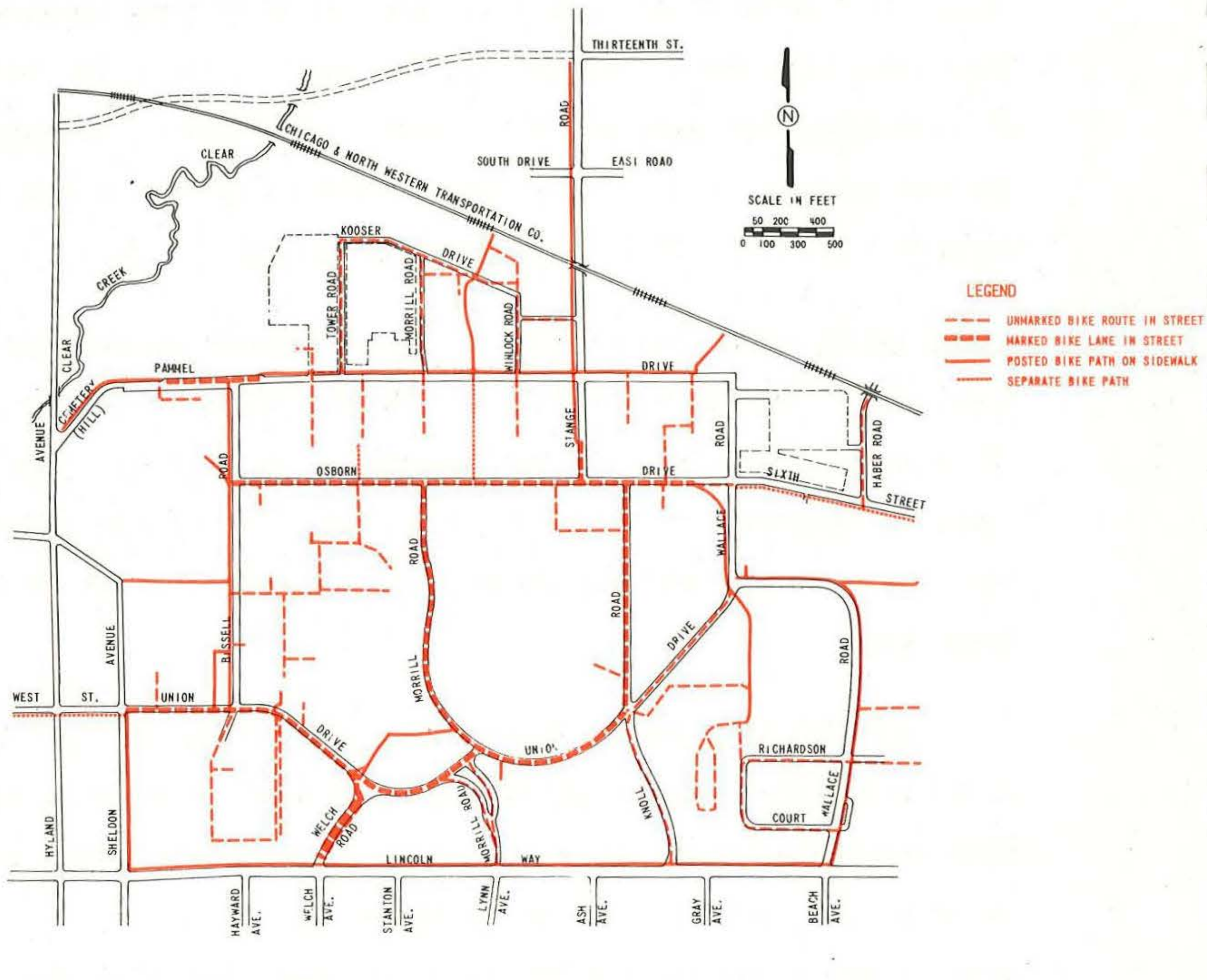


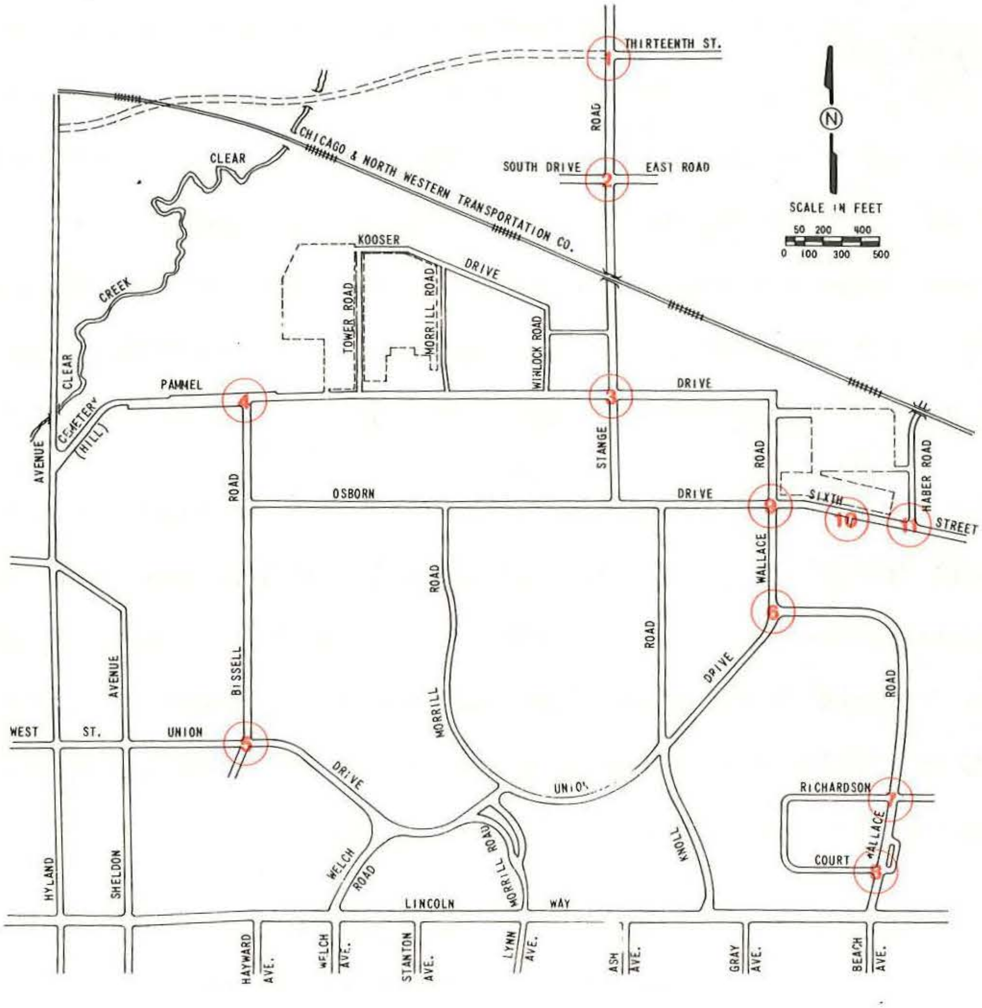
Fig. 2-2. Existing Bicycle Travel Patterns.

INTERSECTION LAYOUTS

Eleven intersections within the Iowa State University campus area were selected for detailed study, as indicated in Figure 2-3. Each intersection was surveyed to determine existing lane widths and corner radii, and to locate all traffic signals, signs, utility poles, buildings, sidewalks and other physical features near each respective intersection. Additional data was obtained for each intersection concerning crosswalk locations, types and location of bicycle facilities, and one-way street signing. Such information was then compiled and is indicated in black on the respective intersection layout diagrams in Figures 2-4 and 2-5.

The numbers shown in a color other than black in Figures 2-4 and 2-5 represent design hourly traffic volumes, which will be considered in subsequent paragraphs of this chapter. The legend pertaining to both figures is found at the lower right-hand corner of Figure 2-4. The numbers in circles are intersection identification numbers, and will be used for reference purposes within the report.

Number	Intersection
1	Stange Road and Thirteenth Street
2	Stange Road and South Drive - East Road
3	Stange Road and Pammel Drive
4	Bissell Road and Pammel Drive
5	Bissell Road and Union Drive
6	Wallace Road and Union Drive
7	Wallace Road and North Richardson Court



NO.	INTERSECTION
1	STANGE ROAD & THIRTEENTH STREET
2	STANGE ROAD & SOUTH DRIVE-EAST ROAD
3	STANGE ROAD & PAMMEL DRIVE
4	BISSELL ROAD & PAMMEL DRIVE
5	BISSELL ROAD & UNION DRIVE
6	WALLACE ROAD & UNION DRIVE
7	WALLACE ROAD & N. RICHARDSON COURT
8	WALLACE ROAD & S. RICHARDSON COURT
9	WALLACE ROAD & OSBORN DRIVE-SIXTH [illegible]EET
10	SIXTH STREET & PHYSICAL PLANT ENT[illegible]E
11	SIXTH STREET & HABER ROAD

Fig. 2-3. Intersections Studied in Detail.

8	Wallace Road and South Richardson Court
9	Wallace Road and Osborn Drive - Sixth Street
10	Sixth Street and Physical Plant Entrance
11	Sixth Street and Haber Road

TRAFFIC VOLUMES

Among the primary considerations in the design of street or highway facilities are the volumes and types of traffic using the roadway. The designs of such features as pavement width, pavement thickness, turning lanes, lighting, traffic signal installations and signing are based on the traffic volumes to be accommodated by the highway or street.

The traffic volume normally considered in the design of highway improvements is the thirtieth highest hourly volume of the year. In other words, the design hourly volume is that volume which will be exceeded only 29 times each year.

Existing traffic volumes were observed at each of the intersections identified in Figure 2-3. These observations, often referred to as "traffic counts", were made on weekdays between the hours of 7:30 A.M. and 5:30 P.M. They represent the existing traffic conditions prior to May, 1975.

The traffic counts at each intersection approach were subdivided into turning movements, both right and left, and through traffic. 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 semi-tractor-trailer trucks. All single-unit trucks, buses and larger trucks were classified as trucks in computing 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, based on the results of the ten-hour traffic counts. The map in Figure 2-6 indicates the A.D.T. for the various streets. These volumes represent the total number of vehicles traveling on the street in both directions on an average day.

Design hourly traffic volumes were also calculated for all movements within each counted intersection, and are shown in Figures 2-4 and 2-5. Included in this data are the hourly volumes of traffic entering and leaving the intersection per approach, turning movements on each approach, and the percentage of trucks observed.

PEDESTRIANS AND BICYCLES

As was noted in Chapter 1, pedestrian and bicycle traffic have become major factors in the design and operation of transportation facilities at Iowa State University. Pedestrians are often in conflict with vehicles desiring to turn at intersections. Furthermore, pedestrians are important considerations in the design of such features as sidewalks, drainage and traffic control devices. Bicycles, in addition, are in competition with both pedestrians and vehicular traffic within intersections.

Several streets and intersections on the Iowa State University campus have been modified in recent years to accommodate bicycle traffic, with designated bike lanes on the roadway itself. At other intersections, bicyclists share the sidewalk with pedestrians or are provided with an exclusive bike path. In any case, bicycles and pedestrians, as well as vehicles, must all be considered in the intersection design.

Pedestrian and bicycle counts were conducted concurrently with vehicular counts at each intersection within the study area. Pedestrian and bicycle traffic is widely dependent on weather conditions and seasonal variations, and thus no values are presented for peak pedestrian or bicycle movements.

The pedestrian and bicycle volumes shown in Figures 2-7 and 2-8, respectively, indicate the highest hourly volumes observed for each of the respective crosswalks. They are representative of pedestrian and bicycle traffic during the Spring quarter at Iowa State University.

Due to weather conditions present at the time of the study, it is expected that peak hourly bicycle volumes will be substantially higher than those indicated in Figure 2-8.

The observed pedestrian and bicycle volume, although not necessarily the peak volumes that might occur within the year, demonstrate the relative density of movements within each crosswalk. Several observations are notable.

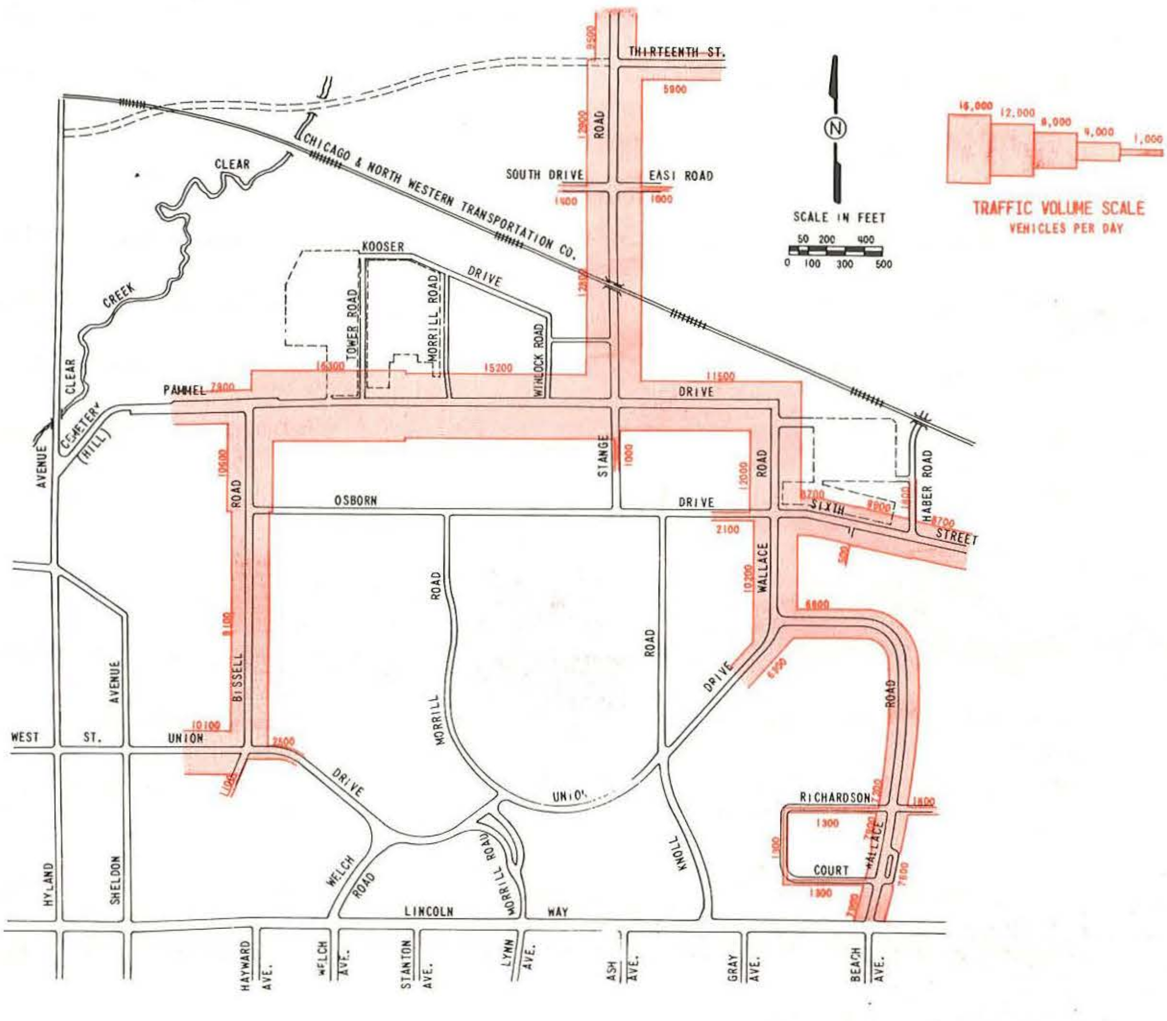


Fig. 2-6. Existing Average Daily Traffic Volumes.

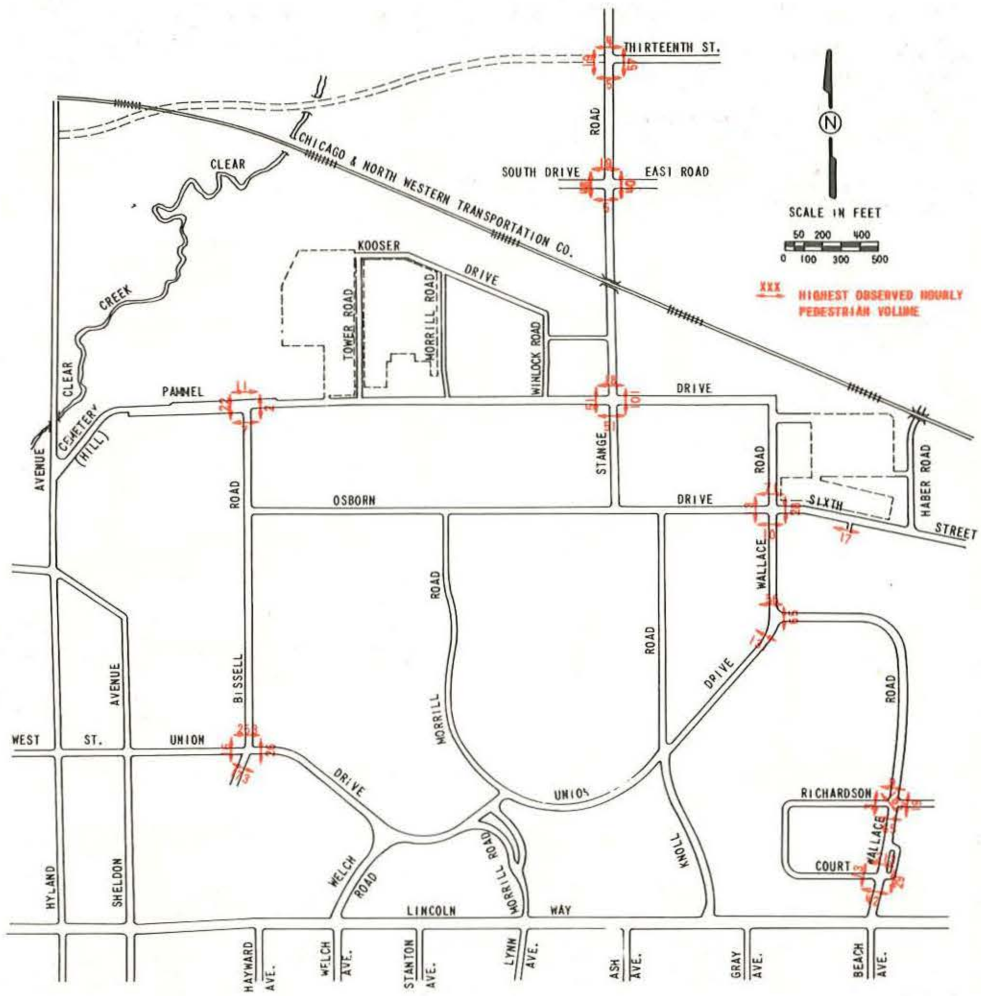


Fig. 2-7. Observed Hourly Pedestrian Volumes.

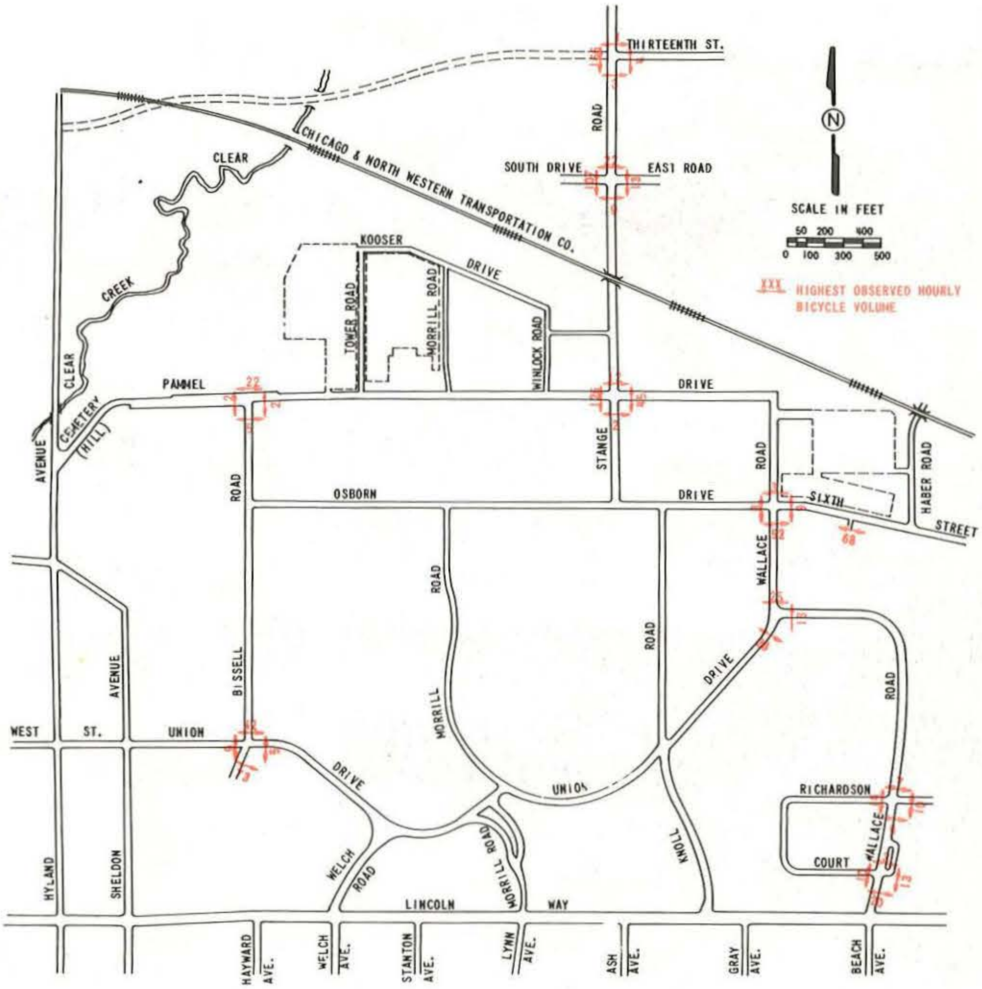


Fig. 2-8. Observed Hourly Bicycle Volumes.

Pedestrian and bicycle counts were subdivided within each hour to separate the 15 minute period during class breaks from the remainder of the hour. The peak 15 minute volume was then compared to the peak hourly volume at each intersection. Results indicated that the peaking characteristics of the bicycle traffic and the pedestrian traffic were very similar. When considering intersections near the campus or residence halls (Intersection Nos. 3-9), approximately half of the pedestrian and bicycle movements during the hour occurred within the peak 15 minute period. For outlying intersections on Stange Road and Sixth Street (Intersection Nos. 1, 2, 10 and 11) the peaking effect was less pronounced, with approximately one-third of the hourly volume occurring within a 15 minute period.

Observance of traffic signals by pedestrians and bicyclists was found to be widely variable. At intersections where vehicular traffic was light, such as the south crosswalk of Bissell Road and Union Drive, traffic signals were practically ignored by pedestrians. Where heavy vehicular traffic was present, such as the intersection of Stange Road and Pammel Drive during the morning rush hour, practically all pedestrians and bicyclists were in observance of the respective signals. Utilization of pedestrian push-buttons was observed to be minimal in most cases where such were provided.

Pedestrians do not necessarily confine themselves to marked crosswalks. For example, at the intersection of Wallace Road and Osborn Drive the majority of pedestrians on the north approach do not utilize the designated crosswalk, but instead cross Wallace Road at some distance farther north. Similar situations were observed at numerous locations throughout the campus.

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".

A limited inventory was made to generally locate all traffic signals, pedestrian crossing signals, stop signs and yield signs within the study area that are present to regulate, warn or guide traffic at Iowa State University. Such information has been indicated in Figure 2-1 relative to the study area in general. Traffic control devices were accurately located within the respective intersections that were chosen to be studied in detail and such are indicated in Figures 2-4 and 2-5.

Stop Signs

"Stop" signs are presently installed at locations indicated in Figure 2-1 and as shown in Figures 2-4 and 2-5.

All existing "stop" signs, relative to those intersections that were studied in detail, appear to be in general conformance with the requirements of the MUTCD.

It was observed that the "four-way" stop plates mounted below the "stop" signs at the intersection of Union Drive and Knoll Road are not in conformance with the MUTCD, in that the required twelve-inch by six-inch sign has white lettering and border on a red background.

Yield Signs

"Yield" signs are presently located at the intersection of Union Drive and Welch Road, as is indicated on Figure 2-1. All three existing yield signs are of the old black-on-yellow style. These signs should be converted to comply with the MUTCD, which sign has a broad red border and red lettering on a white interior.

One instance of an incorrect use of a "yield" sign was noted on Wallace Road, north of North Richardson Court and relative to southbound traffic. An old-style "yield" sign is mounted directly above and in conjunction with a "school crossing" sign and on a common post. This sign assembly is located well in advance of the existing crosswalk and intersection. The basic purpose of a "yield" sign is to assign right-of-way to traffic on certain approaches to an intersection. In addition, in accordance with the MUTCD, "yield" signs should not be installed where "stop" signs are present on other approaches of the same intersection. North Richardson Court is required to stop at Wallace Road. In addition, a "school crossing" sign is intended for erection at, rather than in advance of the crosswalk and is to be supplemented by a "school advance" sign placed in advance of the "school crossing" sign. Therefore neither existing sign, as presently installed, is in conformance with the MUTCD. It is recommended that the "school crossing" sign be placed at the north side of North Richardson Court and that a "school advance" sign be placed further north, in advance of the "school crossing" sign.

Special-Purpose Signs With Flashing Lights

Two of the three special-purpose signs with flashing lights previously mentioned and indicated on Figure 2-1 are battery-operated pedestrian signs used on Pammel Drive. One such sign is located at the west crosswalk at Morrill Road, while the other is located at a crosswalk east of Tower Road. The metal post of each sign supports a flashing yellow light on its uppermost end and nonconforming signs reading "Stop for Pedestrians in Crosswalk" are mounted on both sides of the post. These signs are placed at the centerline of Pammel Drive.

Such roll-out signs are contrary to the provisions of the MUTCD, in that "portable school signs shall not be placed within the roadway at any time". Additionally, part-time stop signs are not permitted by said manual, except for emergencies. The aforementioned MUTCD adds that "A portable traffic signal not meeting all the requirements of this Manual, is not recognized as a standard traffic control device".

The existing roll-out pedestrian signs with flashing lights are therefore not in accordance with provisions of the MUTCD. It is recommended that they be replaced by post-mounted two-piece "ped xing" signs (MUTCD Designation W11-2), placed adjacent to each side of Pammel Drive at the respective crosswalks. It is additionally recommended that yellow hazard identification beacons be mounted on top of each post, all in accordance with respective requirements of the MUTCD.

Another special-purpose sign is located at the centerline of Union Drive, easterly of Morrill Road and west of the Memorial Union parking lot entrance. It is located at the division point of one-way and two-way traffic directions on Union Drive. Union Drive is a one-way eastbound facility from Morrill Road to the Memorial Union parking lot entrance and is a two-way street from said parking lot entrance easterly to Wallace Road. This sign assembly consists of a "One Way Do Not Enter" sign facing east, a "Keep Right" sign facing west and two flashing-white lights mounted on top of the sign assembly. The top of the sign assembly is only approximately three feet above the surface of the pavement, to which it is affixed.

This sign assembly is not in conformance with the MUTCD for several reasons. It is located within the street area, it is of insufficient height and white lights are not an approved color relative to traffic signal lights.

The only other traffic control device present in the vicinity of the end of the one-way portion of Union Drive is a "No Left Turn" sign at the exit from the Memorial Union parking lot.

It is recommended that the existing special-purpose sign and flashing white light assembly be removed and that the following be erected as noted:

1. Erect a "Dead End" sign west of Knoll Road relative to westbound traffic on Union Drive.

2. Erect "Do Not Enter" signs on both sides of Union Drive relative to westbound traffic on Union Road and west of the entrance to the Memorial Union parking lot.

3. Erect a "Left Lane Ends" sign on the north side of Union Drive and east of the intersection of Morrill Road.

4. Erect a "Lane Ends Merge Right" sign on the north side of Union Drive east of the west pedestrian crossing to the Memorial Union.

5. Supplement signing relative to eastbound vehicles with pavement markings to guide them toward the south side of the street.

<u>One-Way Street Signs</u>

Existing one-way streets are indicated in Figure 2-1, as previously noted.

South Richardson Court is currently one-way eastbound, ending at Wallace Road. Current signing is insufficient to prevent motorists from turning from Wallace Road onto South Richardson Court and several motorists were observed making such turns during the traffic counting phase of this study. A small sign, reading "One Way Do Not Enter", is located on the northwest corner of the intersection but is evidently not effective in prohibiting wrong-way traffic flow on the street. It is recommended that "One-Way" and "Do Not Enter" signs be erected west of Wallace Road at South Richardson Court, that "No Right Turn" signs be erected on the west side of Wallace Road relative to southbound vehicles and that "No Left Turn" signs be placed on the east side of Wallace Road relative to northbound traffic to avoid future wrong way traffic on South Richardson Court.

The drop-off lane at the west entrance to the Memorial Union, as previously described and noted in Figure 2-1, is not adequately signed. An eastbound motorist on Union Drive, if not permitted within the restricted central campus area, may presently be obliged to turn into the aforesaid drop-off lane and against the flow of traffic in such lane. "One Way Do Not Enter" signs are presently mounted on the backside of the two "Stop" sign posts at the intersection of the drop-off lane and Union Drive but such do not give advance notice to the eastbound motorist on Union Drive. It is recommended that "One-Way" signs be placed southerly of Union Drive so that such eastbound motorists on Union Drive be made aware that the drop-off lane is one-way northbound. It is also recommended that "One-Way" signs be erected at the junction of the drop-off lane with Morrill Road, as no such signs are presently installed.

In the absence of existing one-way signing, it is recommended that "One-Way" signs be installed on Morrill Road at its intersection with Osborn Drive. Morrill Road is supposed to be one-way southbound from Osborn Drive to Union Drive. The existing stop sign at the southeast corner of the intersection is in relation to northbound traffic on Morrill Road and is recommended to be removed.

A "Stop" sign also exists at the southeast corner of the intersection of Osborn Drive and Knoll Road relative to northbound traffic. Since this street is presently one-way southbound, it is recommended that the "Stop" sign be removed.

Traffic Signalization

The following six intersections on the Iowa State University campus, as indicated in Figure 2-1, are presently controlled by traffic signals:

Stange Road and Thirteenth Street

Stange Road and Pammel Drive

Bissell Road and Pammel Drive

Bissell Road and Union Drive

Wallace Road and Union Drive

Wallace Road and Osborn Drive - Sixth Street

Each of these signal installations was analyzed relative to equipment, operation and compliance with the requirements of the MUTCD.

Traffic Signals

Existing traffic signal installations at each of the six signalized intersections are of the fully - actuated type. Vehicles arriving at these intersections from each approach lane are sensed by induction loop detectors located within the pavement. The signal cycles are then adjusted automatically by the controller, according to the volume and spacing of the approaching traffic. The length of each signal indication, as well as the length of the entire signal cycle, varies and is dependent on the amount of traffic approaching the intersection in each lane.

Data pertaining to each of the existing traffic signal installations is tabulated in Figure 2-9. This table includes the number of signal phases, the traffic movements controlled by each phase, and the existing signal time settings for the respective phases. Explanations of each signal setting are listed below:

Minimum Initial: This setting controls the minimum length of the green signal indication for each phase. It is adjusted to allow all vehicles between the detector and the stop line to start and enter the intersection before the green indication expires.

Passage Time: This portion of the phase, sometimes called the "unit extension", is the additional time by which the

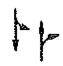
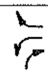
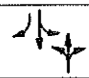
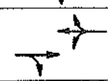
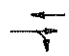
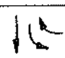
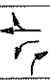
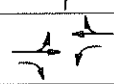
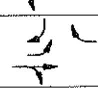
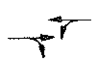
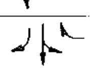
INTERSECTION	PHASE	EXISTING SIGNAL SETTINGS (SECONDS)					
		MINIMUM INITIAL	PASSAGE TIME	MAXIMUM GREEN	CLEARANCE (YELLOW)	WALK	PEDESTRIAN CLEARANCE
STANGE ROAD & 13TH STREET	A. TURNED OFF	---	---	---	---	---	---
	B. 	4	4	40	3½	---	---
	C. 	3	4	45	3½	---	---
STANGE ROAD & PAMMEL DRIVE	A. 	4	4	45	3½	---	---
	B. 	3	3	50	3½	---	---
	C. 	3	3	40	3½	---	---
BISSELL ROAD & PAMMEL DRIVE	A. 	4	4½	50	3½	---	---
	B. 	3	3	40	4	---	---
	C. 	4	3	40	3½	---	---
WALLACE ROAD & UNION DRIVE	A. 	3	3	40	3½	---	---
	B. 	3	3	35	3½	5	5
	C.	4	4	40	3½	---	---
WALLACE ROAD & OSBORN DRIVE-SIXTH STREET	A. 	5	3	40	3½	---	---
	B. 	3	3	40	3½	---	---
	C. 	3	2½	40	3½	---	---
	D. 	3	3	40	3½	---	---
BISSELL ROAD & UNION DRIVE	A. 	4	4	55	3½	---	---
	B. 	4	4	35	4	---	---
	C. 	3	3	35	4	---	---
	D. 	3	3	35	4	5	5

Fig. 2-9. Existing Traffic Signal Settings.

green interval is extended when an approaching vehicle passes over the detector. The time required for this setting is the time needed for a vehicle to travel between the vehicle detector and the stop line.

The passage time also is the maximum time spacing between approaching vehicles which will retain the green indication on a particular approach. The green signal on that approach is lost if no vehicle arrives at the detector within one "passage time" interval of the previous vehicle.

The minimum length of green signal indication on any approach is equal to the "minimum initial" time plus the "passage time".

Maximum Green: This setting determines the maximum length of time for which any approach can retain a green signal indication while vehicles are waiting at any of the other approaches. After the "maximum green" time has elapsed, the signal will then cycle to next phase where traffic is waiting, regardless of the number or spacing of vehicles arriving at the first approach. If no traffic is waiting at any of the other approaches, the "maximum green" limitation does not function. In this case, the green indication will remain indefinitely on the last approach where traffic was present.

Clearance: This setting controls the length of the yellow signal indication, and is a constant for each phase. The length of the clearance interval must be sufficient to allow vehicles near the intersection to pass through the intersection before opposing traffic receives the right-of-way.

The location of each traffic signal head, mounting pole and control cabinet is indicated in Figures 2-4 and 2-5.

Existing signals at each of the studied intersections are mounted on mast-arms, with one signal head overhanging the extension of each approach lane. The placement of the existing traffic signals are in general conformance with the requirements set forth in the MUTCD.

Right turns on red after stop are permitted at all intersections except for the south approach of Wallace Road at Osborn Drive - Sixth Street. Northbound traffic on that approach faces a "No Turn On Red" sign. Right turns on red will be discussed in greater detail in Chapter 4.

The timing of traffic signals should generally be in accordance with the volume of traffic using each signal phase and the capacity of the lanes controlled by each signal phase. According to Figure 2-9, the following existing signal phases appear to be longer than necessary to accommodate the existing traffic:

Bissell Road & Pammel Drive; Phases A & B

Bissell Road & Union Drive; Phases B & D

Wallace Road & Osborn Drive - Sixth Street; Phase D

The lower volumes of traffic utilizing these signal phases could be accommodated adequately with shorter "maximum green" intervals.

Whenever sufficient traffic is present to continually actuate the "passage time" interval of the signal cycle, the signal will remain green on each phase until the "maximum green" time is reached. In this event, the signal cycle will approximate a fixed-time cycle. The following table, Figure 2-10, shows the maximum cycle length at each intersection, which will occur whenever the maximum green time is used for all phases. This table also shows the maximum time a vehicle must wait before receiving a green signal indication, assuming the vehicle arrived at the intersection just after the previous green indication expired.

Intersection	Maximum Cycle Length (Seconds)	Maximum Waiting Time (Seconds)
Stange Road & Thirteenth Street	92	48
Stange Road & Pammel Drive	145	102
Bissell Road & Pammel Drive	141	97
Wallace Road & Union Drive	125	87
Wallace Road & Osborn Drive	174	130
Bissell Road & Union Drive	175	137

Fig. 2-10. Maximum Cycle Lengths and Waiting Times at Signalized Intersections

Maximum cycle lengths and waiting times, as indicated in Figure 2-10, are all relatively long. Waiting times at two of the intersections can exceed two minutes, while the average of the "maximum waiting times" for all six intersections exceeds 100 seconds. Long waiting times are especially detrimental to pedestrian compliance with signal indications.

Existing "passage time" intervals ranged from 2.5 to four seconds for the intersections studied. As previously discussed, the "passage time" should be sufficiently long to allow a vehicle to travel between the detector and the stop line of the intersection. When considering this criterion, existing "passage time" intervals are adequate in length. Such short intervals, however, require a relatively close spacing of vehicles to retain a green signal indication, since the green indication will expire unless a vehicle arrives within one unit of "passage time" of the previous vehicle. At an approach speed of 10 miles per hour, for example, a 2.5 second "passage time" would require vehicle spacings of 37 feet or less to retain a green signal. A three-second passage time would allow vehicles to be spaced at 44 feet, while four seconds would allow a spacing of 59 feet.

Existing Pedestrian Signals

Pedestrian signals are, to varying degrees, provided at each of the five intersections tabulated in Figure 2-11, relative to the designated pedestrian crosswalks.

Except at the intersection of Wallace Road and Union Drive, all present pedestrian signals consist of only "Don't Walk" messages mounted in rectangular signal heads. At such locations, the "Don't Walk" indication is terminated at the time pedestrians are permitted to cross and is resumed at the beginning of the respective red traffic signal indication. There is no positive indication that the pedestrian may "walk". The MUTCD states that "All pedestrian indications shall be rectangular in shape and shall consist of the lettered messages Walk and Don't Walk". Although the required "Walk - Don't Walk" type pedestrian signals are in existence at the north and south crosswalks of the intersection of Wallace Road and Union Drive, no indications are currently provided for the eastbound pedestrians in the south crosswalk.

Pedestrian detectors for actuation of the pedestrian signal phases are provided at the three intersections so indicated in Figure 2-11. These detectors are of the push button type and are currently mounted on traffic signal poles or on separate posts. The only post-mounted detector is located at the southwest corner of Wallace Road and Osborn Drive and is located adjacent to the bicycle lane on the south side of Osborn Drive.

Relative to pedestrian actuations, the MUTCD adds that "Permanent-type signs shall be mounted above or in unit with the detectors, explaining their purpose and use... Where two crosswalks, oriented in different directions, end at or near the same location, the positioning of pedestrian push buttons should clearly indicate which crosswalk signal is actuated by each push button". The only push-button detectors identified by signing are those at the intersection of Bissell Road and Union Drive and such are identified by small, non-standard signs reading "Push To Walk, Wait For Walk Light", although no "Walk" light is in existence. The standard nine-inch by twelve-inch sign for such detectors should read "Push Button For Green Light", in the absence of "Walk" indications, or "Push Button For Walk Signal", when pedestrian signals are present.

Additional requirements of the MUTCD are that "A pedestrian clearance interval shall always be provided where pedestrian signal indications are used. It shall consist of a flashing Don't Walk indication. The duration should be sufficient 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" and "Where traffic signals are of the actuated type, control equipment should provide sufficient pedestrian crossing time when there has been a pedestrian actuation and the minimum vehicular time is less than that needed by the pedestrians". The existing "Don't Walk" pedestrian indications are synchronized with the corresponding red indications at all of the pedestrian signal locations. No pedestrian clearance interval is therefore provided. (See Figure 2-11.)

The pedestrian signals on the north and south crosswalks at the intersection of Wallace Road and Union Drive consist of both Walk and Don't Walk indications. The Walk indication is given concurrently with the green traffic signal indication on the east approach. During the yellow signal light on that approach no pedestrian signal is given, and during the red signal indication the Don't Walk signal is illuminated. With this sequence of signal timing, pedestrians entering the crosswalk near the end of the Walk indication would be allowed only 3½ seconds to cross the street before opposing traffic received a green signal. This time is approximately 8 seconds less than that required for a pedestrian to cross the street.

The Manual on Uniform Traffic Control Devices (MUTCD) has identified four pedestrian indications, as follows: (See Page 37)

Intersection	Pedestrian Crosswalks With Pedestrian Don't Walk Indications	Pedestrian Crosswalks With Pedestrian Walk-Don't Walk Indications	Pedestrian Push-Button Detector Location	Pedestrian Movements Actuating Controls	Existing Signing Relative To Push-Button Detectors	Actuation Or Signal Phases Affecting Other Pedestrian Movements	Traffic Signal Phase For Pedestrian Crossings				Color Of Traffic Signal Indication At Beginning Of Existing "Don't Walk" Indication			
							Crosswalk				Crosswalk			
							N	S	E	W	N	S	E	W
Stange Road & 13th Street	E.	---	---	---	---	Pedestrians cross during green indications for NB & SB vehicular traffic.	-	-	B	-	-	-	Red	-
Stange Road & Pammel Drive	N, S, E, W.	---	---	---	---	Pedestrians cross during respective green indications for vehicular traffic.	C	C	A	A	Red	Red	Red	Red
Bissell Road & Union Drive	N, E.	---	N.W. & N.E. Corners	E.B. & W.B. in N. Crosswalk, S.B. in E. Crosswalk	Push To Walk Wait For Walk Light	E. crosswalk during E.B. Lt. turn vehicle phase. N. & E. crosswalks during N.B. vehicle phase.	D	-	A,D	-	Red	-	Red	-
Wallace Road & Union Drive	---	N., S. (W.B. only)	N.W. & N.E. Corners	E.B. & W.B. in N. Crosswalk	None	Pedestrian actuation N. crosswalk also actuates for W.B. pedestrians in S. crosswalk. In absence of pedestrian actuation, E.B. vehicles actuate pedestrian signals.	B	B	-	-	Red**	Red**	-	-
Wallace Road & Osborn Drive-Sixth Street	N, E.	---	S.E. Corner (S.W. Corner)*	N.B. in E.B. Crosswalk (E.B. in South Crosswalk)*	None	N. crosswalk during E.W. vehicle phases. E. crosswalk during N.B. vehicle phase (S. crosswalk during E.B. vehicle phase)*	C,D	D*	B	-	Red	-	Red	-

*Primarily bicycle crossing - occasional pedestrians.
**"Walk" indication with green traffic signal, no indication with yellow and "Don't Walk" with red traffic signal indication.

Fig. 2-11. Tabulation of Existing Pedestrian Signal Data.

"The Don't Walk indication, steadily illuminated, means that a pedestrian shall not enter the roadway in the direction of the indication.

The Don't Walk indication, while flashing, means that a pedestrian shall not start to cross the roadway in the direction of the indication, but that any pedestrian who has partly completed his crossing during the steady Walk indication shall proceed to a sidewalk, or to a safety island.

The Walk indication, steadily illuminated, means that pedestrians facing the signal indication may proceed across the roadway in the direction of the indication.

The Walk indication, while flashing, means that there is a possible conflict of pedestrians with vehicles."

All pedestrian signals should be operated according to the above guidelines.

According to the aforementioned data relative to existing pedestrian signalization, none of the existing pedestrian signals are in conformance with all of the requirements as set forth in the MUTCD. Additional analyses and recommendations relative to pedestrian signals will be presented subsequently in Chapter 4 of this report.

Traffic Signal Warrants

Traffic signals should not be installed at any intersection unless one or more of the signal warrants, as set forth in the MUTCD, are met. These warrants specify minimum traffic and pedestrian volumes or other conditions necessary for the installation of traffic signals. A brief description of each traffic signal warrant is included in Figure 2-12.

WARRANT NO.	DESCRIPTION OF APPLICATION
1 Minimum Vehicular Volume	Where the volume of traffic on the minor street 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 extend; 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.

Fig. 2-12. Description of Traffic Signal Warrants.

Each of the following five unsignalized intersections within the study area was analyzed relative to the aforementioned traffic signal warrants:

Stange Road and South Drive - East Road

Wallace Road and North Richardson Court

Wallace Road and South Richardson Court

Sixth Street and Physical Plant Entrance

Sixth Street and Haber Road

Results of these analyses, based on existing motor vehicle and pedestrian traffic volumes, indicated that traffic signals are not presently warranted at any of these five intersections. Existing stop sign traffic control is therefore recommended to remain at each intersection.

Existing Pavement Markings

Another traffic control device, in addition to the aforementioned signs and signals, is pavement marking. Pavement markings consist of painted lines, words or symbols on the pavement surface and are used alone or in combination with other aforementioned traffic control devices.

Pavement markings do have limitations in that they may be obliterated by snow, may not be readily visible when wet, and may not be durable when subjected to heavy traffic volumes. Regular programs of maintenance and remarking are usually required to provide a continuing and effective system of pavement markings.

Pavement markings include the following types: center lines, lane lines, parking stall lines, no parking zones, pedestrian crossings, stop lines, railroad crossings, school crossings, no passing zones, bicycle lanes and others.

Existing pavement markings, as observed in the Spring of 1975, appeared to be generally in poor condition relative to visibility. It is recommended that a regular program of maintenance be implemented to assure that all pavement markings are visually adequate at all times.

It was observed that pavement arrow markings are relatively small and somewhat difficult to notice readily. Where certain pavement lanes are to be used for specific movements or turns, it is recommended that pavement arrow markings be used to supplement existing signing. The word "Only" should be used in conjunction with single mandatory movements.

Pedestrian - Bicycle - Vehicle Conflicts

The following is an intersection by intersection description of each signalized intersection relative to existing pedestrian, bicycle and vehicle conflicts: (Refer to Figures 2-6, 2-7, 2-8, 2-9, 2-11 and 2-13):

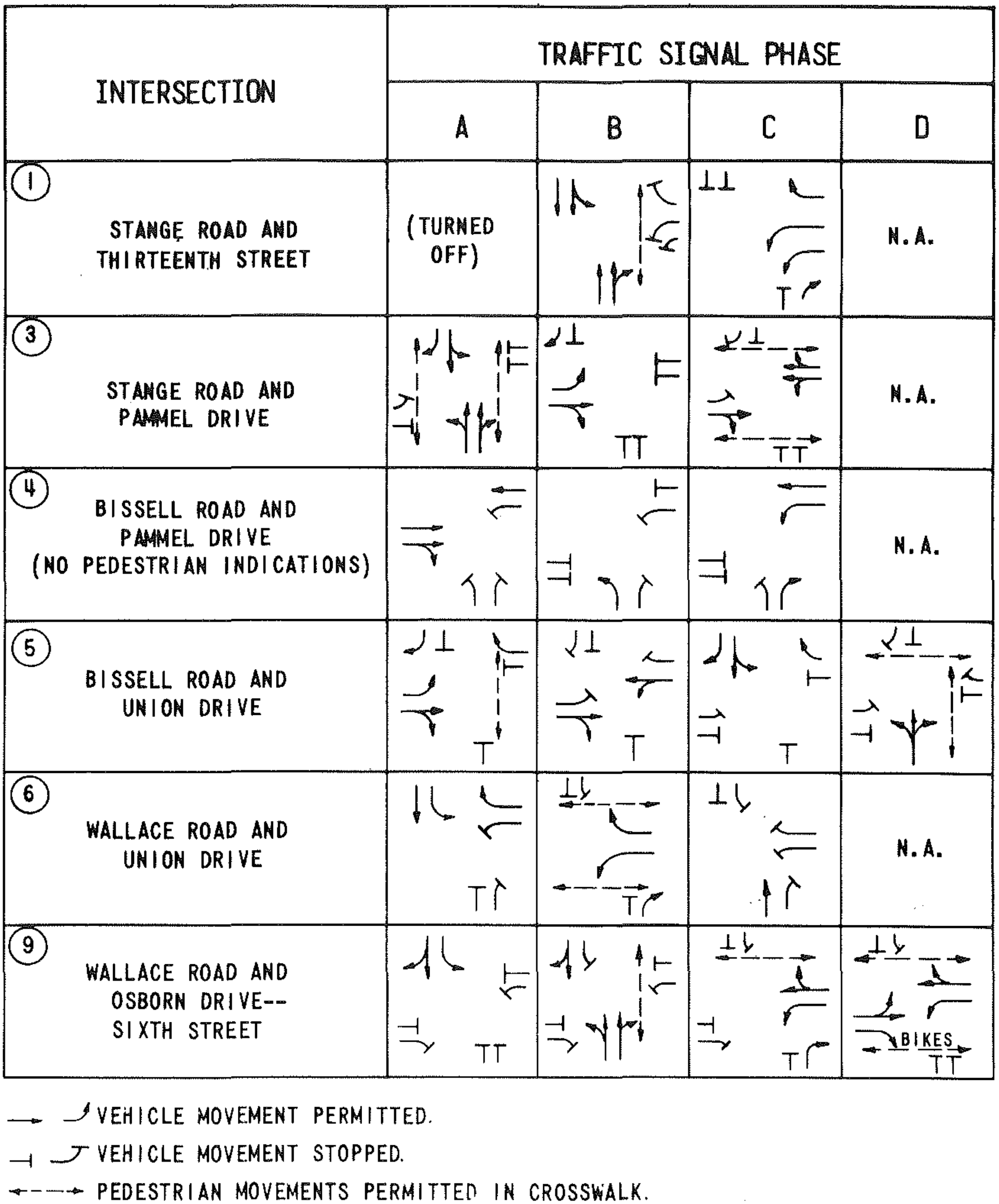


Fig. 2-13. Schematic Diagrams of Existing Traffic Signal Phasing.

Stange Road and Thirteenth Street (Intersection No. 1, Figure 2-13):

Figure 2-13 includes a schematic diagram of the existing traffic and pedestrian signal phasing for this intersection. Pedestrians using the east crosswalk are permitted to cross Thirteenth Street during the green vehicular signal indication of Phase B. Turning vehicles are in potential conflict with pedestrian movements. Pedestrian time with a green signal indication will vary from 8 seconds to 40 seconds, depending on vehicular traffic actuation. If only one vehicle actuates the vehicular phase, the resulting 8 seconds of green plus the 3½ seconds of yellow would not allow a pedestrian enough time to cross the pavement.

Stange Road and Pammel Drive (Intersection No. 3, Figure 2-13):

In reference to Figures 2-9, 2-11 and 2-13, pedestrian crossing times with a green signal indication may vary from 8 to 45 seconds in Phase A, from 6 to 50 seconds in Phase B, and from 6 to 40 seconds in Phase C depending on the relative amounts of vehicular traffic. The minimum times are insufficient for pedestrians to cross either street. The possibility of conflicts between vehicles and pedestrians exists in the east and west crosswalks due to heavy volumes of vehicular turning movements on the north approach and due to heavy pedestrian volumes in each crosswalk.

Bissell Road and Pammel Drive (Intersection No. 4, Figure 2-13):

No pedestrian signals are included as part of the existing signalization of this intersection. Pedestrian and bicycle volumes are also relatively low.

The north eight feet of the existing pavement at this intersection serves as a two-way on-street bicycle lane. Eastbound bicycles must travel adjacent to and against traffic in the northerly westbound traffic lane.

Bissell Road and Union Drive (Intersection No. 5, Figure 2-13):

Pedestrian movements in the east crosswalk are in direct conflict with eastbound vehicular traffic and with right-turning vehicular traffic from the east approach in signal Phase A. The pedestrian indication in such phase is actuated by vehicular traffic.

Through and right-turning vehicles in Phase D are in serious conflict with pedestrians using the north and east crosswalks respectively. These pedestrian signals are actuated by pedestrian actuation of either of the push-button detectors at the north-west or northeast corners of the intersection or by vehicles on the south approach. Northbound motorists that are turning east on Union Drive can observe the pedestrian signal indication for the east crosswalk, which eliminates some of the potential for conflict with pedestrians in that crosswalk. A northbound motorist on the south approach cannot observe, however, that pedestrians in the north crosswalk are permitted to walk across Bissell Road in front of him. Such is a very uncommon and unexpected situation and lends itself directly to serious pedestrian-vehicle conflicts.

Wallace Road and Union Drive (Intersection No. 6, Figure 2-13):

Pedestrian movements in the north and south crosswalks are regulated by "Walk" and "Don't Walk" pedestrian indications, except that eastbound pedestrians in the south crosswalk do not have any signal indications. Pedestrian movements are permitted during Phase B of the green signal indication for traffic on the east approach. This phase is actuated by either pedestrian actuation of push-button detectors at the north crosswalk or by vehicle actuation in the east approach. With pedestrian actuation alone, pedestrians receive approximately ten seconds of the "Walk" indication. The green vehicular signal indication, relative to the east approach, is also illuminated following such pedestrian actuation and vehicles arriving after such actuation extend both the pedestrian and vehicle indications in this phase. If actuation of the phase is by vehicles only, the length of the "Walk" indication may vary from 6 to 35 seconds, depending on the length of the vehicular green indication. The wiring relative to pedestrian time settings in the control cabinet may have been modified due to observed pedestrian "Walk" signal timing. The "Walk" indication ends at the time the green indication for vehicular traffic changes to yellow. The pedestrian "Don't Walk" indication is illuminated during the red signal indication for vehicular traffic.

It was observed that the pedestrian push-button detector at the northeast corner of the intersection is located 15 feet north of the sidewalk. It is very unlikely that a westbound pedestrian will walk this out-of-way distance across the grass parking area to actuate the pedestrian signals but will either wait for other pedestrian or vehicular actuation or will proceed without such actuation.

According to the control cabinet phasing diagrams, the vehicular right-turning movement from the south approach occurs during Phase B of the cycle, which movement is in direct conflict with pedestrian movements in the south crosswalk. Both turning movements from the east approach are potentially in conflict with pedestrian movements in the north and south crosswalks during aforesaid Phase B.

Wallace Road and Osborn Drive - Sixth Street (Intersection No. 9, Figure 2-13):

Pedestrian movements in the east crosswalk are actuated by use of the push-button detector at the southeast corner of the intersection, relative to northbound pedestrians. In the absence of pedestrian actuation, pedestrian signals for the east crosswalk are actuated by Wallace Road traffic in Phase B of the signal cycle. Southbound pedestrians cannot actuate the pedestrian signals.

No pedestrian actuation is present relative to the north crosswalk, as such pedestrian signals are illuminated during the green and the yellow vehicular traffic signal indications of Phases C and D of the signal cycle.

The south "crosswalk" is essentially a bicycle lane crossing, which proceeds from the bicycle lane along the southern portion of the Osborn Drive pavement, west of Wallace Road, and proceeds to join the off-street bicycle path east of Wallace Road. Occasionally, pedestrians use this "crosswalk", as well as an unmarked crosswalk at the west side of the intersection. Eastbound bicycles may actuate Phase D of the traffic signal cycle by using the post-mounted pushbutton detector located adjacent to the roadway paving west of Wallace Road. This phase is also actuated by eastbound vehicles on Osborn Drive and Sixth Street. The movement of eastbound vehicles and bicycles is controlled by the vehicular traffic signals, and no pedestrian signals are present for this south "crosswalk". Westbound bicycles and pedestrians cannot actuate the signal phase, but must wait for the signals to be actuated by vehicular traffic or by eastbound bicycle traffic. A separate traffic signal is located at the southwest corner of the intersection and is primarily for westbound bicycle and occasional pedestrian movements. This signal, with red, yellow and green indications in Phase D, is louvered so that its indications cannot be readily observed by westbound vehicular traffic on Sixth Street, particularly those in the left-turning lane.

It should be noted that the left lane of the east approach of the intersection is signed as a left-turn only lane. During Phase C of the traffic signal cycle, left-turning traffic is controlled by a circular green indication plus a green left-turn arrow and eastbound vehicular and bicycle traffic on Osborn Drive is stopped. Westbound bicycle and pedestrian traffic in the south "crosswalk" also faces a red signal indication. Then, during Phase D of the cycle, the green left-turn arrow indication is darkened, leaving a circular green signal relative to the left-turn lane on the east approach to the intersection. A green indication is simultaneously shown for eastbound traffic, along with a green indication relative to westbound bicycle and pedestrian traffic in the south "crosswalk".

Vehicular turning movements in Phases B, C and D of the signal cycle are in potential conflict with pedestrian and bicycle movements, as such movements are permitted concurrently, as indicated in Figure 2-13. All of these potential conflicts are those ordinarily expected, with the exception of potential vehicle-bicycle conflicts on the west approach. The south nine feet of Osborn Drive west of Wallace Road is used as a right-turn lane for vehicular traffic and as a bicycle lane for eastbound bicycle traffic. Not only is there competition for use of this lane, but there is the potential for accidents between right-turning vehicles and eastbound bicycles.

In addition to the present signalized intersections, there are other studied intersections which have potential for vehicle-pedestrian-bicycle conflicts. Such are noted for the following existing intersections:

Wallace Road and South Richardson Court:

Pedestrian traffic volumes crossing Wallace Road are high, especially at the north crosswalk, where a peak of 218 pedestrians were observed to cross in an hour. Only eastbound vehicular traffic on South Richardson Court is required to stop at this intersection.

Wallace Road and North Richardson Court:

The south crosswalk and the diagonal crosswalk (northwest to southeast) were observed to accommodate 65 and 183 pedestrians per hour respectively at this intersection. The south crosswalk crosses only Wallace Road but the diagonal crosswalk, connecting the northwest and southeast corners of the intersection, crosses both streets within the intersection. Based on the hourly vehicular traffic volumes shown in Figure 2-5 and the hourly pedestrian volumes shown in Figure 2-7, there are currently a possibility of 196,239 vehicle-pedestrian conflicts per hour relative to the five existing crosswalks. The number of conflicts indicated is the summation of the number of vehicles times the number of pedestrians for each crosswalk. If the diagonal crosswalk was not present or used and its pedestrians used the south and west crosswalks instead, there would be a possibility of 230,277 vehicle-pedestrian conflicts per hour, or 17.3 percent more conflicts then the present system of crosswalks. Should the same pedestrians use the east and north crosswalks rather than the existing diagonal crosswalk, there would be 225,153 potential vehicle-pedestrian conflicts per hour, or 14.7 percent more conflicts than the existing layout. More potential vehicle-pedestrian conflicts appear to result if the existing diagonal crosswalk is removed, as many vehicles will cross high volumes of pedestrians at two crosswalks instead of once as for the existing diagonal crosswalk.

Intersection Capacity Analysis and Levels of Service

After design hourly volumes were determined, each intersection was analyzed relative to its capacity and level of service. Included in this analysis were the respective traffic volumes (vehicular, pedestrian and bicycle), amount of turning traffic, percentage of trucks, pavement width, lane arrangements, parking conditions, and existing traffic signal timing, with each intersection approach being considered separately.

The level of service is an index for rating the operational characteristics of an intersection or roadway. Such characteristics include 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. The table in Figure 2-14 indicates the characteristics of each respective level of service.

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 lane 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.

Fig. 2-14. Levels of Service Characteristics.

Levels of service, as determined for each of the eleven intersections, are tabulated in Figure 2-15. The levels indicated pertain to the design hourly traffic volumes for the respective intersections, and thus are representative of operating conditions during the thirtieth highest hourly traffic volumes of the year. Everyday traffic volumes during most hours of the year are, in varying degrees, lower than the design hourly volumes. As a result, during most hours of the year, the level of service of these intersections will be higher than indicated in Figure 2-15.

Highway and street facilities are normally designed to operate at a level of service "C" when considering design hourly traffic volumes. Consequently, an intersection which experiences a level of service D, E or F on any approach is considered deficient in either design, or operation, or both.

As shown in Figure 2-15, the level of service at the following intersections is below level "C":

Stange Road and Pammel Drive; north, east and west approaches

Bissell Road and Pammel Drive; east approach

Wallace Road and Osborn Drive-Sixth Street; north, south, and east approaches

The remaining eight intersections studied operate at satisfactory levels of service, when considering existing traffic volumes and other factors.

Intersection	Approach To Intersection	Level Of Service		
		Right Turn	Left Turn	Through
Stange Road & Thirteenth Street	N S E	- B C	A - C	A B -
Stange Road & South Drive-East Road	N S E W	A A A A	A A A A	A A A A
Stange Road & Pammel Drive	N S E W	F A F A	E A F D	E A F A
Bissell Road & Pammel Drive	S E W	C - C	A D -	- A C
Bissell Road & Union Drive	N S E W	C A A A	A A A C	A A A A
Wallace Road & Union Drive	N S E	- A C	C - C	A A -
Wallace Road & N. Richardson Court	N S E	A A A	A A A	A A A
Wallace Road & S. Richardson Court	N S W	- A A	A - A	A A A
Wallace Road & Osborn Drive-Sixth Street	N S E W	F F F A	F F F A	F F F A
Sixth Street & Physical Plant Entrance	S E W	A - A	A A -	- A A
Sixth Street & Haber Road	N E W	A A -	A - A	- A A

Fig. 2-15. Existing Levels of Service

SPEED LIMITS

According to the "Traffic and Parking Regulations" of Iowa State University, "the maximum speed limit on all campus drives, roads, and streets is 25 m.p.h. unless otherwise posted". No signs allowing speeds in excess of 25 miles per hour (m.p.h.) were observed on any of the streets in the campus area. However, a posted speed limit of 15 m.p.h. was observed in the parking area between Friley Hall and Helser Hall. Speed limits on South Drive and East Road are posted at 10 m.p.h. in the married-student housing areas.

As part of this project, a speed study was conducted on a portion of Sixth Street in the vicinity of Iowa State University. Speeds were observed through the use of radar equipment mounted in an unmarked vehicle. Efforts were made to choose inconspicuous observation points in order to avoid any effect on normal driving patterns in the area.

Data was collected at two points on Sixth Street, one being near its intersection with Haber Road, and the other being approximately 800 feet east of the same intersection. Speeds for vehicles traveling in each direction were recorded separately, with a sufficient number of readings taken to assure the validity of the results. The speeds observed represent the conditions for morning traffic (10:00 to 12:00 A.M.) during the summer of 1975.

The cumulative speed distribution curves for each of the observed locations are shown in Figure 2-16. These curves represent the percentage of the total vehicles observed that were traveling at or below the indicated speeds.

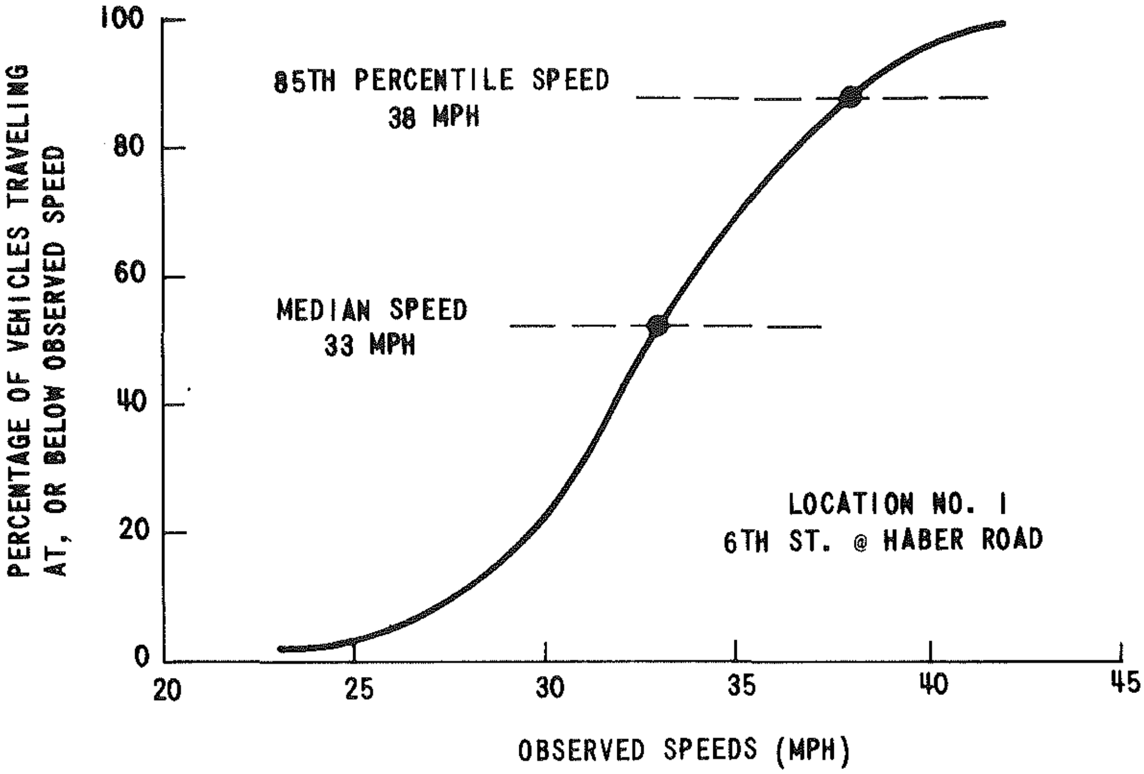
Figure 2-17 is a tabulation of the various categories of speeds at the two aforementioned locations. The minimum and maximum observed speeds, along with the range of speeds, are indicated for traffic in each direction and for total traffic in both directions at each location. Some of the categories found in this table are explained as follows:

The "average speed" is equal to the arithmetic mean, 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 will 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 28.8 m.p.h. and 37.2 m.p.h.

The "median speed" is that speed which is exceeded by 50 percent of the vehicles. Median speeds are shown in Figure 2-16 and are also tabulated in Figure 2-17.

The "eighty-fifth percentile speed", as shown in Figures 2-16 and 2-17, is the speed at or below which 85 percent of the vehicles travel and is sometimes referred to as the critical speed. 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.



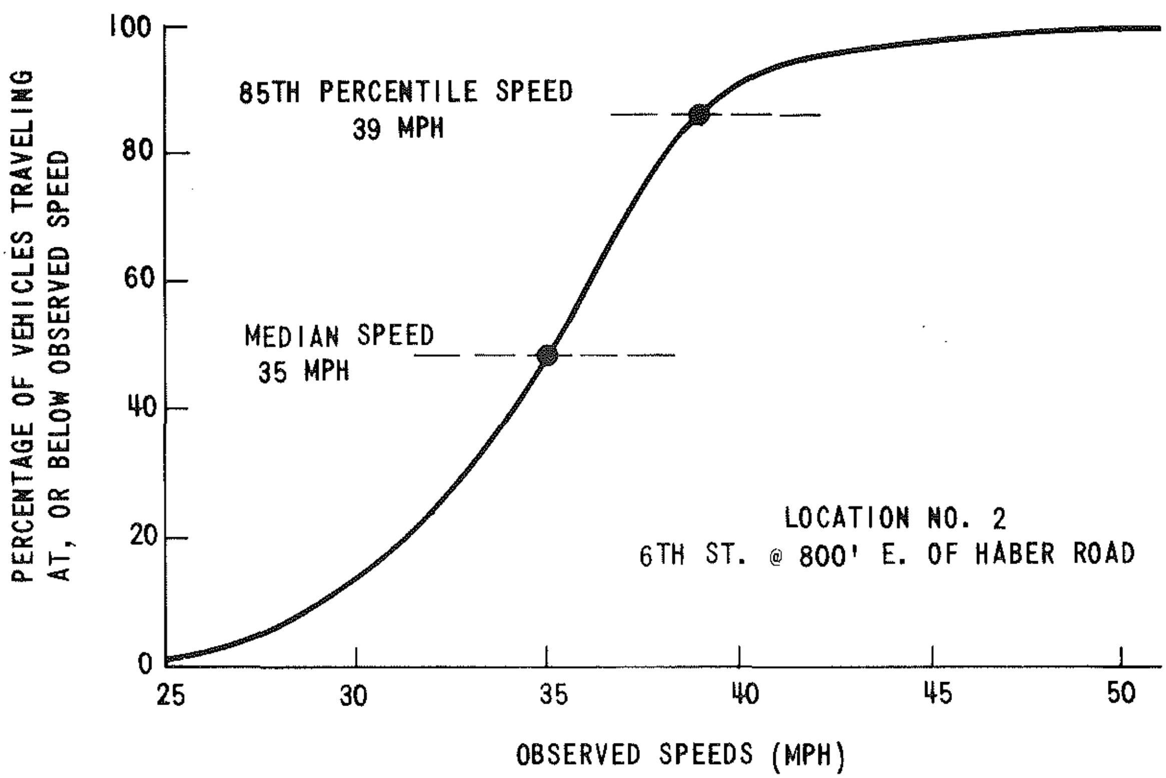


Fig. 2-16. Speed Distribution Curves Relative to Speed Studies.

A comparison of the two locations studied indicates that the traffic at Location No. 2 was traveling, on the average, about two miles per hour faster than traffic at Location No. 1. There was no significant difference between the speeds of eastbound and westbound traffic at either of the observed locations. A wider variation in speeds was observed at Location No. 2 with speeds ranging from 25 m.p.h. to 51 m.p.h. Less than 3 percent of the observed vehicles were traveling at or below the posted speed limit of 25 m.p.h., while 51 percent of the same vehicles were traveling 10 m.p.h. or more in excess of the speed limit.

Several factors must be considered in the establishment of a speed limit on any street, including the prevailing vehicle speeds, the physical features of the roadway, the accident experience of the street in question, the characteristics of the traffic and traffic control. Considering only the existing running speeds, a speed limit of 35 m.p.h. would be appropriate for the section of Sixth Street which was studied. This result includes consideration of the average speed, the 85th percentile speed, and the range of speeds in which the greatest number of vehicles were observed.

The acceptable speed limit on Sixth Street will also be influenced by the design of the roadway itself. The horizontal curves on either side of the railroad underpass have a radius of approximately 350 feet, which is only suitable for speeds between 30 and 35 m.p.h. In addition, a bicycle path is located on the south side of the street, with approximately 2½ feet of clearance between the edges of the street and the bicycle lane. These two features, individually and in combination, could increase the accident potential on Sixth Street if running speeds are increased excessively. The detailed study of traffic accidents, however, is beyond the scope of this report.

The traffic characteristics on Sixth Street including traffic volumes, turning movements, and vehicular-pedestrian conflicts, should not limit the acceptable speed for sections east of Haber Road. The presence of traffic signals at Wallace Road and the heavy turning movements at that intersection, however, will influence the running speeds on Sixth Street west of Haber Road.

Location Number	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% Speed	Recommended Speed
1	Sixth Street At Haber Road	25	23	42	19	33	4.2	33	38	30
	Eastbound Traffic		27	40	13	34	3.6	33	38	
	Westbound Traffic		23	42	19	33	4.8	33	38	
2	On Sixth Street, 800' East Of Haber Road	25	25	51	26	35	4.6	35	39	30
	Eastbound Traffic		26	47	21	35	4.2	35	39	
	Westbound Traffic		25	51	26	36	5.1	36	40	

Fig. 2-17. Tabulation of Speed Data Resulting From Speed Studies

Considering all the above factors, it is recommended that the speed limit on Sixth Street be increased to 30 m.p.h. for the section east of Haber Road, and that the speed limit remain at 25 m.p.h. west of the Haber Road intersection. Law enforcement efforts in this area should be directed toward the reduction of excessive driving speeds.

SUMMARY

This chapter has essentially included presentation of data relative to existing traffic conditions. Subject areas included herein included existing traffic circulation patterns and controls, intersection characteristics, traffic volume (including vehicular, pedestrian and bicycle), traffic control devices (including signs, markings and traffic signals), pedestrian-bicycle-vehicle conflicts, intersection capacity analysis, levels of service and speed limits. Some recommendations were made within such chapter relative to only certain subject areas. Subsequent chapters of this report will include other factors to be considered and will contain most of the recommendations that will be made as part of this study.

CHAPTER 3
FUTURE DEVELOPMENTS

SCOPE

Several contemplated developments on or near the campus of Iowa State University will affect traffic movements on now existing roadways and intersections. The purpose of this chapter is to outline such future developments and determine their effects on the existing traffic patterns and movements. Preliminary traffic projections for the year 1995 will also be analyzed relative to their effects on traffic on or in the vicinity of the Iowa State University campus.

PROPOSED ROADWAY EXTENSIONS

Based on previous and current campus planning and the Ames transportation system planning, several existing streets or roadways are anticipated to be extended. In addition, portions of certain existing streets may be closed to through traffic as part of other developments. Each planned extension or closure will hereinafter be described and analyzed according to its effect upon existing roadway elements of the future street network.

Current Transportation Planning Alternates

The Ames metropolitan area is presently being analyzed relative to various alternate transportation networks in its transportation planning process. Preliminary traffic volumes have been made available to the Consultant for use in this study. Such information included hereinafter should be regarded as preliminary and subject to revision subsequent to additional analysis as part of the transportation planning process. The data is useful, however, in showing the relative effects of the various alternates on traffic movements. Traffic assignments have been provided to the Consultant for the following networks:

Existing Plus Committed Network.

The existing plus committed transportation network includes existing streets and the extension of Thirteenth Street from its present intersection with Stange Road westerly to the vicinity of the present intersection of Ontario Street and Hyland Avenue. The resulting preliminary daily traffic volumes, projected for the year 1995, are indicated in Figure 3-1.

Alternate A - 1995 Network.

Alternate A, in addition to the roadway elements present in the existing plus committed network, includes the following in the vicinity of the Iowa State University campus:

1. Extension of Elwood Drive northerly from Lincoln Way to Top-O-Hollow Road.

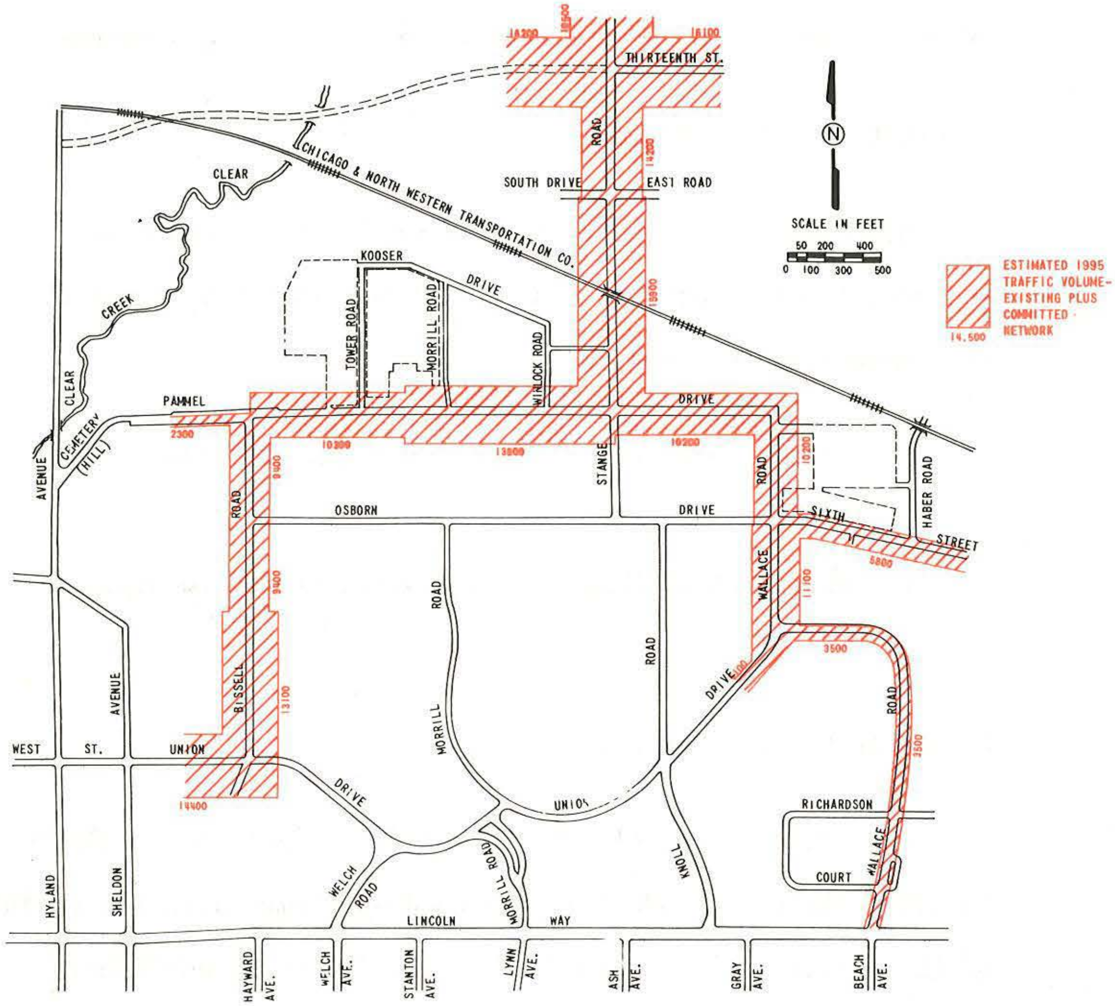


Fig. 3-1. Preliminary 1995 Average Daily Traffic Volumes for Existing Plus Committed Transportation Network.

2. Sheldon Avenue extended north to Pammel Drive.

3. Closure of Cemetery Hill on Pammel Drive.

Traffic volumes are indicated in Figure 3-2 for this network.

Alternate B - 1995 Network.

Alternate B, in addition to elements of Alternate A, includes the following roadway extensions in the vicinity of the campus; as is shown in Figure 3-3:

1. Extension of Bissell Road from Pammel Drive to Kooser Drive.
2. Extension of Pammel Drive southeasterly to Sixth Street.

Alternate C - 1995 Network.

The traffic projections indicated in Figure 3-4, relative to Alternate C, include the same roadway elements in the vicinity of the campus as Alternate B, with the following addition:

1. Extension of Bissell Road from Kooser Drive to Thirteenth Street extended.

Campus Planning

In addition to the aforementioned Ames transportation planning, the contemplated construction of the Design Center on the west side

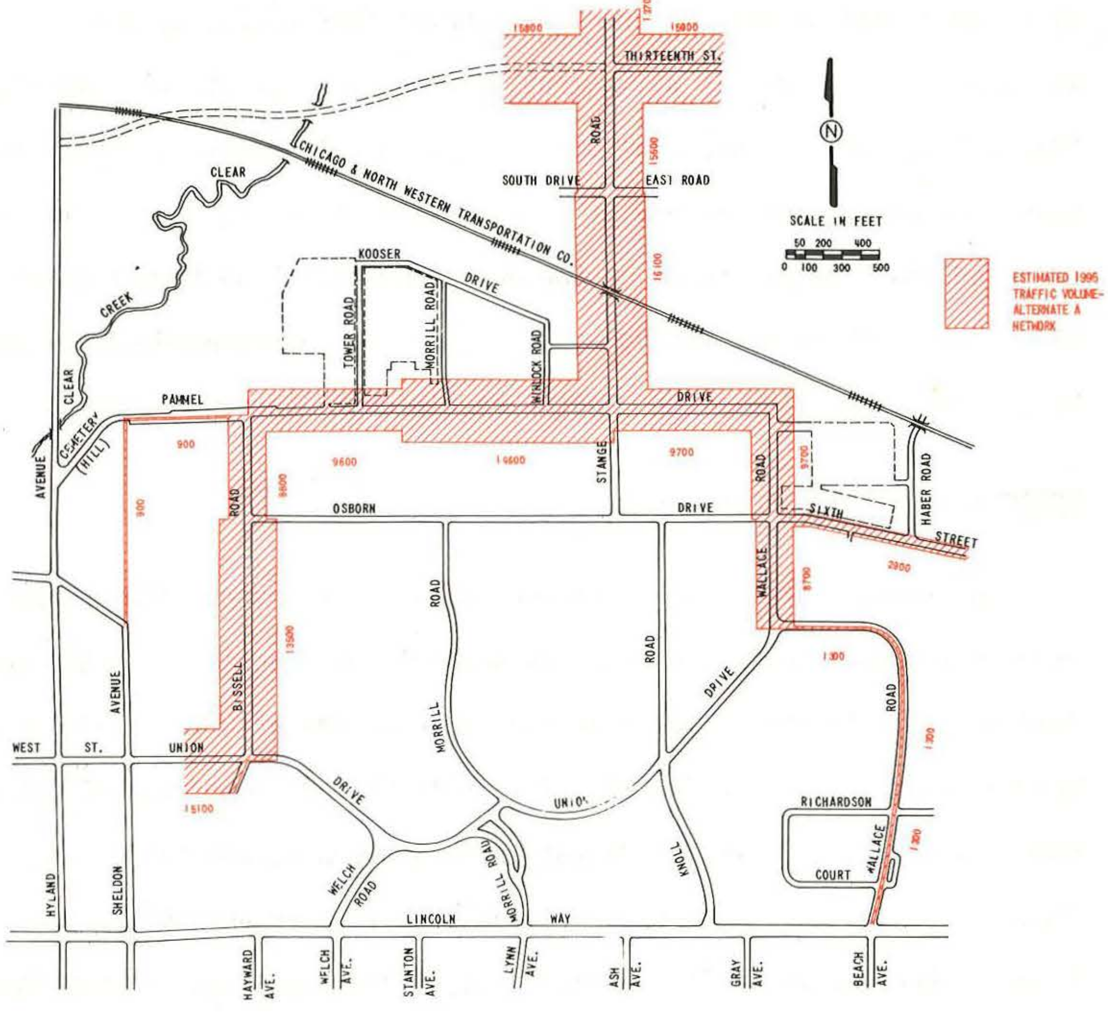


Fig. 3-2. Preliminary 1995 Average Daily Traffic Volumes for Transportation Network Alternate A.

of Bissell Road in the vicinity of Osborn Drive may cause the closure of Bissell Road between Osborn Drive and Marston Court, at least to through travel. Traffic assignments made as part of the aforementioned Ames metropolitan transportation planning do not, however, appear to have considered such closure of this portion of Bissell Road. It is expected that the extension of Sheldon Avenue north to Pammel Drive will carry much of the through-type traffic now associated with Bissell Road should a portion of the latter be closed to through traffic.

Extension of Thirteenth Street

Thirteenth Street, as an element of local transportation planning is proposed to be extended from its present intersection with Stange Road westerly to the vicinity of the intersection of Ontario Street and Hyland Avenue. This roadway facility will have an immediate effect of reducing traffic volumes on Pammel Drive between Hyland Avenue and Stange Road and on Stange Road between Pammel Drive and Thirteenth Street. Currently, traffic originating at and traveling between the northwest and northeast quadrants of the City of Ames travel between the two termini via the Hyland Avenue-Pammel Drive-Stange Road route.

The traffic volumes shown in Figure 3-1 indicate that approximately 16,200 vehicles per day will use this Thirteenth Street extension in 1995, if only Thirteenth Street is extended. Traffic on Pammel Drive will experience a decrease in traffic volumes for this network, when compared with existing traffic volumes previously indicated in Figure 2-6.

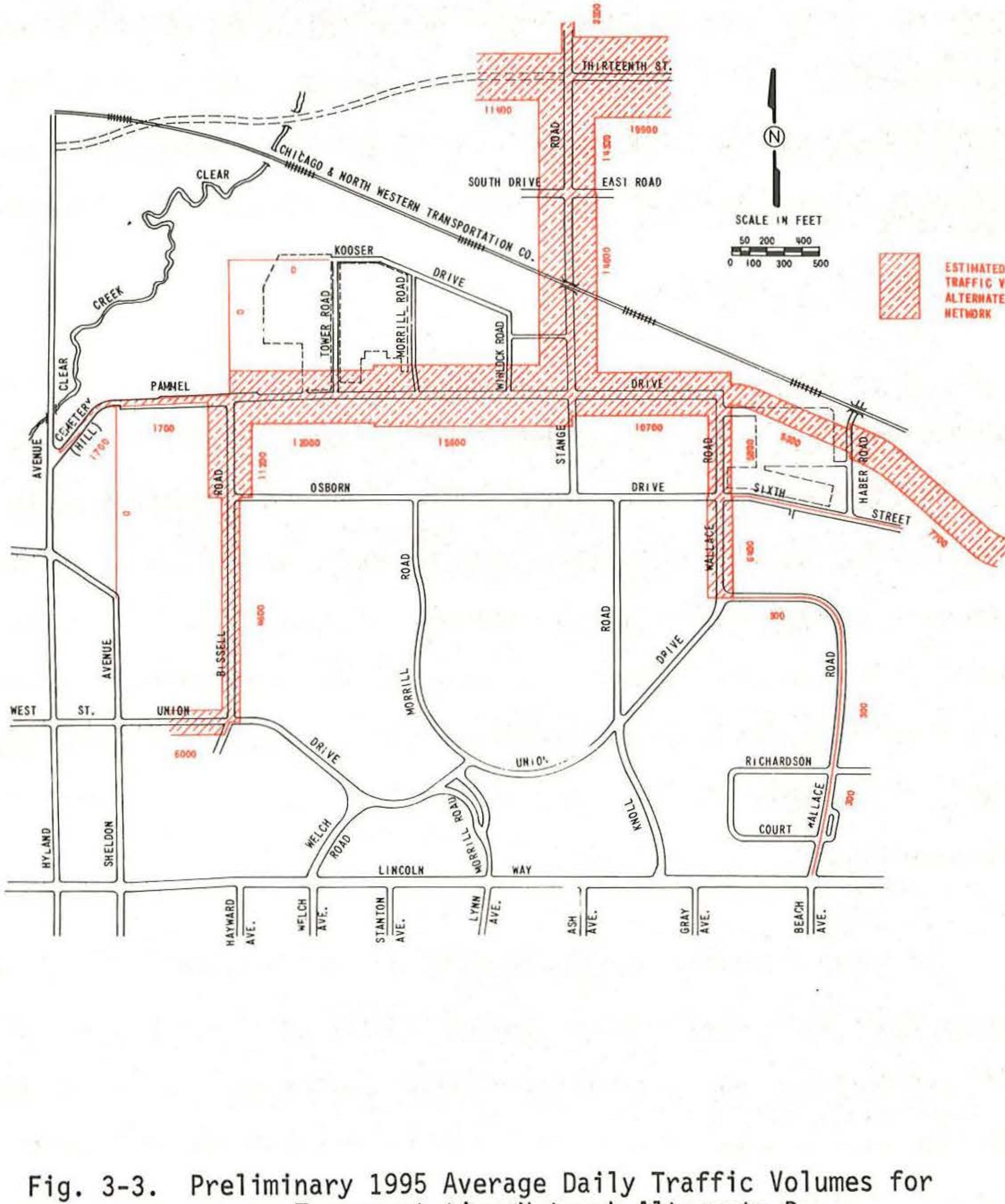


Fig. 3-3. Preliminary 1995 Average Daily Traffic Volumes for Transportation Network Alternate B.

Relative to Alternate Networks A, B and C, traffic volumes on Pammel Drive are expected to generally increase for Alternates A and B and to decrease for Alternate C, when compared with the existing plus committed network. It appears that traffic on Stange Road will generally increase for Alternate A and will decrease for Alternates B and C. The effect of these future street extensions will be to generally reduce traffic volume problems at the Pammel Drive intersections of Stange Road and Bissell Road.

Extension of Bissell Road

The extension of Bissell Road was initially considered as being from Pammel Drive to Thirteenth Street in prior campus planning. Such a facility, included in Alternate C, Figure 3-4, and further shown in Figure 3-5, would serve to extend the perimeter of the campus and would provide improved traffic service between the present campus and the northwestern portion of Ames. In addition, this connection would attract a considerable amount of the traffic presently using Pammel Drive and Stange Road, thus reducing congestion on both streets and at their common intersection.

Although a connection from Pammel Drive to Thirteenth Street appears to be desirable from the standpoint of traffic service, the construction of such a street may be extremely difficult and costly, primarily that portion between a westerly extension of Kooser Drive and Thirteenth Street. The existing topography within the corridor of such a route varies in elevation by approximately 40 to 60 feet, depending on the alignment, and includes a crossing of the Chicago and North Western Transportation Company trackage.

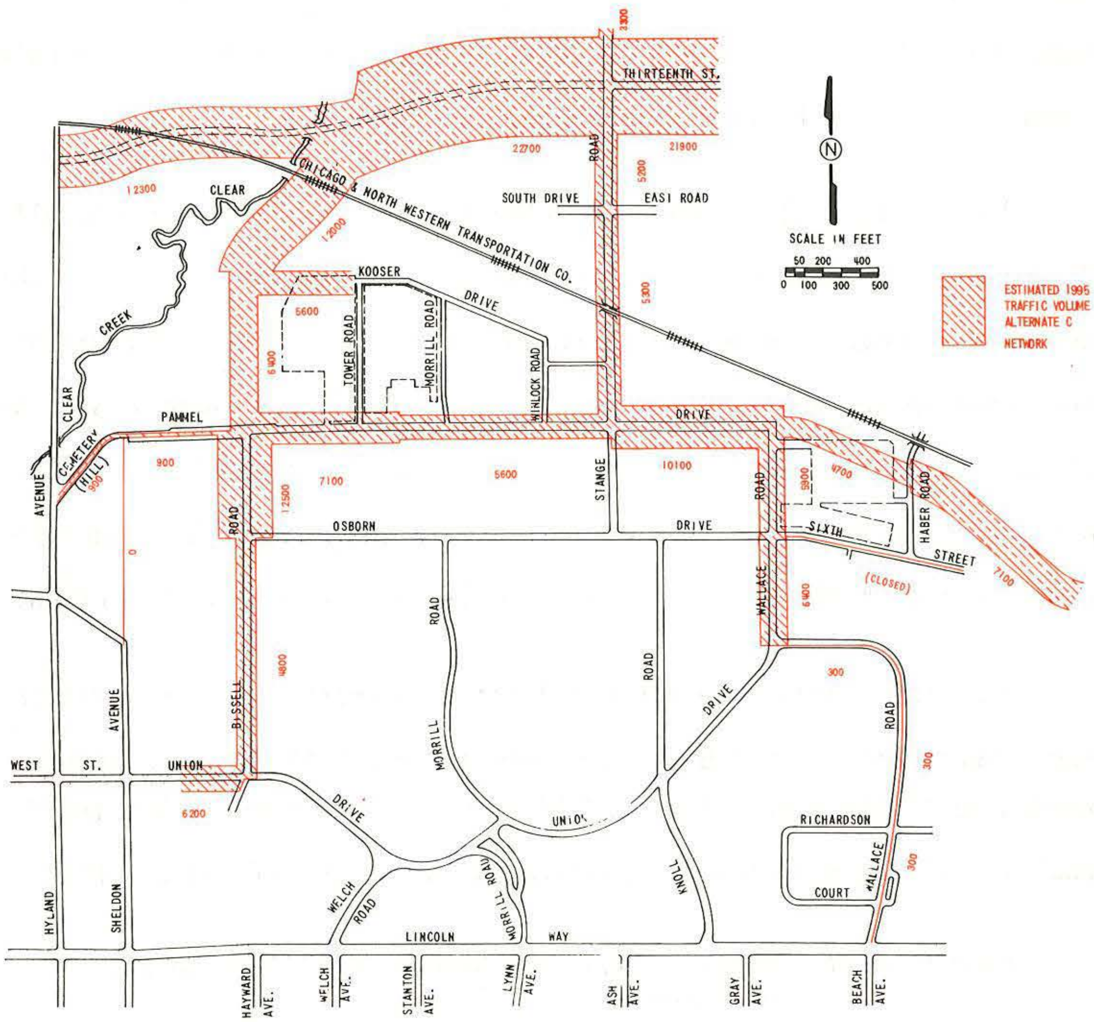


Fig. 3-4. Preliminary 1995 Average Daily Traffic Volumes for Transportation Network Alternate C.

As an alternate or first-stage solution, an extension of Bissell Road from Pammel Drive to a westerly extension of Kooser Drive was examined. This facility was included in the aforementioned Alternate B, Figure 3-3 and is further illustrated in Figure 3-5.

A capacity analysis was conducted for the resulting new Bissell Road-Pammel Drive intersection to determine the volume of traffic which could be accommodated on the north approach. Existing street widths were used in the analysis for the east, west and south approaches, and it was assumed that the existing bike lane would be removed from the north edge of Pammel Drive. A bike lane in the roadway would not be compatible with the traffic volumes projected for this intersection.

Traffic volumes were estimated for each traffic movement within the intersection, based on data obtained through the traffic counts conducted in the area. Two conditions were considered in the traffic analysis of the new street, relative to the status of Bissell Road:

Condition I: Bissell Road open between Pammel Drive and Union Drive.

Condition II: Bissell Road closed to through traffic south of Pammel Drive.

The estimated hourly traffic volumes for each of these conditions, as well as existing traffic volumes, are indicated in Figure 3-6. The existing condition represents the existing design hourly traffic volumes at the intersection. The traffic data shown for Condition I and Condition II represent the maximum traffic volumes that can be added to

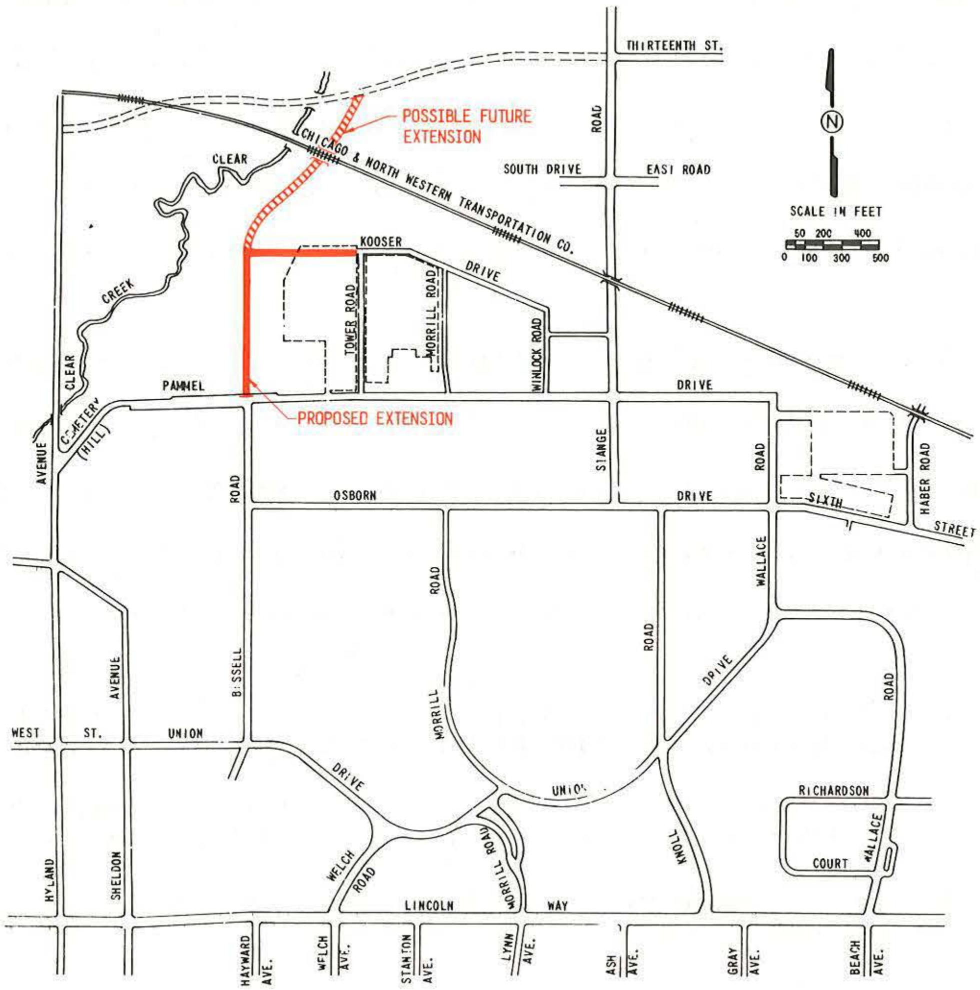


Fig. 3-5. Proposed Bissell Road Extension.

the north approach, without widening of Pammel Drive. As shown in Figure 3-6, approximately 600 vehicles per hour can be accommodated on the north approach at a level of service "C", regardless of whether Bissell Road is closed southerly of Pammel Drive. The estimated design hourly volumes indicated in Figure 3-6 are generally higher for this intersection than are the hourly volumes for Alternates A, B or C previously noted, the latter being projections for 1995 traffic conditions.

As discussed previously in Chapter 2, the existing intersection of Bissell Road and Pammel Drive operates at a low level of service, due primarily to the heavy left-turning movement from the east approach onto Bissell Road. The number of such left-turning vehicles is expected to decrease relative to each of the following improvements (See Figure 3-6):

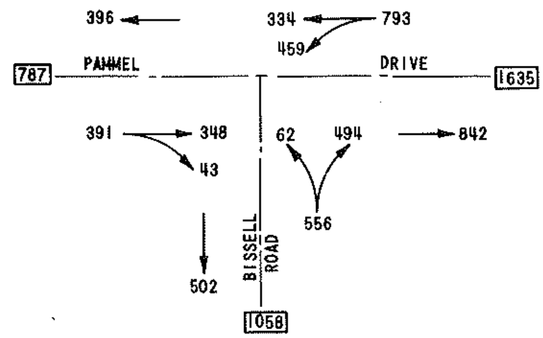
1. The northerly extension of Bissell Road to intersect with the westerly extension of Kooser Drive.

   Some of the traffic from parking lots north of Pammel Drive is expected to use Bissell Road north of Pammel Drive.

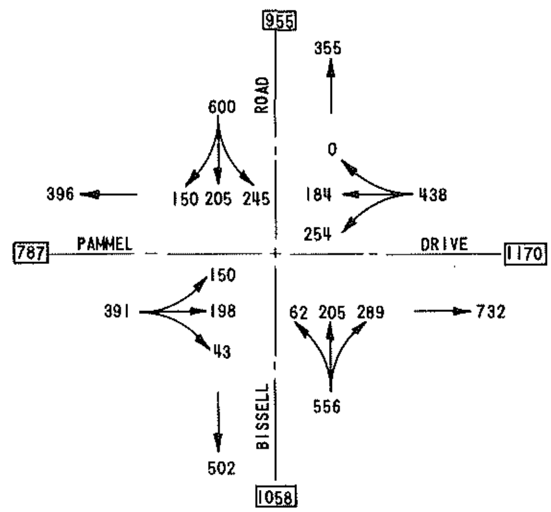
2. The closure of Bissell Road to through traffic to the south of Pammel Drive.

   Traffic from the east approach, other than that destined for central campus, will have no reason to turn left onto Bissell Road.

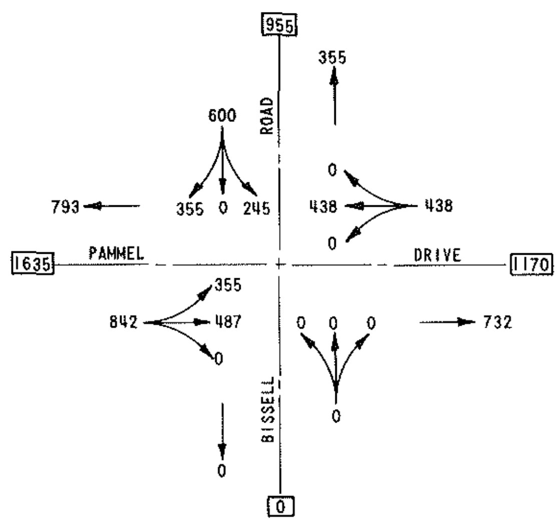
Another benefit of a westerly extension of Kooser Drive and a northerly extension of Bissell Road is the reduction of traffic volumes on Pammel Drive east of Bissell Road. This reduction of traffic, due to parking lot access to and from Bissell Road extended, will provide for safer movements of pedestrian, bicycle and vehicular traffic on Pammel Drive.



EXISTING TRAFFIC



TRAFFIC WITH BISSELL ROAD EXTENSION. CONDITION I



TRAFFIC WITH BISSELL ROAD EXTENSION. CONDITION II

Fig. 3-6. Estimated Hourly Traffic Volumes on Proposed Bissell Road Extension.

Additional comments relative to the parking lots north of Pammel Drive will be made in later portions of this report.

It is recommended that Bissell Road be extended to the aforementioned westerly extension of Kooser Drive as the first stage of improvements. It is also recommended that a detailed investigation be made to determine the feasibility of extending Bissell Road further north to intersect with Thirteenth Street.

Extension of Sheldon Avenue

Another element of current transportation planning is the northerly extension of Sheldon Avenue from the curve north of West Street-Union Drive to Pammel Drive. This street would pass between the existing parking lot and athletic fields on the west edge of the campus, as indicated in Figure 3-7.

The major function of this proposed extension is to accommodate traffic displaced by the future possible closing of Bissell Road to through traffic, as was indicated earlier in the report. A major portion of the traffic now using Bissell Road would be transferred to this new outer perimeter campus road.

Traffic volume projections for this roadway, in Alternates A, B and C appear to be based on Bissell Road remaining open from Union Drive to Pammel Drive and the closing of Cemetery Hill on Pammel Drive. Such traffic volumes on the proposed extension of Sheldon Avenue do not include that traffic that would normally be associated with Bissell Road but only that traffic for Cemetery Hill.

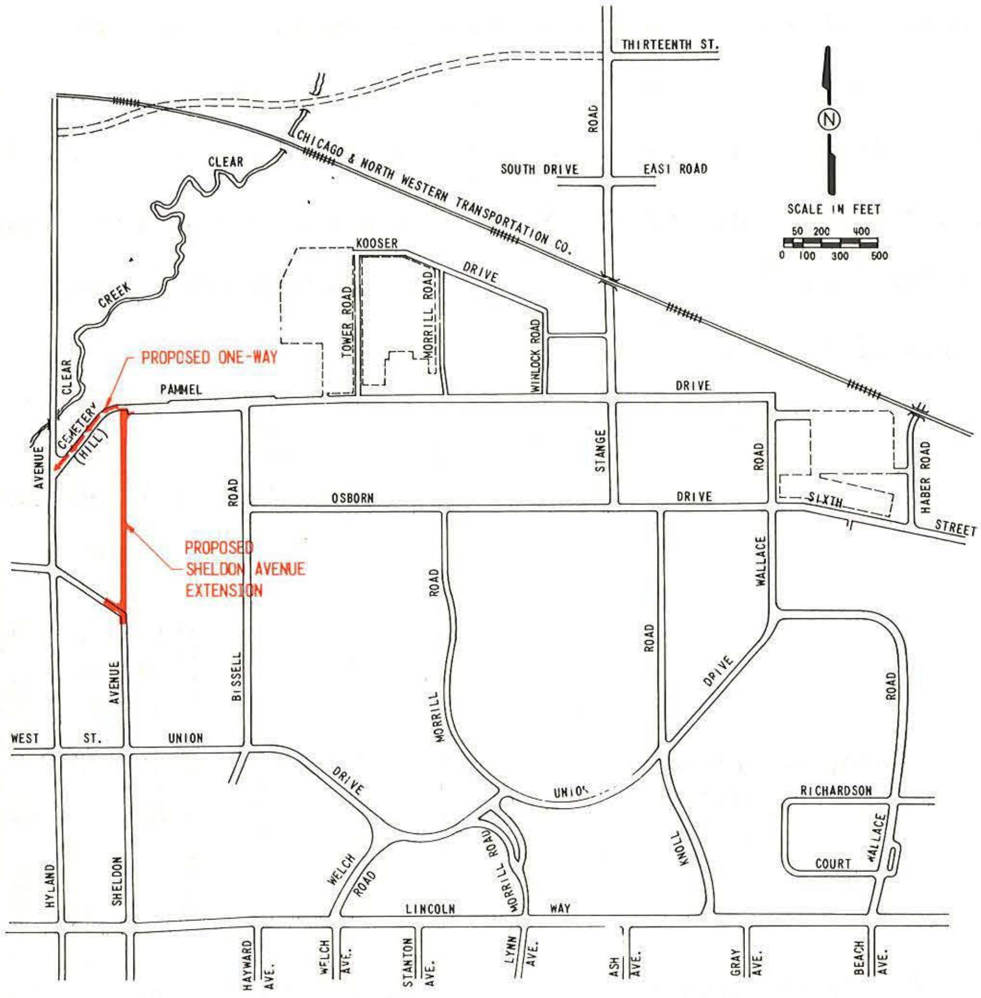


Fig. 3-7. Proposed Sheldon Avenue Extension.

Traffic counts at intersections west of Bissell Road are beyond the range of this study, and thus no data is presented relative to existing traffic volumes in the vicinity of Sheldon Avenue. The effects of the proposed extension on traffic, however, can be described in terms of travel distance. Figure 3-8 indicates the travel distance between the Bissell Road-Pammel Drive intersection and various other intersections, both for existing conditions and with the proposed street extension.

Point of Origin (Intersection)	Travel Distance To Pammel-Bissell Intersection (Feet)		
	Existing Streets	With New Connection (Cemetery Hill Open)	With New Connection (Cemetery Hill Closed)
West Street & Hyland Avenue	2,690	2,690	2,870
West Street & Sheldon Avenue	2,500	2,500	2,500
Sheldon Avenue & Parking Lot Entrance (south end of new connection)	2,150	1,770	1,770
Sheldon Avenue & Hyland Avenue	1,700	1,700	2,220
Hyland Avenue & Cemetery Hill	1,200	1,200	2,720

Fig. 3-8. Travel Distance Comparisons Relative to Proposed Sheldon Avenue Extension

As evidenced by data in Figure 3-8, the effect of the proposed extension of Sheldon Avenue to Pammel Drive relative to travel distance is minimal, assuming that Cemetery Hill on Pammel Drive remains open to traffic. In this case, only traffic originating on Sheldon Avenue north of West Street would benefit from reduced travel distances, while traffic originating at other points would be unaffected relative to travel distances. On the other hand, the closure of Cemetery Hill would significantly increase travel distances for much of the traffic. Most notably, the travel distance between the northwest sector of Ames and the Iowa State University campus would be increased by 1,520 feet over existing conditions.

Considering its effect on travel distances, Cemetery Hill serves as an important link between the campus and parts of the City of Ames. However, operational problems can be expected on Cemetery Hill if Sheldon Avenue is extended to Pammel Drive.

The existing grade on Cemetery Hill between Hyland Avenue and the proposed extension is approximately 12 percent. Eastbound traffic on the Cemetery Hill portion of Pammel Drive would experience difficulties during winter driving conditions, especially if such traffic was required to stop at the proposed intersection of Sheldon Avenue. Since the proposed extension is expected to carry traffic volumes similar to those now traveling on Bissell Road, signalization might be required at its intersection with Pammel Drive, and eastbound traffic on Cemetery Hill would therefore be required to stop at times. Resumption of speed on a 12 percent grade is difficult or impossible during snowy or icy road conditions.

In addition to the operational difficulties, the sight distance at the intersection of Pammel Drive and the extension of Sheldon Avenue will be restricted, and will cause visibility problems if Cemetery Hill remains open to eastbound traffic. Due to the 12 percent grade and horizontal curvature of Cemetery Hill, northbound traffic on Sheldon Avenue extended would be unable to see approaching traffic from the west, resulting in a hazardous situation at the intersection.

Since it is not feasible to reconstruct the existing streets and eliminate the above problems, it is recommended that eastbound traffic not be permitted on the Cemetery Hill portion of Pammel Drive after the Sheldon Avenue extension is built. The section of Cemetery Hill between this extension and Hyland Avenue is recommended to be one-way westbound.

Traffic which presently uses Pammel Drive as an inbound route to the campus from the west will be required to use other streets by the above recommendation. The shortest alternate route for this traffic would be south on Hyland Avenue, then southeast on Sheldon Avenue and thence north on the proposed Sheldon Avenue extension. As a result, increased traffic can be expected along this route if Cemetery Hill becomes one-way westbound. Some reconstruction will be required at the south end of the proposed extension, to alleviate the acute-angled turning movements between the aforesaid extension and existing Sheldon Avenue to the northwest.

Pammel Drive - Sixth Street Connection

Previous campus planning and present transportation planning includes a proposed Pammel Drive-Sixth Street connection. This connection proceeds generally southeasterly from the intersection of Pammel Drive and Wallace Road and intersects with existing Sixth Street easterly of Haber Road. Alternates B and C of the Ames transportation planning networks include this connection. (See Figures 3-3 and 3-4.)

Traffic assignments were also made for this new street connection, based on existing traffic volumes at adjacent intersections. These assignments represent the estimated design hourly traffic volumes which may utilize the new connection. Different traffic volumes can be expected to use the new street, depending on whether Sixth Street between Wallace Road and the new street remains open or is closed. As a result, two separate traffic conditions were analyzed relative to the new connection:

Condition I: Sixth Street closed east of Wallace Road.

Condition II: Sixth Street open east of Wallace Road and connected to the new street.

Design hourly traffic volumes in both directions on the new street are estimated at 1,044 vehicles per hour for Condition I, and 580 vehicles per hour under Condition II. A further breakdown of the traffic volumes is shown in Figure 3-9.

Several observations are noted concerning the previous estimated traffic volumes.

The introduction of a new connection between Pammel Drive and Sixth Street will significantly reduce the volume of traffic passing through the Wallace Road and Osborn Drive-Sixth Street intersection. Existing traffic volumes entering this intersection total 1,974 vehicles per hour. With the addition of the new connection, this volume will be reduced to approximately 1,359 vehicles per hour under Condition I, and to 1,394 vehicles per hour under Condition II.

The construction of the new street under either Condition I or Condition II will relieve the existing traffic congestion at the Wallace Road and Osborn Drive-Sixth Street intersection. Existing street widths at this intersection are adequate to accommodate the reduced traffic volumes at a level of service "C". Changes in the signalization and pavement markings would be required to facilitate the new traffic patterns, however.

The closing of Sixth Street east of Wallace Road, as considered under Condition I, would have varying effects on traffic operations in the area. Traffic movement along the proposed new street would be improved with a closure of Sixth Street, due to the removal of turning

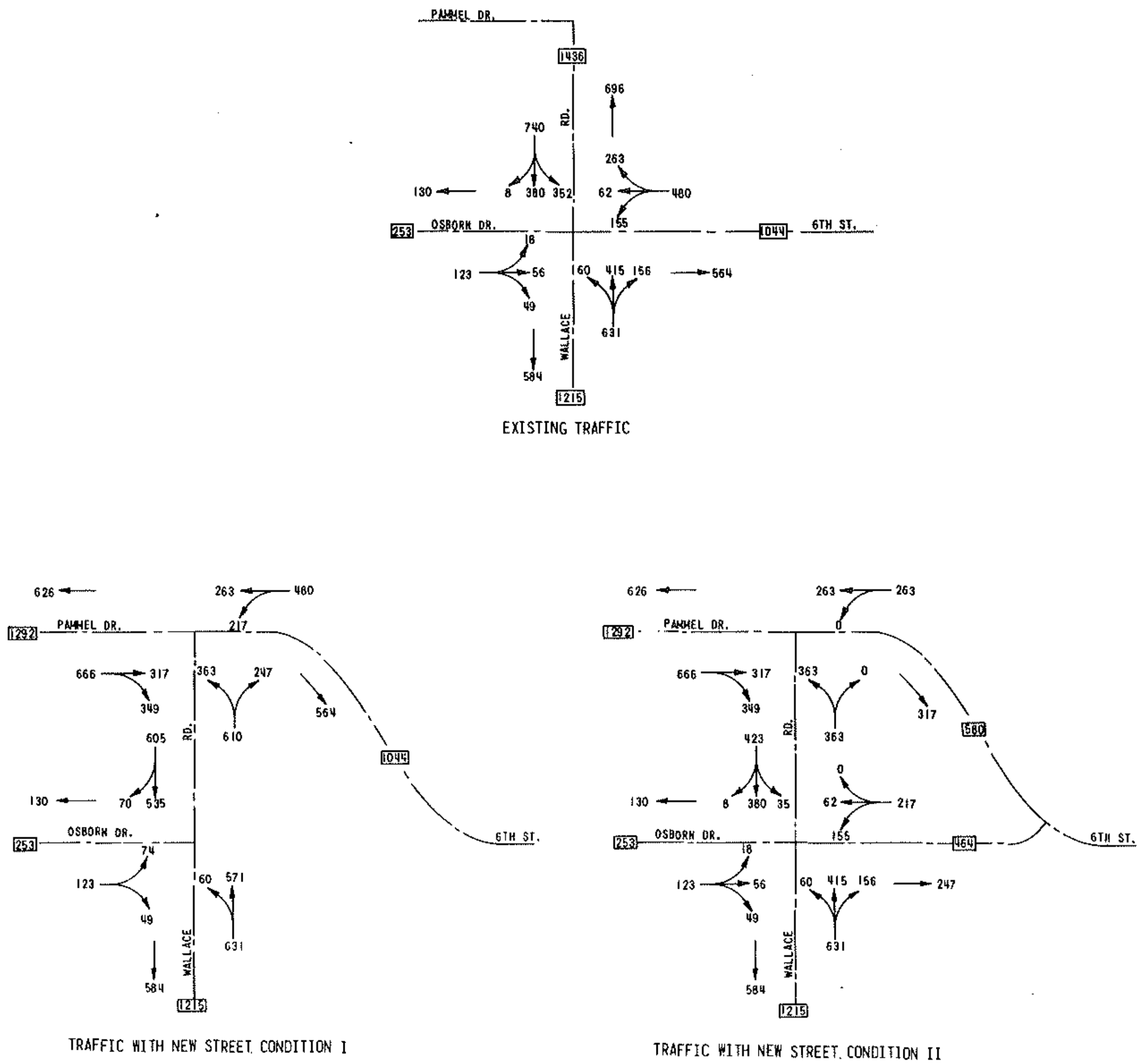


Fig. 3-9. Estimated Hourly Traffic Volumes on Proposed Pammel Drive-Sixth Street Connection.

movements to and from Sixth Street. Any traffic moving between Pammel Drive and Sixth Street would benefit from the reduced delays associated with this condition. Traffic moving between Sixth Street and Wallace Road to the south, however, would be subjected to increased travel distance, travel time and delay caused by the more circuitous route. The existing traffic volume so affected is approximately equal to 3,900 vehicles per day.

Closure of Sixth Street would also induce higher traffic volumes, and especially a higher left-turning movement from the east, at the intersection of Wallace Road and Pammel Drive. The design hourly traffic volume entering this intersection is estimated at 1,756 vehicles per hour if Sixth Street is closed, and 1,292 vehicles per hour if Sixth Street remains open. The higher traffic volumes would represent an increase in delays and a lower level of service at that intersection if Sixth Street were closed.

In consideration of the above, it is recommended that the new connection between Pammel Drive and Sixth Street be constructed, and that Sixth Street remain open between Wallace Road and the new connection. This combination will result in improved traffic operations along Wallace Road, and will reduce travel time and delays for the majority of traffic.

Several locations are feasible for a connection between Pammel Drive and Sixth Street, two of which are shown in Figure 3-10. The first alignment shown passes diagonally through a parking lot and intersects Sixth Street in the vicinity of Haber Road, while the second alignment generally parallels the Chicago and North Western Transportation Company trackage and connects with Sixth Street near the present railroad underpass. Although traffic volumes will be approximately the same for these two alignments, each will have different design and operating characteristics.

The first alignment, while shorter in length than the second, will eliminate a larger portion of the existing parking lot. An estimated 110 parking spaces will be eliminated due to Alignment No. 1, while Alignment No. 2 will eliminate approximately 60 existing parking spaces. In addition, Alignment No. 1 will bisect the parking lot, requiring additional entrances to be provided for the northeast portion of the parking lot. By connecting with Sixth Street near Haber Road, the first alignment contains one less intersection while serving the same traffic needs as Alignment No. 2. An intersection in the vicinity of Haber Road and Sixth Street, however, would pass through an existing landscaped area and require removal of several trees.

The second alignment shown is more northerly and will enclose a greater area within the Iowa State University campus. In this respect, it better serves the function of a perimeter road around the campus than does the first alignment. Alignment No. 2 also is less disruptive to the existing parking lot and will not cause parking to be located to the north of the new street. With the parking lot enclosed within the campus by the perimeter road, fewer pedestrian crossings of the road can be expected.

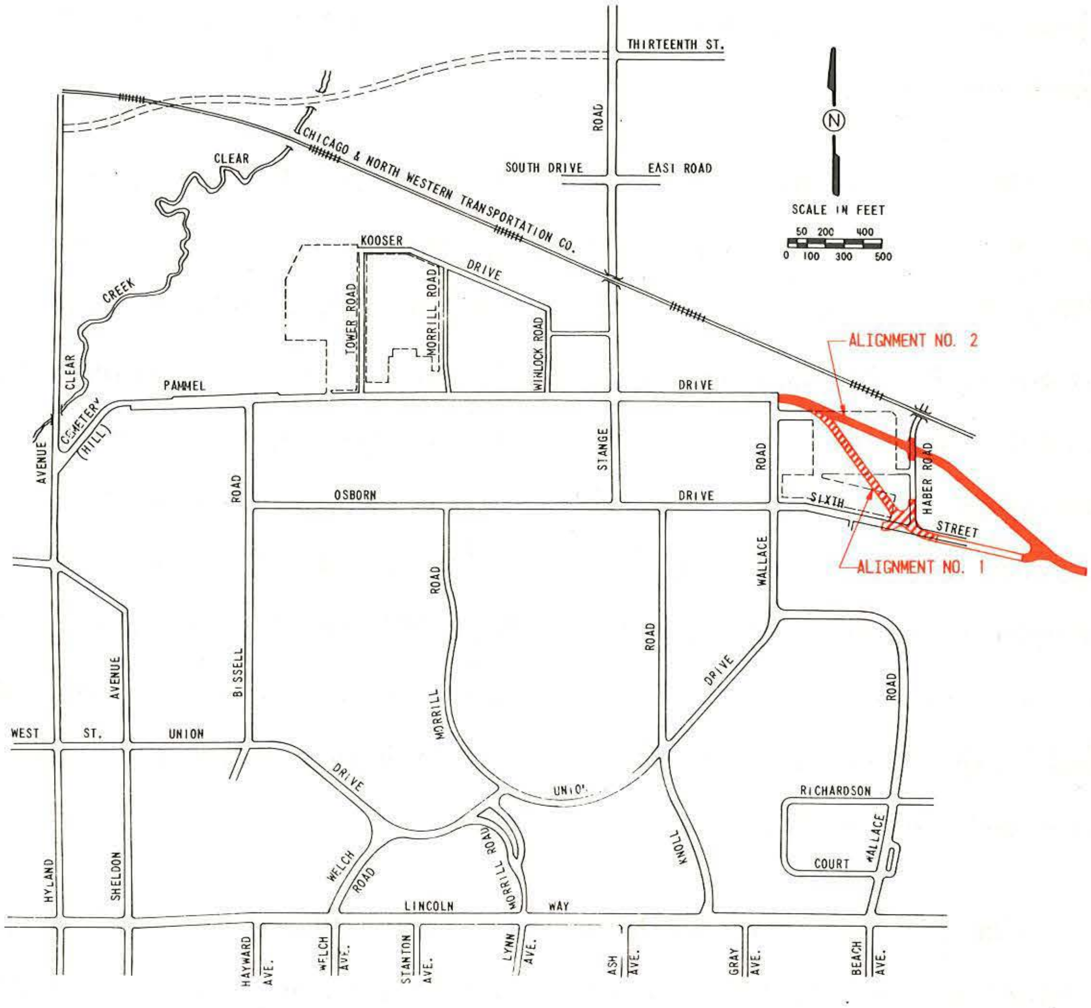


Fig. 3-10. Alternate Alignments of Proposed Pammel Drive-Sixth Street Connection.

The intersection of Alignment No. 2 with Haber Road will be located south of the existing railroad underpass. Sight distance on the north approach to this intersection would be restricted by the underpass structure, and could cause safety problems unless it is properly signed.

Due to the existing topography and the location of the railroad, Alignment No. 2 will pass through a portion of the horticulture gardens east of Haber Road. The remaining area east of Haber Road through which this alignment passes is presently undeveloped.

Alignment No. 2 intersects with existing Sixth Street west of the railroad underpass. Future planning for the City of Ames includes an extension of Elwood Drive to intersect Sixth Street in this same general area. This factor should be considered in the location of the Pammel Drive-Sixth Street connection, in order to avoid any conflicts between the two intersections. It appears that the Pammel Drive-Sixth Street connection should connect to Sixth Street westerly of its proposed Elwood Drive intersection.

The final alignment for the Pammel Drive-Sixth Street connection depends on many factors, in addition to those included in this report. The selection of any location should be integrated with the overall future planning for this area of the campus.

Traffic assignments relative to the aforementioned Alternates B and C indicate that traffic volumes will be reduced on Wallace Road in the future. The major factor contributing to such decreases in traffic volumes is the extension of Elwood Drive, a north-south facility to the east of Wallace Road. Such reduced traffic volumes should afford safer pedestrian, bicycle and vehicular traffic movements at North Richardson Court, South Richardson Court, Union Drive, Osborn Drive-Sixth Street and at Pammel Drive.

CHAPTER 4
TRAFFIC OPERATIONS

SCOPE

The purpose of this chapter is to analyze the movement and control of pedestrian, bicycle, and vehicular traffic on the Iowa State University campus in regard to present and future traffic conditions. Included in this chapter are analyses of pedestrian, bicycle and vehicular movements, parking lot access, and traffic signalization and control. Recommendations will be made relative to each subject area, which will result in improved traffic operations in the campus area.

INTERSECTION IMPROVEMENTS - EXISTING CONDITIONS

As was previously indicated in Chapter 2, the following three of eleven intersections studied in detail do not accommodate existing traffic volumes at acceptable levels of service:

Stange Road and Pammel Drive Intersection

Bissell Road and Pammel Drive Intersection

Wallace Road and Osborn Drive - Sixth Street Intersection

Intersection improvements, including widening of the respective streets and changes in signalization, could raise the levels of service at these intersections to acceptable levels. Each intersection was

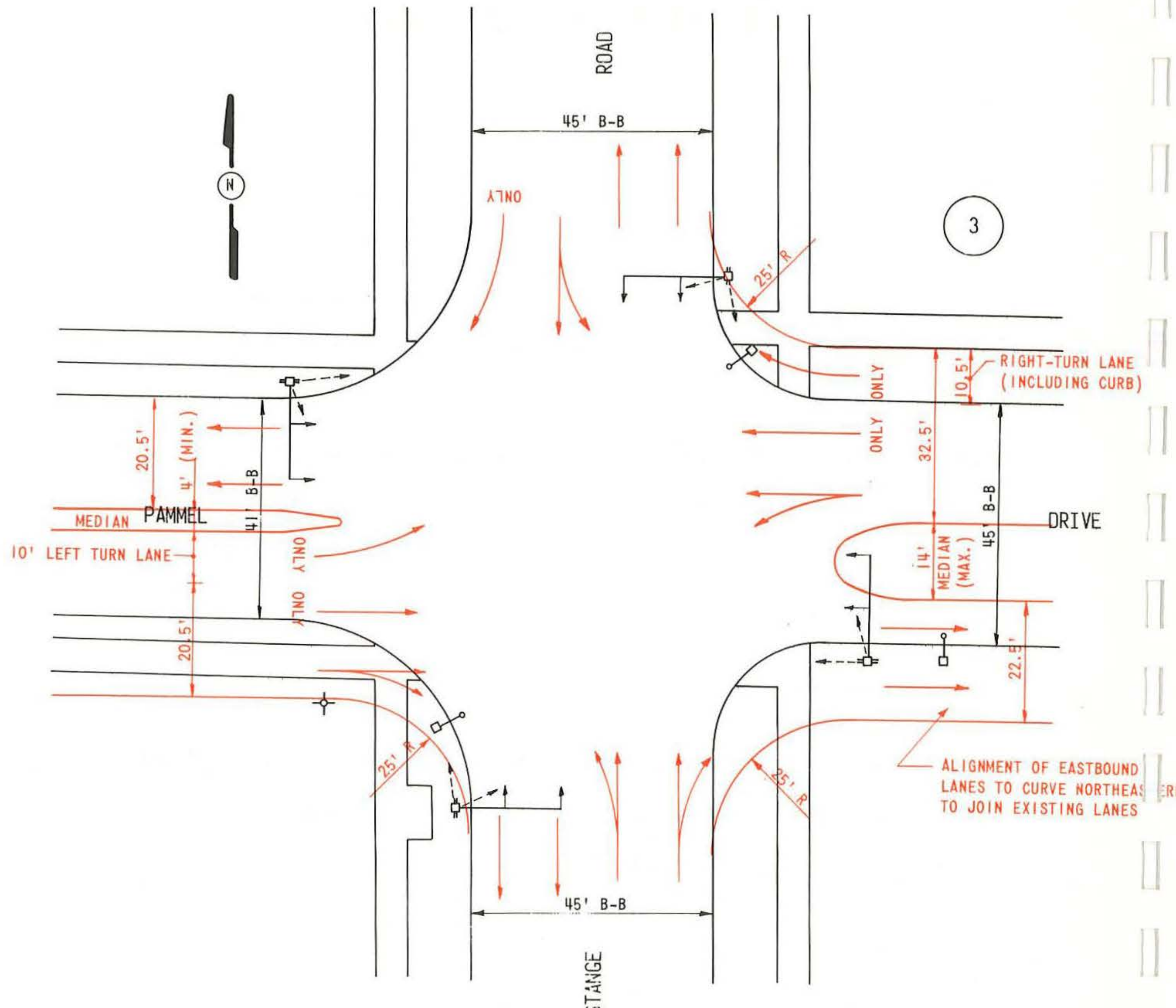


Fig. 4-1. Stange Road & Pammel Drive Intersection Improvements Relative to Existing Conditions.

analyzed to determine the minimum design necessary to obtain a level of service "C" or higher for all traffic movements. Results showed that the following intersection changes would be required in the absence of any other improvements.

Stange Road and Pammel Drive Intersection (Intersection No. 3, Figures 2-4 and 4-1)

According to pedestrian, bicycle and vehicular traffic data and existing traffic signal data presented in Chapter 2, intersection and traffic signal improvements are needed to accommodate the existing modes of traffic. (See Figure 2-4.) Relatively high volumes of turning vehicles on the north approach, left-turning vehicles on the west approach and right-turning vehicles on the east approach, in combination with heavy volumes of pedestrian and bicycle traffic in the east and west crosswalks, have affected the low levels of service at the respective approaches of this intersection.

Various designs were evaluated relative to existing traffic volumes and with minimal pedestrian intervals. It is not possible to provide for operational qualities comparable to that of Level of Service "C" without the provision of double-turning movements. Through the construction of respective right and left turn lanes, an optimum Level of Service "D" can be provided. In order to provide the latter level of service, no change in pavement width is necessary relative to Stange Road. The west approach to the intersection must be widened by the addition of a left-turn lane however, resulting in a minimum paving-width increase of ten to 14 feet, depending on paint markings or median construction respectively. For the same level of service, the east approach of Pammel Drive would have to be widened by 10 feet to provide a right-turning lane and by an additional 10 to 14 feet to provide continuity with the aforementioned west approach. It appears that the intersection may operate at capacity, Level of Service "E" through the construction of only the additional right-turn lane on the east approach.

Future traffic volumes in the vicinity of this intersection, as described in Chapter 3 relative to the proposed alternates of the current Ames Transportation Planning Study, are estimated to increase on Stange Road for all except Alternate No. C. Traffic volumes on Pammel Drive are expected to decrease for practically all alternates.

Bissell Road and Pammel Drive Intersection (Intersection No. 4, Figures 2-4 and 4-2)

The presence of a two-way bicycle lane along the north side of the pavement of Pammel Drive, in addition to a relatively heavy existing left-turning traffic movement on the east approach, produces low levels of service at the intersection of Bissell Road and Pammel Drive. (See Figure 2-4.)

An improved level of service could be obtained by the removal of the bicycle lane from the north edge of the pavement and the installation of a separate left-turn lane and median for westbound traffic. (See Figure 4-2.) A median with provisions for a future left-turn lane could be installed on the west approach to the intersection, also, and opposite the proposed left-turn lane and median on the east approach. The bicycle

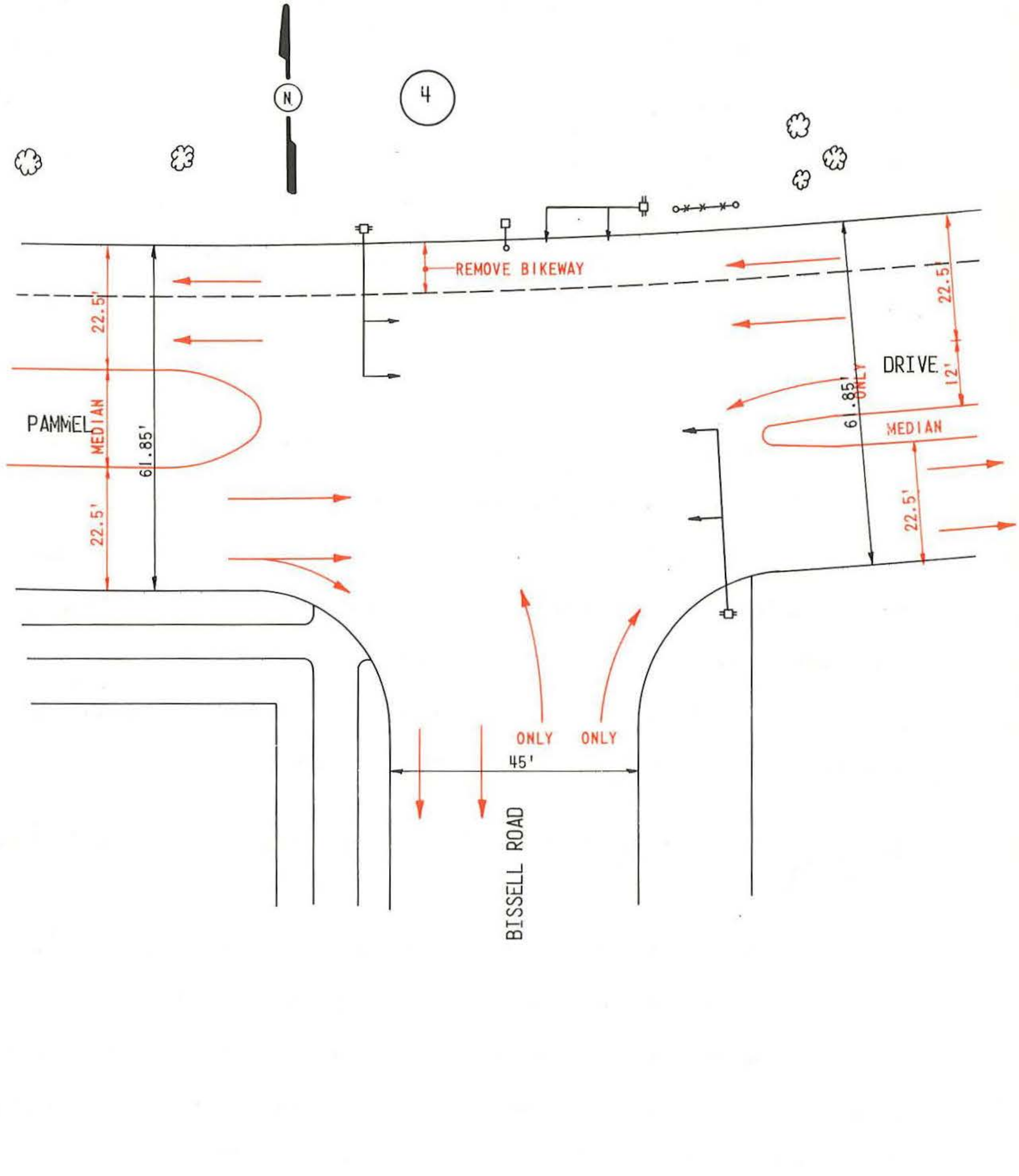


Fig. 4-2. Bissell Road & Pammel Drive Intersection Improvements Relative to Existing Conditions.

facility could be relocated north of the existing pavement as a separate bicycle path. The present paving on Pammel Drive is approximately 62 feet wide from the centerline of Bissell Road to approximately 150 feet east of the centerline of Bissell Road. It then narrows to 41 feet wide in the succeeding 100 feet. The 62-foot paving width extends for approximately 390 feet west of the centerline of Bissell Road before narrowing to approximately 50 feet in width. Pavement markings, in addition to the aforementioned medians, would be needed in this area to provide for the safe movement of traffic.

Proposed changes in existing street networks and traffic flow, as indicated in Chapter 3, are expected to reduce traffic volumes on the south and east approaches to the existing intersection, in addition to providing for the extension of Bissell Road to the north of Pammel Drive. Left-turning volumes for the east approach are expected to decrease in the future due to such roadway extensions and closures, but left-turning volumes will increase relative to the west approach.

Wallace Road and Osborn Drive - Sixth Street (Intersection No. 9, Figures 2-5 and 4-3)

Existing high-volume turning movements onto Sixth Street, heavy through movements on the north and south approaches on Wallace Road and heavy turning movements from the Sixth Street approach result in low levels of service at this intersection. (See Figure 2-5.) The presence of an on-street bicycle lane on the west approach and its crossing of Wallace Road on the south side of the intersection further affects the low levels of service found at this intersection.

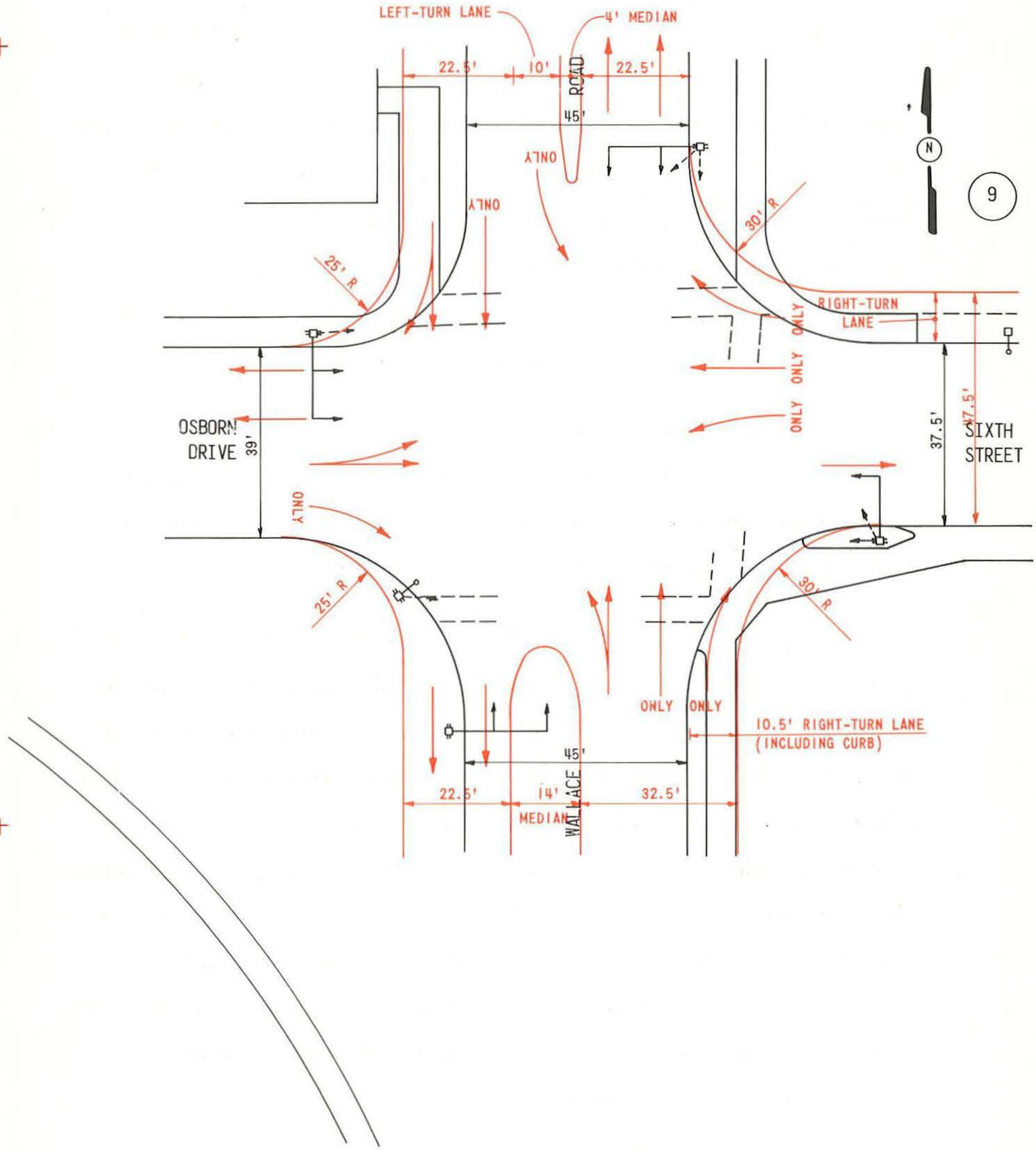


Fig. 4-3. Wallace Road & Osborn Drive-Sixth Street Intersection Improvements Relative to Existing Conditions.

In order to accommodate existing traffic at this intersection at acceptable levels of service, it would be necessary to widen the north approach by one lane to provide for a left-turn lane; to widen the south approach by two lanes to provide for a right-turn lane and a median opposite the north approach left-turn lane; and to widen the east approach by the addition of a right-turn lane. (See Figure 4-3.) Traffic signal modifications would also be necessary, in addition to relocation of the bicycle lane on the west approach.

The proposed extension of Pammel Drive easterly of Wallace Road, as described in Chapter 3, will effectively reduce traffic volumes at the intersection of Wallace Road and Osborn Drive - Sixth Street and make widening of the respective approaches unnecessary.

The previous discussions relative to the three intersections for which deficiencies were noted, serve to show what physical intersection improvements would be necessary to accommodate existing traffic volumes. No details were included relative to pedestrians, bicycles or to traffic signal improvements, all of which will be discussed subsequently in this report. In addition, no reference was made to physical problems involved in the widening of such streets, which will include such items as major sidewalk and drainage revisions, tree removal, reduced clearances to buildings, relocation of traffic control devices and other considerations. Street widening alone, as a solution to existing transportation deficiencies, is not recommended.

PEDESTRIAN OPERATIONS

Pedestrians at many of the intersections studied, comprise a significant portion of the overall traffic. The average ratio of pedestrians to vehicular traffic was approximately 1 to 6 for the counted intersections, with several intersections experiencing a considerably higher ratio. Pedestrians in any quantity are a source of conflict with vehicular traffic, and will influence the design and signalization of intersections where such conflicts exist.

Existing Pedestrian Conditions

As discussed previously in Chapter 2, the most severe pedestrian-vehicular conflicts were observed at the following locations:

Wallace Road and South Richardson Court - North Crosswalk

Wallace Road and North Richardson Court - South Crosswalk and Northwest-Southeast Diagonal Crosswalk

Stange Road and Pammel Drive - East and West Crosswalks

Bissell Road and Union Drive - North Crosswalk

Wallace Road and Union Drive - North and South Crosswalks

Although the heaviest pedestrian volumes were present at the above intersections, all of the studied intersections experienced some degree of pedestrian-vehicular interference.

Installation of traffic signals is one method of improving pedestrian crossings. The Manual on Uniform Traffic Control Devices (MUTCD) has set forth warrants for such signalization, based on the actual volumes of pedestrians and vehicular traffic entering an intersection. In order for signals to be warranted, the respective volumes must exceed a minimum value during at least eight hours of an average day.

At the intersections of Wallace Road with South Richardson Court and Wallace Road with North Richardson Court, the observed traffic and pedestrian volumes are insufficient to warrant traffic signals. In addition, the distance between South Richardson Court and Lincoln Way is relatively short, and would result in interference between the two intersections if both were signalized.

Future traffic projections indicate that traffic volumes on Wallace Road north of Lincoln Way will decline to less than half of their present value by the year 1995. (See Figures 3-2 through 3-4.) The lower traffic volumes expected on this section of Wallace Road will decrease the number of conflicts with the continued heavy pedestrian crossings.

For the aforementioned reasons, traffic signals are not recommended at either the intersections of Wallace Road and North Richardson Court or Wallace Road and South Richardson Court.

No significant conflicts between pedestrians and vehicular traffic were observed at the remaining unsignalized intersections. Traffic signals are not warranted at such locations and no special provisions for pedestrians, other than existing sidewalks, are required at the following intersections:

Stange Road and South Drive

Sixth Street and Haber Road

Sixth Street and Physical Plant Entrance

Traffic signalization at each of the six existing signalized intersections include inadequate provisions for pedestrians, as was discussed in detail in Chapter 2 of this report.

Each of these signalized intersections was analyzed relative to the improvement of pedestrian movements. Consideration was given to existing pedestrian volumes, existing crosswalks, reduction of pedestrian-vehicular conflicts, future campus expansion and locations of future pedestrian crossings. An attempt was made to allow optimum usage of existing signal equipment, in addition to satisfying the requirements of the MUTCD concerning pedestrian signalization.

Short-Range Pedestrian Recommendations

As an immediate solution, it is recommended that all pedestrian crosswalks at signalized intersections be provided with "Walk" and "Don't Walk" signals, and that such be operated in accordance with the provisions of the MUTCD. Push buttons should be provided for each crosswalk, and should be located to clearly indicate which crosswalk signal each such detector controls. A minimum of 7 seconds should normally be provided for the initial "Walk" indication, although a 5-second "Walk" interval is recommended at the intersection of Stange Road and Thirteenth Street because of the heavy traffic and light pedestrian volumes. In cases where no conflict is present between vehicles and pedestrians in the crosswalk, the "Walk" indication should be steady, while a flashing indication should be used when vehicular traffic is permitted to turn across the crosswalk. The pedestrian clearance interval, which follows the "Walk" indication, should allow a pedestrian leaving the curb to travel to the center of the farthest traveled lane before opposing traffic receives the right-of-way. Pedestrian clearance intervals are indicated by a flashing "Don't Walk" signal.

The table in Figure 4-4 lists the recommendations concerning pedestrian signal indications and signal timing. All existing crosswalks are included in Figure 4-4, as well as possible future crosswalks at certain intersections.

Crosswalks may become necessary at these locations in conjunction with future campus facilities and increasing traffic or pedestrian volumes. Some of the recommendations are explained below.

The east crosswalk at the intersection of Stange Road and Thirteenth Street is currently provided with "Don't Walk" signals. It is recommended that new "Walk" signals and push-button detectors be added and that the signal timing be adjusted to accommodate an adequate pedestrian clearance interval.

At the intersection of Stange Road and Pammel Drive, pedestrian signals are recommended at each crosswalk. "Walk" signals and push buttons should be installed at each location, in addition to existing "Don't Walk" signals, with signal timing as shown in Figure 4-4.

Intersection	Signalized Crosswalks	Walk Interval (Seconds)	Pedestrian Clearance Interval (Seconds)
Stange Road & Thirteenth Street	E, W* S*	5 5	18 10
Stange Road & Pammel Drive	N, S E, W	7 7	14 10
Bissell Road & Pammel Drive	E*, W* N*, S*	7 7	14 12
Bissell Road & Union Drive	N E	7 7	12 10
Wallace Road & Union Drive	N, S, E	7	12
Wallace Road & Osborn Drive-Sixth Street	N, S** E, W*	7 7	12 12

*Possible future crosswalk.
**Presently primarily bicycle crossing with occasional pedestrians.

Fig. 4-4. Recommended Pedestrian Signal Timing Data

No pedestrian accommodations exist at the intersection of Bissell Road and Pammel Drive, either as painted crosswalks or as pedestrian signals. Existing pedestrian volumes at this intersection are light and do not warrant signalized crosswalks. However, changes in traffic patterns and pedestrian volumes will accompany any street improvements in the area or any campus development north of Pammel Drive, and pedestrian signals may become necessary in the future. Figure 4-4 includes recommended signal timing for each of the four potential pedestrian crossings at this intersection.

The present phasing of the traffic signals at the intersection of Bissell Road and Union Drive, as previously discussed in Chapter 2, causes pedestrian-vehicular conflicts to occur on the north and east crosswalks. Modifications in the signal phasing are recommended later in this chapter, to eliminate such conflicts. In addition, it is recommended that "Walk" and "Don't Walk" signals, push-button detectors and revised signal timing be provided for the north and east crosswalks, as indicated in Figure 4-4.

Both "Walk" and "Don't Walk" signals are currently provided at the intersection of Wallace Road and Union Drive, although only the north crosswalk is equipped with push-buttons to actuate such signals. In addition, only pedestrians using the north crosswalk and westbound pedestrians using the south crosswalk are controlled by the existing pedestrian signals. Traffic volumes at this intersection, both existing and projected for the year 1995, are low enough to allow an all-pedestrian signal phase while retaining a level of service "C" for vehicular traffic at this tee intersection. It is recommended that such a phase be included in the signal cycle, with all vehicular traffic being stopped during the pedestrian phase. The timing of this phase is recommended to include 7 seconds for the initial "Walk" indication followed by 12 seconds for the pedestrian clearance interval. Push buttons should be located at each crosswalk to actuate the pedestrian signal phase.

The last signalized intersection to be considered is that of Wallace Road and Osborn Drive-Sixth Street. Existing crosswalks at this intersection are located on the north, east and south approaches, with only the east crosswalk being provided with push-button detectors. The south crosswalk is used predominantly as a bicycle crossing, although no signing is present to restrict pedestrians. Several pedestrians were observed to utilize this south crossing. Currently there are no pedestrian signals provided for the south crosswalk. It is recommended that updated pedestrian signals and push buttons be installed for the east and north and south crosswalks, with timing of such signals as shown in Figure 4-4. The west approach should be considered as a possible future crosswalk location.

The introduction of a pedestrian phase into the traffic signal cycle will necessitate modifications in the signal phasing at certain intersections in order to eliminate potential vehicular-pedestrian conflicts. Such modifications will be considered later under "Traffic Signalization".

One of the more noticeable impacts of pedestrian signalization is its effect on the length of a signal phase. Existing signal timing includes a "minimum green" interval of 6 to 8 seconds, allowing the signals to cycle rapidly from phase to phase whenever traffic is light. With the addition of pedestrian signalization, the "minimum green" time must be extended sufficiently to allow pedestrians to cross the street. For the intersections studied, minimum green times in the range of 12 to 21 seconds will be required to accommodate pedestrian crossings.

During periods of relatively light traffic volumes, the use of pedestrian signals will cause the signals to cycle at a slower rate, resulting in increased delays to vehicular traffic. Since pedestrian signals operate only when actuated by a pedestrian push-button, the signal phases will revert to the shorter 6 to 8 second "minimum green" whenever a pedestrian actuation is lacking.

During times of heavier traffic, the green signal interval on each phase will be extended by continued vehicular actuations, and the "maximum green" limitation will control the cycle length. In this case, the presence of pedestrian signals will have no effect on the length of the signal phases.

Observations of pedestrians on the Iowa State University Campus indicate that many pedestrians do not utilize pedestrian signals extensively in the absence of heavy vehicular traffic. The overall effect of pedestrian signalization relative to increasing cycle lengths and vehicular delays should be minimal. At the same time, such signalization will be an asset to safer pedestrian movements.

In order to encourage greater observance of pedestrian signals, it is recommended that all traffic signal cycles be shortened by reducing the "maximum green" intervals. This will result in a shorter waiting time for a "Walk" signal when heavier traffic volumes are present. More specific recommendations concerning traffic signal timing are considered later in this chapter.

Longer Range Pedestrian Recommendations

As future street improvements and new campus facilities develop, modifications of pedestrian operations will become necessary. This section includes general considerations for such modifications. Specific recommendations concerning pedestrian facilities will depend on the location, staging and final design of related campus improvements, as well as the desires of pedestrians themselves.

The future extension of Thirteenth Street west of Stange Road will introduce a crosswalk on the west approach of that intersection. In addition, an east-west crosswalk across Stange Road may become necessary if pedestrian volumes increase appreciably, although only 10 crossings per day were observed during the Spring of 1975. The most desirable location for an east-west crosswalk at this intersection would be the south approach to Thirteenth Street, in view of the lower traffic volumes projected for that section of Stange Road.

The proposal to close Bissell Road to through traffic between Union Drive and Pammel Drive will cause a considerable reduction in traffic volumes along Bissell Road. Such a reduction in traffic may allow the removal of signalization altogether, including pedestrian signals, at the intersection of Bissell Road and Union Drive.

Traffic and pedestrian volumes at the intersection of Bissell Road and Pammel Drive will be affected by several proposed improvements, including the extension of Sheldon Avenue to Pammel Drive, the Bissell Road extension, the closure of Bissell Road and the expansion of campus facilities in the area. Increased pedestrian volumes resulting from such improvements may require pedestrian signalization at the intersection. Crosswalks located on the south and east approaches at the Pammel Drive-Bissell Road intersection would experience the least interference from vehicular traffic, and would be separated from the bicycle crossing on the north approach. In this respect, the south and east approaches would be desirable locations for future crosswalks, if such become necessary.

At the intersection of Wallace Road and Osborn Drive-Sixth Street, the existing westerly north-south sidewalk terminates just north of Osborn Drive. Future developments to the northwest of this intersection, including the proposed seed laboratory, may interrupt alternate north-south pedestrian routes and require an extension of the existing sidewalk to the north. This sidewalk could be extended north across Pammel Drive, and connected to the existing pedestrian underpass at the railroad. In order to provide continuity to the pedestrian route, such an extension should be accompanied by sidewalks on the southwest corner of the Wallace Road-Osborn Drive intersection, both for north-south and east-west pedestrian movements. If a new north-south sidewalk is constructed, consideration should be given to separating pedestrian and bicycle traffic through the use of individual facilities.

Signalization would be required for crosswalks at the Wallace Road and Osborn Drive-Sixth Street intersection, with timing as indicated in Figure 4-4. In addition, the proposed extension of Pammel Drive to Sixth Street will require signalization of the Wallace Road-Pammel Drive intersection, including pedestrian signals if a crosswalk is provided on the west approach.

BICYCLE OPERATIONS

As a result of the aforementioned rise in popularity of travel by bicycle and the closing of the central campus area to through vehicular travel, bicycles are in competition with pedestrians and vehicular traffic for use of street, sidewalk and crosswalk facilities. The possibility of conflicts among these three modes of travel becomes most apparent at intersections.

At the intersection, pedestrians and motor vehicles generally have defined avenues of approach and departure and their respective behavioral patterns are essentially predictable or established. The bicycle, however, is somewhere between and there presently is confusion as to whether a bicycle should be considered as a pedestrian or as part of the on-street, vehicular traffic. In addition, there are differing opinions among bicyclists themselves as to whether they should be treated as pedestrians or as vehicular traffic. Physical and attitudinal conflicts are therefore possible.

Bicycle Facilities in General

Bicycle facilities also vary, generally. The following terminology and definitions, relative to bicycle facilities (bikeways), further illustrate the somewhat compromising position of the bicycle or bicyclist:

Bicycle Route - A shared right-of-way designated as such by signs placed on posts or stenciled on pavement. This type of bikeway is often classified as a Class III Bikeway. Additionally, any bikeway which shares its through-traffic right-of-way with either or both moving (not parking) motor vehicles and pedestrians is considered as a Class III Bikeway.

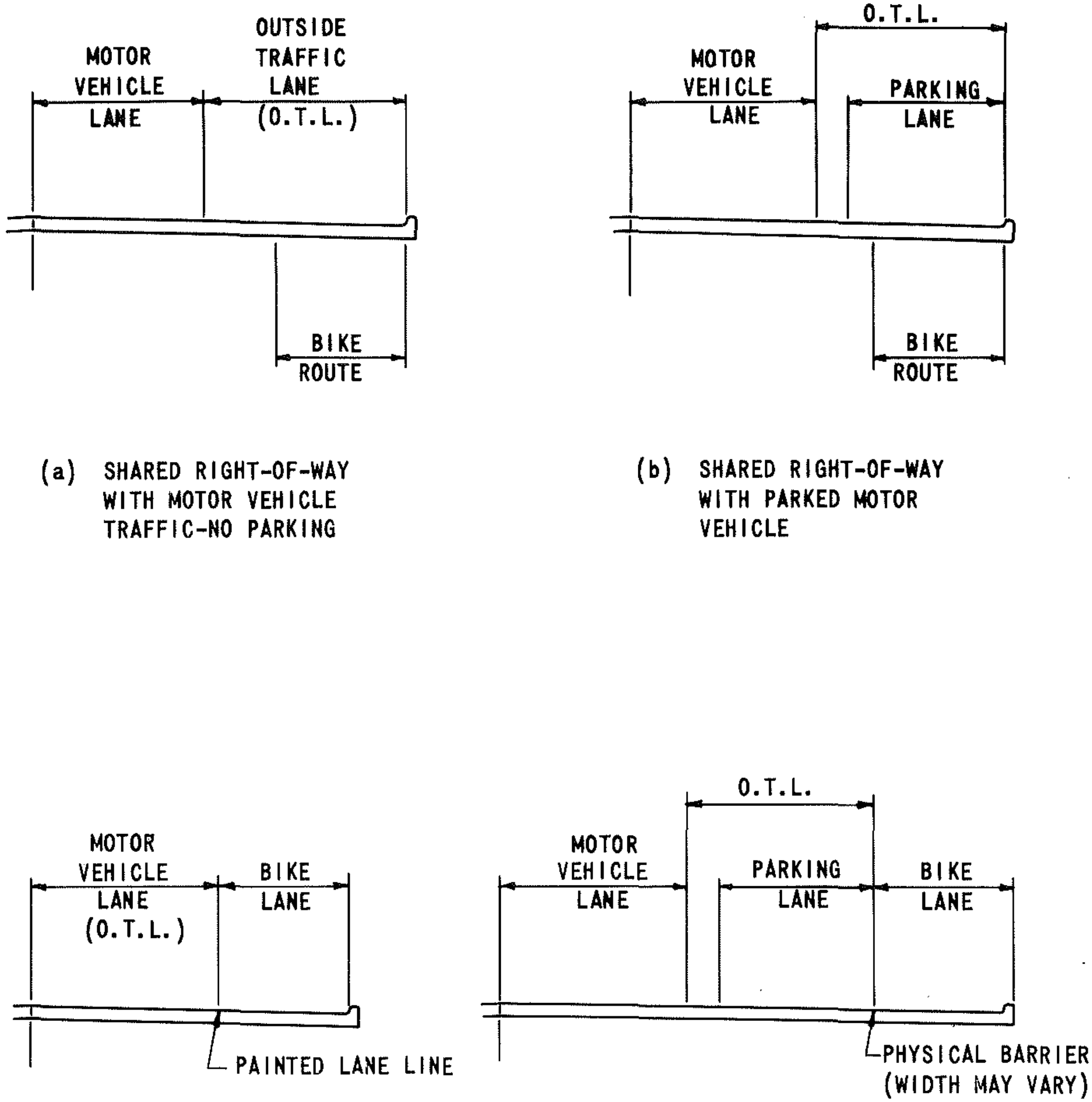
Bicycle Lane - A restricted right-of-way designated for the exclusive or semi-exclusive use of bicycles. Through travel by motor vehicles or pedestrians is not allowed. Cross-flows by motorists, for example, to gain access to driveways or parking facilities, is allowed; pedestrian cross-flows, for example, to gain access to parked vehicles or bus stops or associated land use, is allowed. This category of bikeway is often referred to as a Class II Bikeway.

Bicycle Path - A completely separated right-of-way designated for the exclusive use of bicycles. Cross-flows by pedestrians and motorists are minimized. This category is often classified as a Class I Bikeway.

On a bicycle route, no protection is afforded the bicycle other than through signing to indicate to the motorists, pedestrians and bicyclists that such a street or sidewalk is a bicycle route. Many times, such routes are of little value to the bicyclist for either recreation or other trip purposes, due to placement, traffic conditions, routing, alignment, or grades.

Bicycle lanes are generally adjacent to motor vehicle traffic lanes, although some type of separation may be provided. Figure 4-5 indicates several types of separations, varying from only painted lane markings to physical-type separations. Conflicts are possible between bicycles and moving vehicles, bicycles and parked vehicles (mainly with opened or opening car doors) and bicycles and fixed objects (curbs, utility poles, etc.), depending upon type of treatment.

As was mentioned previously, conflicts are generally much more likely at intersections than at other locations, relative to the three aforementioned modes of travel. Varying combinations of bicycle routes, lanes or paths with vehicular traffic and its associated turning lanes and traffic signalization, and with pedestrian movements, crosswalks and



(a) SHARED RIGHT-OF-WAY WITH MOTOR VEHICLE TRAFFIC-NO PARKING

(b) SHARED RIGHT-OF-WAY WITH PARKED MOTOR VEHICLE

(c) BIKE LANE ON STREET ADJACENT TO MOTOR VEHICLE TRAFFIC

(d) BIKE LANE ON STREET SEPARATED FROM MOTOR VEHICLE TRAFFIC

Fig. 4-5. General Types of On-Street Bicycle Lanes.

pedestrian signals, result in situations often times difficult to control effectively and uniformly.

Uniformity of traffic control devices relative to motor vehicle and pedestrian travel is currently being aided by the use of the MUTCD. No uniform standards are available, however, in the relatively new field of control of bicycle travel. Methods of controlling such bicycle movements therefore vary among the various jurisdictions that are presently attempting to provide such controls.

Existing Bicycle Facilities at Iowa State University

Existing bicycle facilities, as indicated in "Traffic and Parking Regulations, Iowa State University, Ames, Iowa", as revised in 1974, have been shown in Figure 2-2 in Chapter 2 of this report. Relative to the eleven intersections studied in detail, one discrepancy was noted in relation to the aforementioned regulations. There no longer exists a marked bicycle lane in the street on the south side of Union Drive in the vicinity of its intersection of Bissell Road. The bicycle path on the south side of West Street therefore terminates at Sheldon Avenue and resumes east of Sheldon Avenue as an unidentified bicycle route.

The most prevalent type of bicycle facility present on the campus, within the study area and relative to the eleven studied intersections, is of the bicycle-route-on-sidewalk type. Under such conditions, the bicycles are treated as pedestrians at the intersections. The bikeway along the south side of Sixth Street between Wallace Road and Haber Road, identified in the aforementioned regulations as a separate bike lane, actually functions as a bicycle route, in that numerous pedestrians were observed to utilize it in combination with bicycles. East of Haber Road, however, it appeared to be functioning as a bicycle path.

Bicycles on the west side of the intersection of Stange Road and Thirteenth Street, on the north side of Pammel Drive at Bissell Road, and on the south side of Sixth Street at the Physical Plant Entrance and at Haber Road, are essentially unaffected by through motor vehicle traffic. However, bicycles at the following sides of intersections are treated essentially the same as traffic:

South side of Union Drive at Bissell Road

South side of Osborn Drive at Wallace Road

North and South Richardson Court at Wallace Road

Bicycle Facilities Design Considerations

Bicycle Operating Space[1]:

Figure 4-6(a) indicates the operating space for bicycle travel. The space required for a bicycle traveling along a truly straight path is approximately 24 inches wide, 90 inches high and 70 inches along the path of travel. However, since a bicycle cannot be operated along such a true straight line and tends to weave along its projectory, an additional

1 Reference: Bikeways-State of the Art-1974, U.S. Department of Transportation, Federal Highway Administration, FHWA-RD-74-56.

eight inches in width must be added to each side of the physically occupied space, yielding a 40-inch width requirement. An additional lateral clearance of ten inches, sometimes referred to as "shy" distance, is required on each side of the operating space to allow clearance between the bicycle and other bicycles, pedestrians, motor vehicles or fixed objects. These dimensions are indicated in Figure 4-6(b).

In areas where two lanes of bicycle travel are permitted, the resulting clearance diagram is shown in Figure 4-6(c). This condition is present when two-directional travel is permitted or where side-by-side or passing operations are permitted in one direction of travel.

Pedestrian Space Requirements[1]:

Relative to sidewalk bike routes, pedestrian space requirements are also important considerations. The data in Figure 4-7(a) indicates that the physically occupied space for a pedestrian is generally 24 inches wide, 78 inches tall and 18 inches along the path of travel[2].

Based on a minimum 18-inch-radius, "No Touch" zone, Figure 4-7(b) illustrates the pedestrian clearance diagram, which provides approximately six inches of clearance to each side. The clearance diagram for the 21-inch-radius, "Personal Comfort" zone, allows nine inches of clearance to each side, according to Figure 4-7(c).

1 Reference: Bikeways-State of the Art-1974, U.S. Department of Transportation, Federal Highway Administration, FHWA-RD-74-56.

2 Reference: Pedestrian Planning and Design, John J. Fruin, Metropolitan Association of Urban Designers and Environmental Planners, Inc., New York, N.Y., 1971.

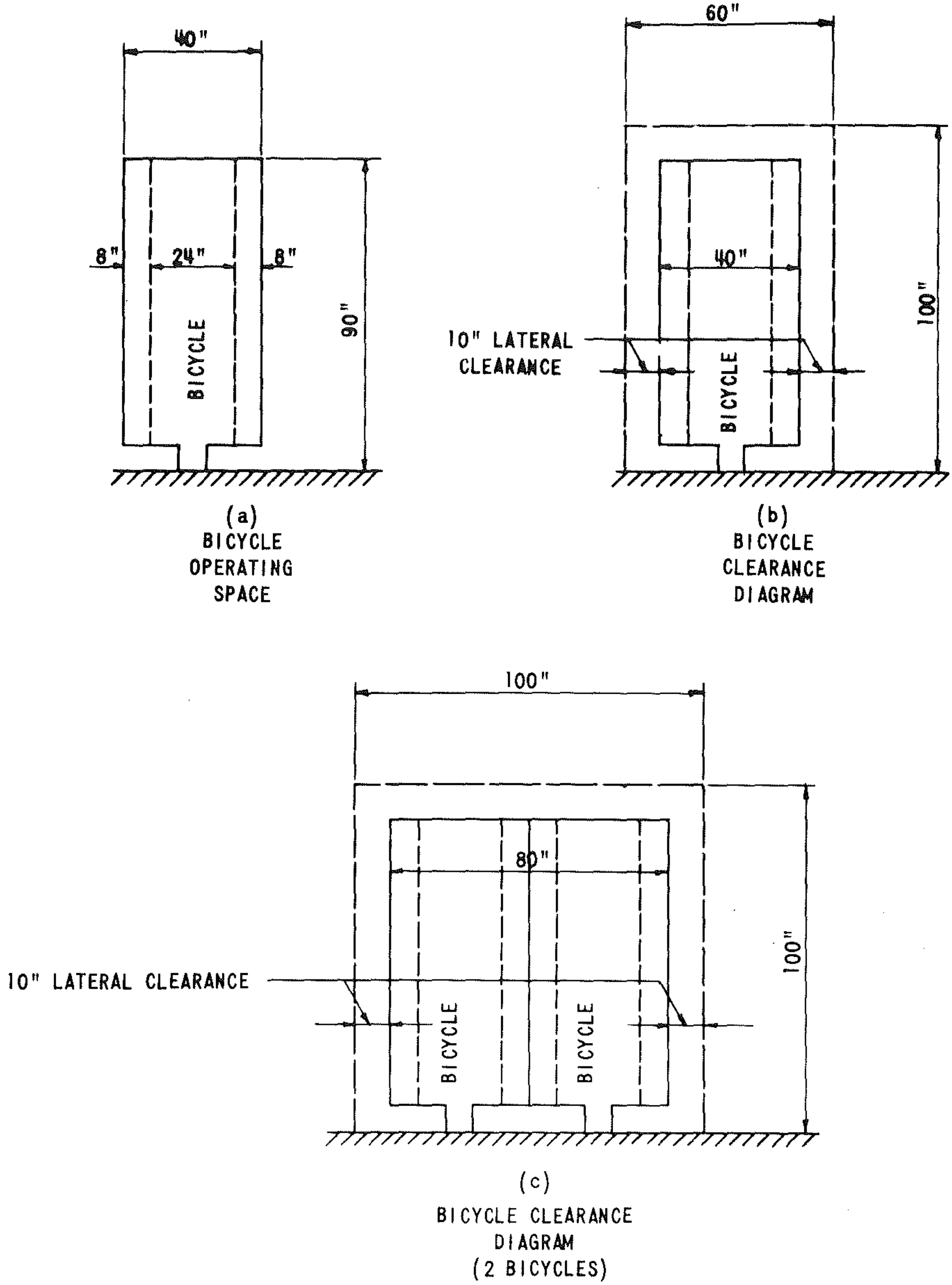


Fig. 4-6. Bicycle Operating Space and Clearance Diagrams.

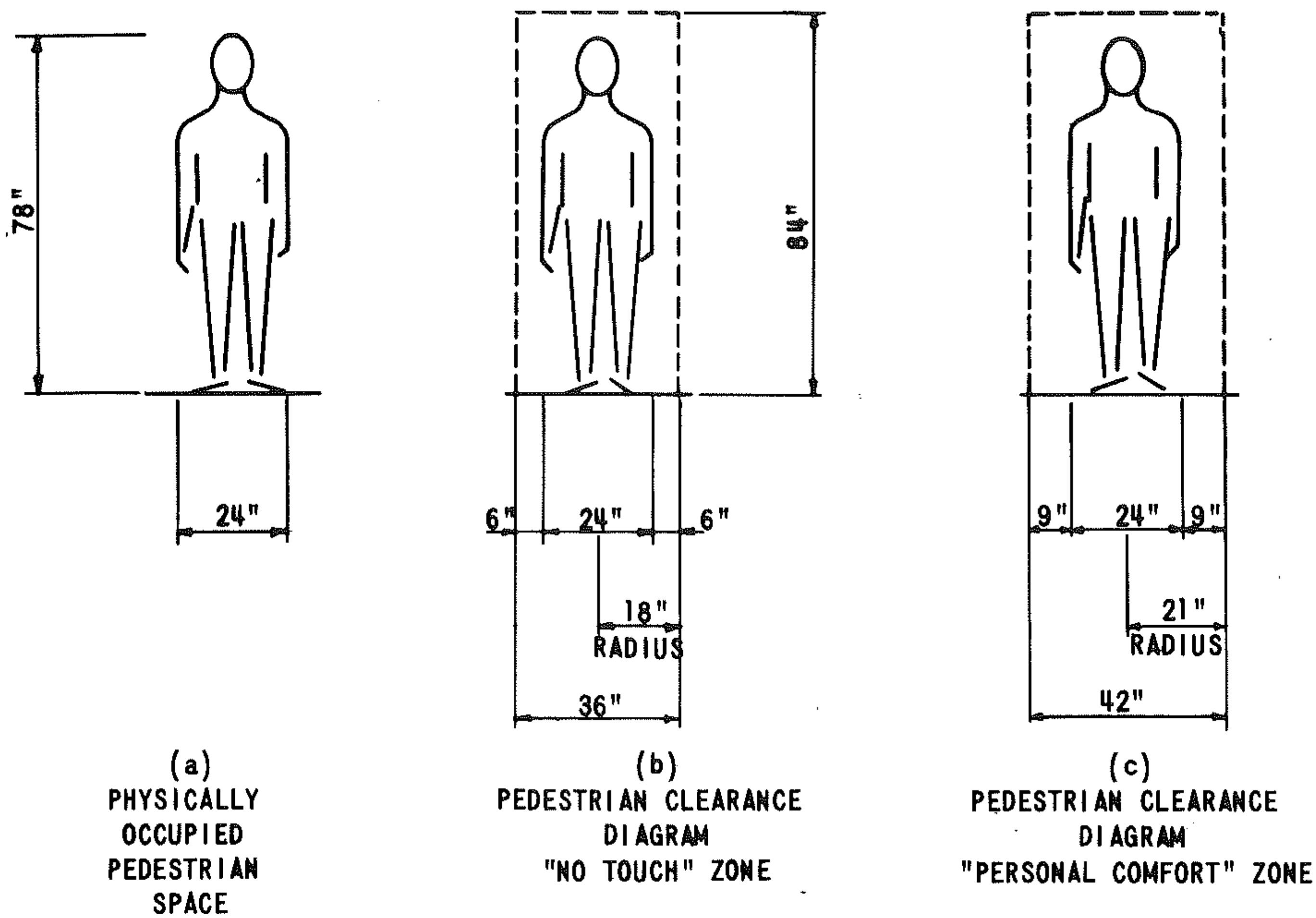


Fig. 4-7. Pedestrian Occupied Space and Clearance Diagrams.

In areas where side-by-side or two-directional pedestrian travel is possible, the resulting clearance diagrams are twice as wide as shown in Figure 4-7(b) and (c).

Combined Bicycle and Pedestrian Travel:

Sidewalk bikeways, as previously mentioned, accommodate both bicycle and pedestrian movements. Combinations of such modes of travel result in the clearance diagrams shown in Figure 4-8. Figure 4-8(b) indicates two lanes of bicycle travel adjacent to one row of pedestrians, while Figure 4-8(c) indicates one lane of bicycle flow adjacent to two rows of pedestrian flow.

Sidewalk Bikeway Widths:

The minimum sidewalk-bikeway widths for various combinations of bicycle and pedestrian travel are defined by that width or distance from 12 inches outside the centerline of bicycle movement to 12 inches outside the centerline of pedestrian movement. (See Figure 4-8.) The resulting minimum sidewalk-bikeway widths are tabulated in Figure 4-9 for the noted combinations of bicycle and pedestrian travel. Where such sidewalk-bicycle routes are permitted, sidewalk widths should be at least six feet wide and preferably nine feet wide, allowing some additional space for pedestrians carrying books or packages.

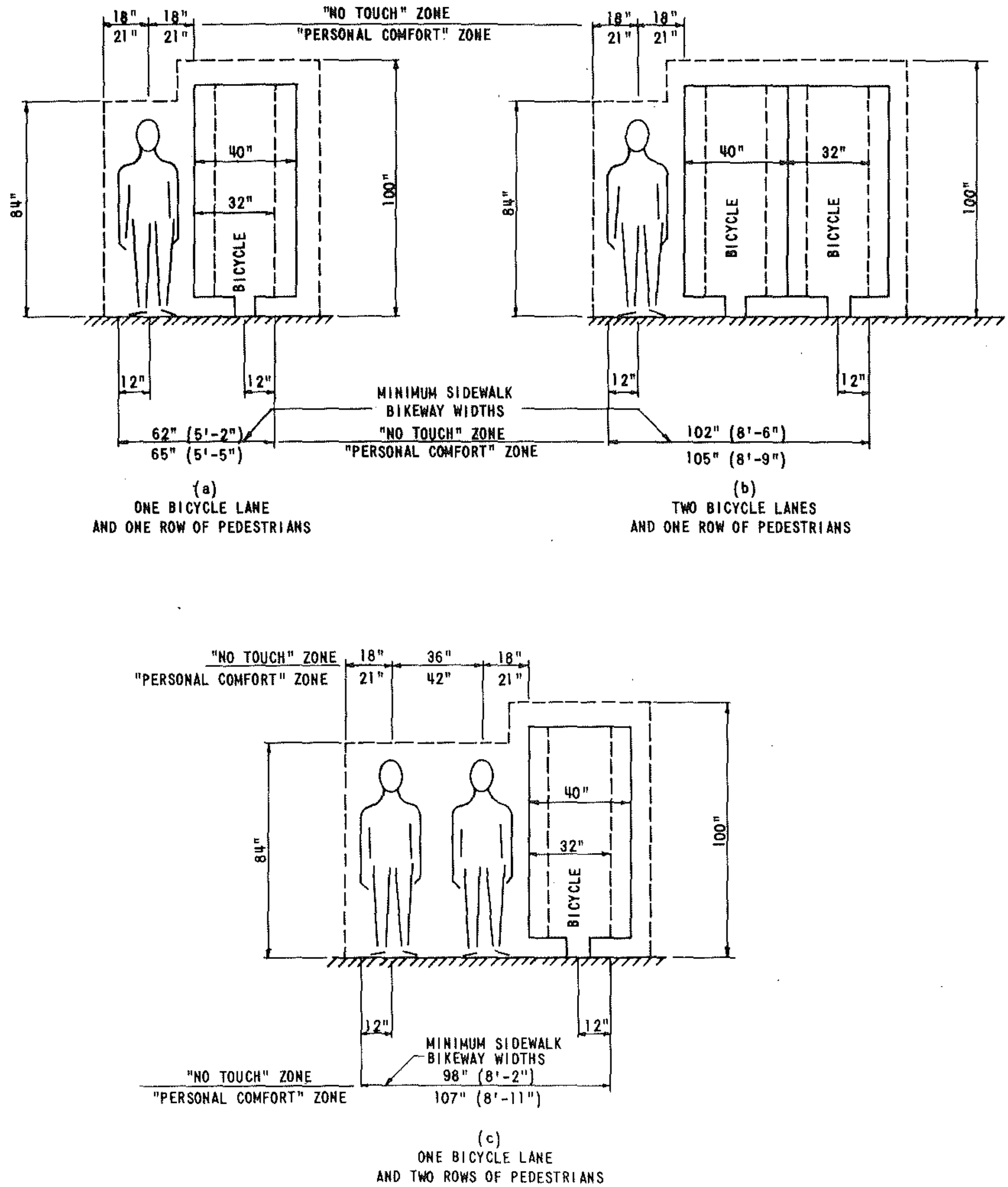


Fig. 4-8. Clearance Diagrams and Minimum Sidewalk-Bikeway Widths.

Minimum Sidewalk Bikeway Width				
Bicycle Travel	Pedestrian Travel			
Number of Lanes	Number of Rows			
	"No Touch" Zone		"Personal Comfort" Zone	
	1 Row	2 Rows	1 Row	2 Rows
1	62" (5'-2")	98" (8'-2")	65" (5'-5")	107" (8'-11")
2	102" (8'-6")	---	105" (8'-9")	---

Fig. 4-9. Tabulation of Minimum Sidewalk Bikeway Widths

Sidewalk Bikeway Locations Relative to Pavement:

Relative to traffic movement and safety, any object adjacent to the traffic lane which is greater than one foot in height will produce a lateral shifting of traffic away from such object. The extent of such shifting has generally been observed (not locally) to provide a clearance of approximately two feet. In accordance with this observation, roadside features such as signs, utility poles, street lights and the like are usually located so that they are no closer than two feet laterally from the face of curb to the object. (Approximately 1.5 feet from the back of curb.) Therefore, it is recommended that there be at least two feet of separation between the face of curb (or edge of non-curbed pavement) and the street-edge of sidewalks or sidewalk bikeways. (The presence of pedestrians and bicycles on facilities adjacent to through traffic, likewise influences the movement of motor vehicles to provide two feet of clearance.)

In many instances, utility poles, signs, street lights and the like are located between the pavement and the sidewalk or sidewalk bikeway. Bicycle traffic should be located relative to such fixtures so that at least the aforementioned ten-inch clearance is maintained. Based on a two-foot clearance relative to vehicular traffic, the ten-inch bicycle clearance, and the width of the fixture itself, a minimum separation between the pavement and a sidewalk or sidewalk bikeway may vary from approximately four to six feet, depending upon the width of fixture.

Sidewalk Bikeway Locations in Vicinity of Intersections:

Figure 4-10 illustrates a European design for sidewalk-bikeways at major intersections where turning volumes are heavy and bikeways intersect. The principal element of this type of intersection is the offsetting of the through bikeway location relative to the through traffic location. The suggested offset ranges from 16.4 to 32.8 feet (5 to 10 meters). Offsetting the bikeway crossing has the following advantages and disadvantages:

<u>Advantages</u>:

1. Bicyclist has good angle of view of right-turning motorist approaching from his left. Bicyclist does not have to look back over his left-shoulder as would be the case if bikeway crossing was near to the parallel traffic lane.
2. Offset space would provide added time for a right-turning motorist to react to presence of bicycles crossing street, thus providing an added

safety benefit. This may be of benefit relative to right turns on red at signalized intersections during which bicycles are using the bikeway crossing against a signal indication.

3. One or two right-turning motorists are able to complete their turning movements before stopping for bicycles in the bikeway crossing, thus allowing succeeding through traffic to proceed.
4. Pedestrians and bicycles can be separated at the street crossing and therefore not be in conflict with each other while crossing.
5. Except for the queuing areas adjacent to the crossing and the crossing itself, the sidewalk-bikeways accommodate both bicycles and pedestrians. Continuity of operation is therefore preserved.

Disadvantages:

1. Additional street right-of-way is required to accommodate such sidewalk-bikeway facilities at the intersection. Relocation of existing utility poles, street lights, traffic signals and removal of shrubbery may be necessitated.
2. The intersection layout tends to provide for the counterclockwise movement of bicycles relative to those cyclists desiring to turn left at an intersection. The resulting route may be somewhat circuitous in nature and may cause such cyclists to wait through an extra signal cycle. (This problem may not exist if all sidewalk-bikeways crossings permit two-way bicycle travel in addition to pedestrian movements and if 2:1 slope on sidewalk-bikeway was revised to a 1:1 slope.)

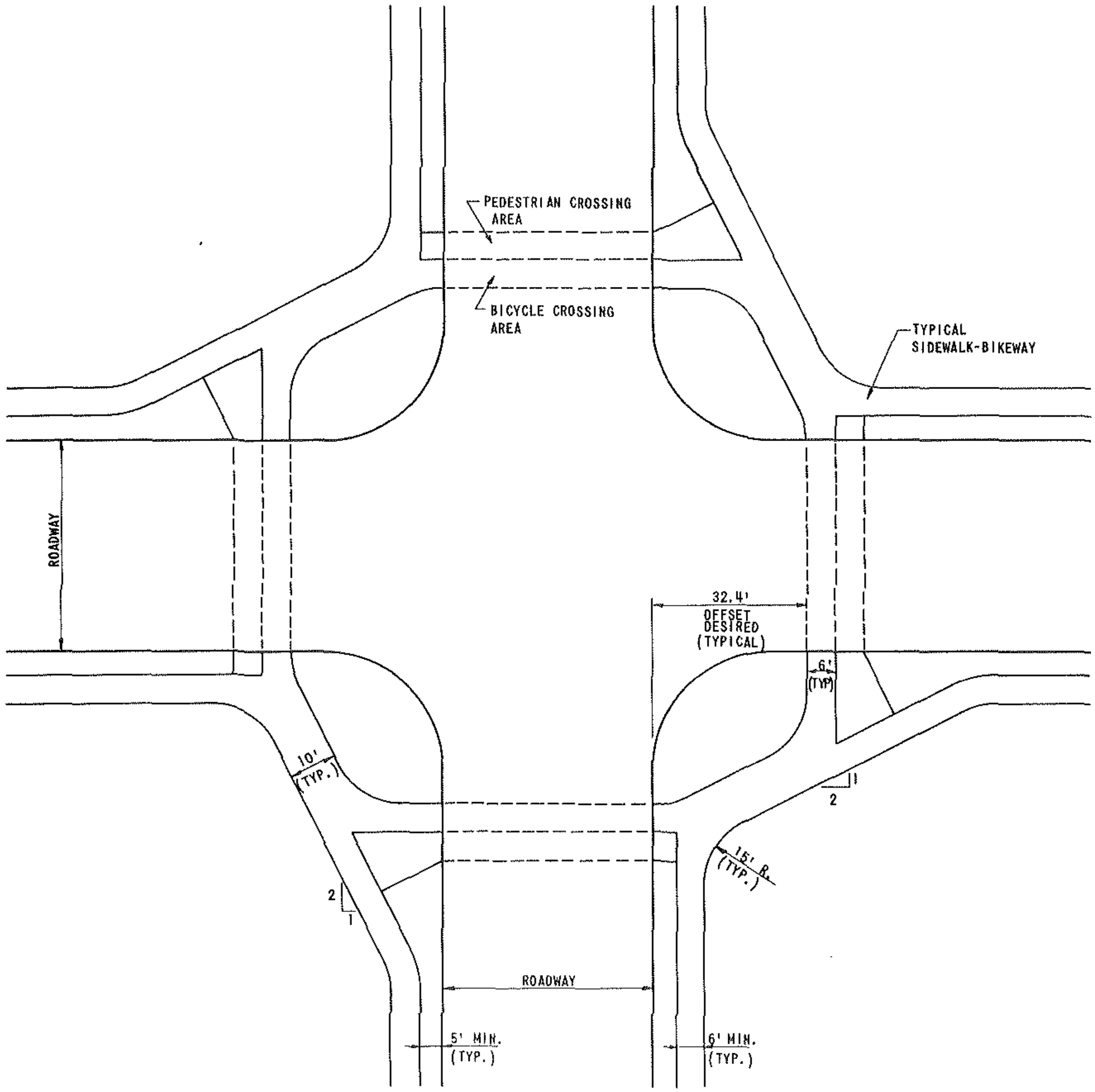


Fig. 4-10. Typical Sidewalk-Bikeway Layout at Intersection.

It is the opinion of the writer that this type of facility is compatible with current treatment of pedestrians and bicyclists on the Iowa State University Campus. During the existence of current traffic-volume conditions, there is virtually no roadway space available for on-street bicycle routes or lanes, especially at the aforementioned intersections studied. Such bikeways could only be provided by additional pavement widenings beyond that required to accommodate motor vehicle traffic. Space may be available for on-street bikeways upon completion of the aforementioned future roadway extensions. Intersections would have to be modified at that time to prevent vehicular-pedestrian and bicycle conflicts.

On-Street Bicycle Lanes:

Existing on-street bicycle lanes include unmarked bicycle routes and marked bicycle lanes. The only marked bicycle lanes noted within the study were located along the north side of the tee-intersection of Bissell Road and Pammel Drive. This lane, being nine feet in width, is a two-way facility. Under current conditions, the eastbound bicycle lane is located immediately adjacent to the westbound traffic lane. With the simultaneous presence of bicycles in both bike lanes and westbound motorists in the opposing traffic lane, serious conflicts could occur. Also, the presence of such a two-way bike lane at or approaching an intersection lends itself to serious conflicts.

It is recommended that any future on-street bike lanes be one-way lanes with movement being in the same relative direction as that of adjacent traffic lanes. A lane width of not less than four feet should be provided, although such will not provide for passing maneuvers within the bike lane. It is recommended that bike lanes be at least six feet and preferably eight feet in width.

PAMMEL DRIVE PARKING LOT ACCESS

A multiplicity of streets, driveways and parking lot entrances are currently located along Pammel Drive between Bissell Road and Stange Road. A majority of these entrances and drives serve relatively small parking areas or provide access to buildings.

Two major parking areas north of Pammel Drive, identified as "Lot A" and "Lot B" in Figure 4-11, have a combined capacity of 1,496 parking spaces. Of its capacity of 845 parking spaces, Lot A includes 318 spaces for residence hall parking. The balance of Lot A and all of Lot B parking spaces (1178 spaces) include metered, reserved, permit, staff and Ames Laboratory parking. Except for the residence hall parking, most of the parking spaces experience parking turnover on a daily basis, when used. Three entrances onto Pammel Drive essentially provide access to these 1,496 parking spaces, including Tower Road, Morrill Road and a driveway west of Tower Road. Kooser Drive, connecting the northerly ends of Tower Road, Morrill Road and Winlock Road, also provides access to various buildings and parking areas north of Pammel Drive.

The remaining entrances on Pammel Drive serve relatively smaller parking areas, ranging in capacity from only a few spaces to a maximum of

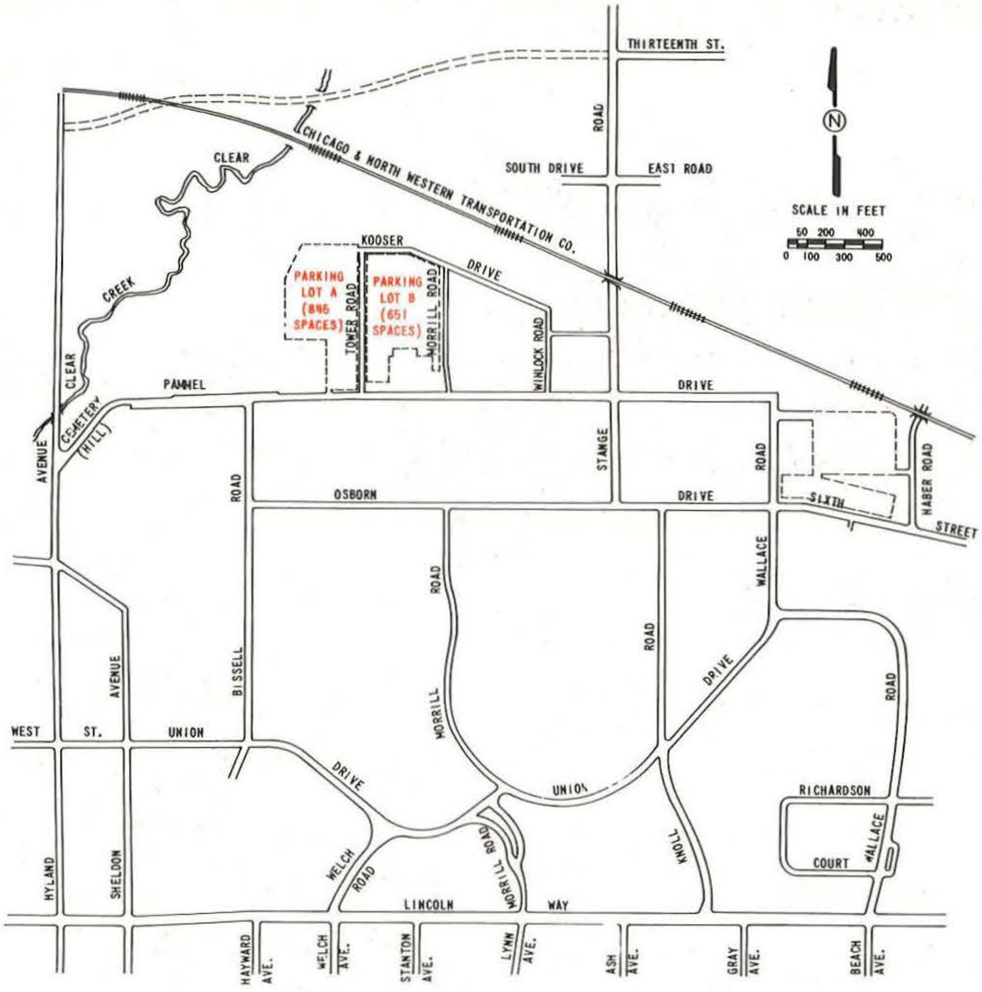


Fig. 4-11. Parking Lots North of Pammel Drive.

113 spaces, in addition to providing access to each building. While not conducive to improved traffic flow along Pammel Drive, most of these access points appear to be necessary. Each parking lot, however, should be limited to one entrance onto Pammel Drive.

An existing driveway on the west side of Stange Road, located approximately midway between the Chicago and North Western Transportation Company trackage and Pammel Drive, provides access to a parking area north of the veterinary clinic. This parking area is also served by an access onto Winlock Road.

It has been observed, during morning peak traffic conditions, that the driveway entrance onto Stange Road has been blocked by an existing vehicle that was unable to get onto Stange Road. At the same time, right-turning vehicles on Stange Road, unable to turn into this driveway, caused blockage of southbound traffic flow. In order to avoid such situations, regardless of how infrequent this condition may occur, it is recommended that this driveway be signed as one-way westbound from Stange Road to the parking area.

The aforementioned extension of Bissell Road north of Pammel Drive and westerly extension of Kooser Drive to intersect with it will provide a needed access to the parking lots north of Pammel Drive, particularly those identified as Lots "A" and "B". It is expected that these roadway extensions will help to alleviate traffic congestion on Pammel Drive.

It is recommended that the parking lot access west of Tower Road and north of Pammel Drive be closed and its access be diverted to Tower

Road. Furthermore, it is recommended that two of the three drives onto Pammel Drive relative to the parking lot north of the Armory be closed and that internal circulation patterns be modified accordingly. The removal of the three aforementioned of the 13 parking lot accesses onto Pammel Drive is expected to improve access to Pammel Drive.

INTERSECTION MODIFICATIONS

Intersection improvements for three presently deficient intersections were noted earlier in this chapter, such improvements being based on existing conditions. Additionally, the proposed extensions of various roadways in the vicinity of the Iowa State University campus are expected to result in revised amounts of vehicular traffic at all intersections.

Relative to such future extensions, the construction of the extension of Pammel Drive to Sixth Street, appears in the Iowa Department of Transportation's "Five Year Construction Program and Work to be Accomplished in 1976". This project, referred to as "Sixth Street Reconstruction, Phases I and II", is scheduled for construction in 1978 and 1979.

The construction of the Design Center on Bissell Road is expected to be completed in the Fall of 1978. With the associated closing of Bissell Road to through traffic between Marston Court and Osborn Drive, the extension of Sheldon Avenue north to Pammel Drive will become a necessity and should be open to traffic upon completion of the Design Center.

The extension of Thirteenth Street westerly of Stange Road is the only "committed" element of the "existing plus committed" transportation network of the Ames Transportation Study in the vicinity of the campus, as was previously mentioned. Its construction is expected to result in generally decreased traffic volumes on Pammel Drive.

In view of the existing conditions and deficiencies and the proposed future roadway extensions, the following recommendations are made relative to intersection modifications.

Stange Road and Thirteenth Street (Intersection No. 1, Figure 4-12)

No deficiencies have been noted relative to the existing intersection layout and present motor vehicle volumes. It is recommended that the east sidewalk be shifted east to provide for 17 feet of clearance between the extension of the east curb line of Stange Road and the west edge of the sidewalk. This design will provide clearances to crossing bicycles and pedestrians relative to right-turning motor vehicles from northbound Stange Road and will provide a shorter crossing distance for pedestrians crossing Thirteenth Street. Bicycles will be required to maneuver around the west end of the existing median, unless such is shortened or an opening is made in the median.

The future extension of Thirteenth Street, west of Stange Road, will result in a suggested layout shown in dashed lines, Figure 4-12. The west sidewalk-bikeway is likewise shown, separated from the west curb line of Stange Road by a clearance distance of 17 feet.

Stange Road and South Drive-East Road (Intersection No. 2, Figure 4-12)

No modifications of this intersection are contemplated for either existing or future conditions.

Stange Road and Pammel Drive (Intersection No. 3, Figure 4-12)

This intersection was found to be deficient relative to its present layout and existing traffic conditions. Furthermore, it does not appear practical to design this intersection to accommodate any level of service higher than Level "D", based on present traffic volumes.

Future traffic volumes, appearing to decrease somewhat on Pammel Drive, but to generally increase on Stange Road, may result in traffic conditions comparable to existing conditions. Available traffic projection data for 1995 is preliminary in nature and no turning volume data is available.

The extent of intersection improvements necessary to meet the operational qualities or characteristics of Level of Service "D" are quite extensive, as was indicated earlier in this chapter. Such improvements are indicated in Figure 4-12 relative to the intersection proper, including sidewalk-bikeways and relocation of traffic signals. Figure 4-13 indicates the recommended improvements for the respective approaches of the intersection, although not in as much detail as that shown in Figure 4-12. Such improvements of Pammel Drive are expected to include adjustments in or relocation of such items as street lights, traffic signals, trees, sidewalks, parking areas, pavement and drainage.

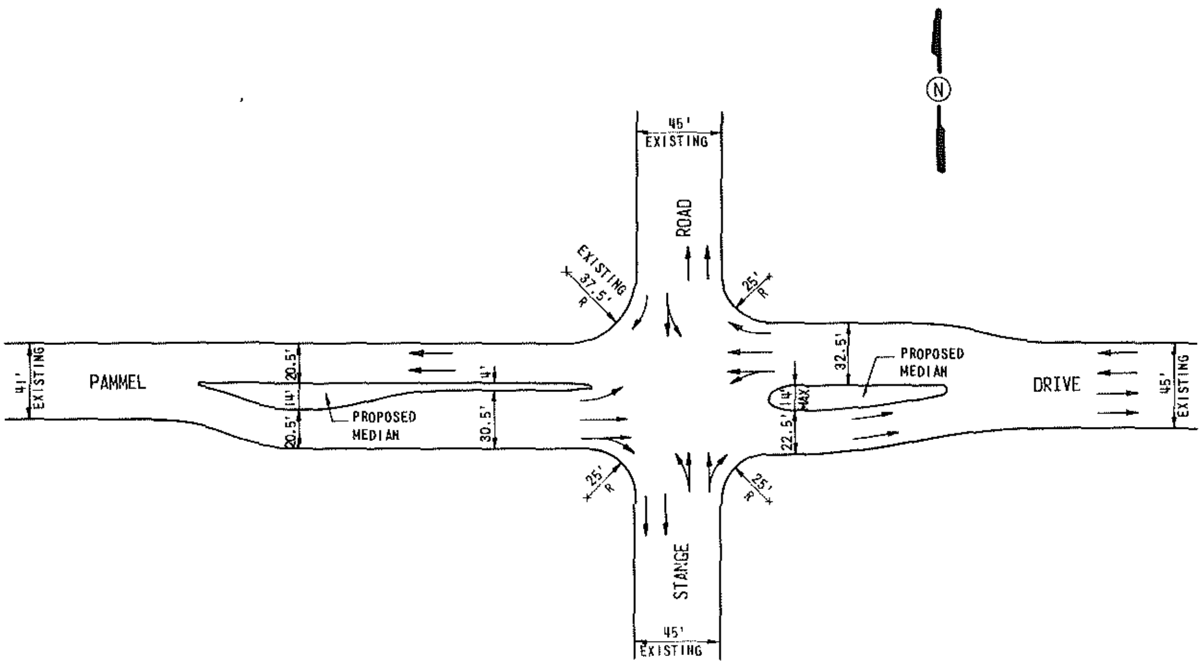


Fig. 4-13. Recommended Street Layout in Vicinity of Intersection of Stange Road and Pammel Drive.

Bissell Road and Pammel Drive Intersection (Intersection No. 4, Figure 4-12)

All approaches to the present intersection operate at Level of Service "C" or better, except for the left-turn lane on the east approach, as was previously noted in this report.

Provision of a separate left-turn lane for such traffic, within the present roadway of Pammel Drive, along with the removal of the bike lanes from within the pavement surface, will result in a Level of Service "C" at this intersection. (See Figure 4-12.)

The extension of Bissell Road northerly of Pammel Drive, along with the westerly extension of Kooser Drive was previously discussed and recommended. With the northerly extension of Bissell Road as a 45-foot wide pavement and the construction of left-turn lanes within existing Pammel Drive, the resulting intersection is expected to operate at capacity relative to Condition I, whereby Bissell Road is open between Union Drive and Pammel Drive. In order for the intersection to operate at Level of Service "C", two-lane approaches plus separate left-turn lanes may be required on all four approaches. However, with Bissell Road closed to through traffic between Union Drive and Pammel Drive, Condition II previously described, the intersection should operate at Level of Service "C" with left-turn lanes on Pammel Drive and 45-foot wide pavement north and south on Bissell Road.

Upon completion of the various future roadway extensions and the closure of Bissell Road to through traffic south of Pammel Drive, the intersection improvements shown in Figure 4-12 are expected to accommodate a Level of Service "D" or "C", depending upon traffic volumes.

It is therefore recommended that Bissell Road be extended north of Pammel Drive as a 45-foot wide pavement and that separate left-turn lanes be constructed within the pavement of Pammel Drive. Sidewalk-bikeway and pedestrian provisions are likewise recommended, according to Figure 4-12.

Bissell Road and Union Drive Intersection (Intersection No. 5, Figure 4-12)

No changes are contemplated relative to the pavement layout at this intersection. Changes in pedestrian and traffic signals are recommended to eliminate present deficiencies in signalization.

Recommended sidewalk-bikeway facilities are indicated in Figure 4-12.

Upon the future closure of Bissell Road to through traffic between Union Drive and Pammel Drive, traffic volumes should decrease considerably at this intersection. At such time, the primary traffic movements will remain as they presently exist, being heaviest on the north and west approaches. If traffic volumes decrease considerably at such future time, signalization might possibly be no longer needed.

Wallace Road and Union Drive Intersection (Intersection No. 6, Figure 4-14)

The existing pavement geometrics of the intersection of Wallace Road and Union Drive are satisfactory for the accommodation of existing pedestrian, bicycle and vehicular traffic volumes at Level of Service "C" or better.

Existing signalization does not, however, provide satisfactorily for the movements of bicycle and pedestrian traffic, as was previously noted. Suggested sidewalk-bikeways are indicated in Figure 4-14, while recommended signalization is discussed separately.

Future traffic volumes may be considerably less than existing upon completion of various roadway extensions, including that of Elwood Drive.

Wallace Road and North Richardson Court Intersection (Intersection No. 7, Figure 4-14)

No revisions of the pavement are recommended at this stop sign controlled intersection, although signing revisions were previously noted in Chapter 2.

As was also discussed in Chapter 2, there may be more potential for vehicle-pedestrian conflicts if the present diagonal crosswalk is removed, when considering the observed numbers of pedestrians and vehicular traffic movements. Pedestrians must often look back over their shoulders to observe approaching vehicles on each of the three street approaches while using this diagonal crossing. From this standpoint, pedestrians appear much more vulnerable than the previously cited figures indicate. It is recommended that the diagonal crosswalk be removed and that pedestrians use the south and west crosswalks.

Future street extensions, as previously noted, may reduce the amount of vehicular traffic on Wallace Road and thus reduce the potential for vehicle-pedestrian conflicts.

Wallace Road and South Richardson Court Intersection (Intersection No. 8, Figure 4-14)

Present intersection geometrics are satisfactory at this intersection, based on existing levels of pedestrian, bicycle and vehicular movements.

Wallace Road and Osborn Drive-Sixth Street Intersection (Intersection No. 9, Figure 4-14)

This intersection is the most deficient of any of the intersections analyzed, as is evident upon reference to Figure 2-15 in Chapter 2. The movement of traffic on and between Wallace Road and Sixth Street, with resulting high volumes of turning and through traffic, accounts for the low levels of service on the north, south and east legs of this intersection.

Based on the design hourly volumes shown in Figure 2-5, the intersection could be expected to operate at capacity conditions, Level of Service "E", by the addition of a right-turn lane on either the east or south approach and through traffic signalization modifications.

In order for the intersection to function at Level of Service "C", extensive changes would be necessary, including the addition of left-turn lanes on Wallace Road, both north and south of Osborn Drive and the addition of right-turn lanes on Wallace Road south of Sixth Street and on Sixth Street east of Wallace Road. These improvements would extend north and south on Wallace Road and east on Sixth Street and would necessitate the modifications of sidewalks, street lights, traffic signals, pavement, drainage and landscaping. A sketch of this intersection is shown in Figure 4-3.

The future extension of Pammel Drive, easterly of Wallace Road, and intersecting with Sixth Street in the vicinity of Haber Road, was previously mentioned. Such an extension would reduce traffic volumes at the present intersection of Wallace Road and Osborn Drive-Sixth Street, as was also previously noted relative to Conditions I and II. Based on estimated traffic volumes at the existing intersection, resulting from the aforementioned Condition II, no intersection modifications will be necessary for operation at Level of Service "C", other than modifications in traffic signal timing and phasing.

In view of the aforementioned future extension of Pammel Drive, it is recommended that a right-turn lane be added to the south approach and that traffic signal modifications accompany such intersection revisions. Upon extension of Pammel Drive, this right-turn lane may continue in use, whereby a right-turn lane on the east approach would be of no significant value at such time. Figure 4-14 includes the proposed layout for this intersection, while Figure 4-15 includes a sketch of the intersection and the entire proposed right-turn lane on Wallace Road.

An unmarked on-street bike route is currently located along the south side of Osborn Drive westerly of Wallace Road. Bicycles share the southern-most lane of Osborn Drive in the vicinity of the intersection until crossing to the east side of the intersection via the south crossing area. East of Wallace Road, a separate sidewalk-bikeway exists. Due to the vulnerability of conflicts between bicyclists and right-turning motorists on Osborn Drive, it is recommended that the marked on-street bicycle lane that presently proceeds east of Knoll Road (See Figure 2-2, Chapter 2) be terminated at the first driveway west of Wallace Road. It is further recommended that bicycle traffic be transferred to the existing sidewalk-bikeway at such driveway and that a new sidewalk-bikeway be constructed parallel to the Osborn Drive pavement easterly of the point of curvature of the existing sidewalk-bikeway. (See Figure 4-14.) With the indicated sidewalk-bikeway improvements at this intersection, bicyclists may more safely cross Wallace Road.

It is further recommended that the south lane of the existing west approach be signed and marked as an exclusive right-turn lane, as eastbound Sixth Street becomes essentially one-lane in width easterly of Wallace Road.

Sixth Street and Physical Plant Entrance Intersection (Intersection No. 10, Figure 4-14)

No intersection modifications are recommended for this intersection.

Sixth Street and Haber Road Intersection (Intersection No. 11, Figure 4-14)

No intersection modifications are recommended for this intersection.

TRAFFIC SIGNALIZATION

Recommendations relative to pedestrian signals have been previously included in this chapter, under the heading of "PEDESTRIAN OPERATIONS". Such recommendations shall be considered as being a part of the recommendations for "TRAFFIC SIGNALIZATION" also.

Various deficiencies in existing traffic and pedestrian signal timing and phasing have been previously noted throughout this report,

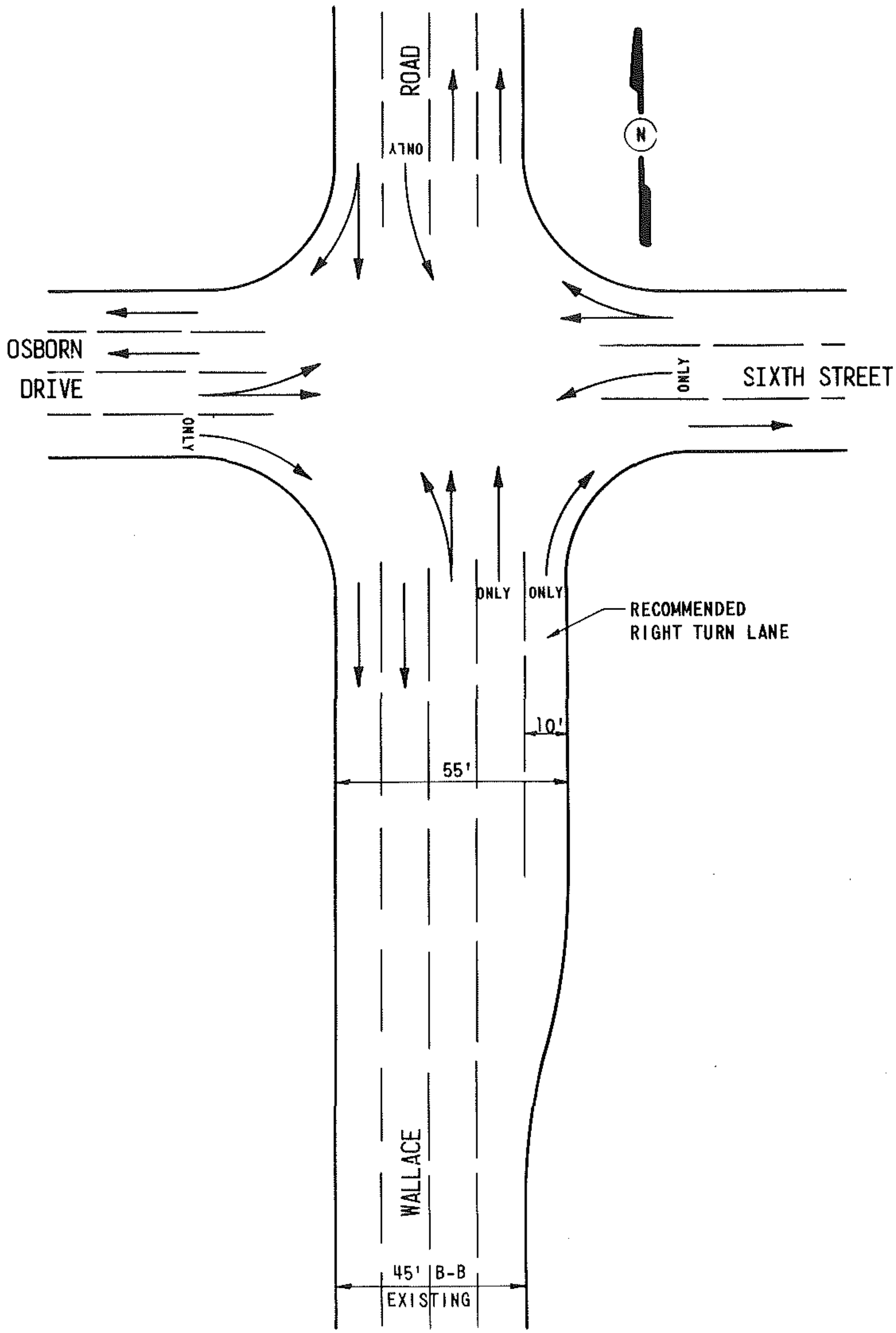


Fig. 4-15. Recommended Street Layout in Vicinity of Intersection of Wallace Road & Osborn Drive-Sixth Street.

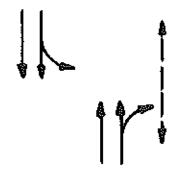
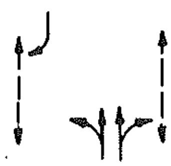
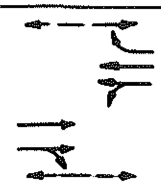
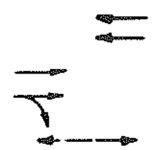
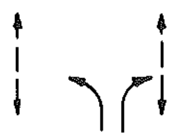
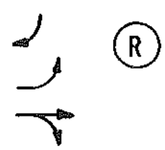
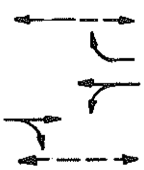
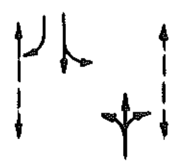
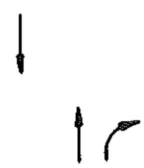
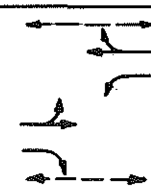
in addition to intersection deficiencies. It is recommended that revisions be made in existing traffic signalization, in addition to the aforementioned modifications in intersection layouts.

The initial changes in traffic signal phasing are suggested for the period of time that current traffic circulation patterns and conditions continue to exist. Figure 4-16 is a tabulation of suggested signal phasing for this period of time, and includes consideration of the recommended intersection modifications previously noted.

Upon subsequent extension of various roadways, as previously mentioned, additional signal modifications will be necessary to accommodate related changes in traffic movements. Suggested traffic signal phasing for such long range changes are indicated in Figure 4-17. The phasing indicated for the intersection of Bissell Road and Pammel Drive is based on the closure of Bissell Road to through traffic southerly of Pammel Drive and the extension of Bissell Road north of Pammel Drive. Such future signal phasing is based on currently available preliminary projected traffic volume data and must be revised upon formulation of more accurate traffic volume data.

Signs displaying messages as "No Right Turn On Red" or "No Turns On Red" are required where such turns are not to be permitted during red signal indications. The jurisdictions having authority to effect traffic control measures are required to install such signs in order to prohibit such traffic movements, which would otherwise be permitted. The decision to install this type of signing is generally based on safety considerations relative to pedestrian movements and/or traffic densities.

Due to such pedestrian and traffic considerations, it is recommended that "No Right Turn On Red" signs be installed at various intersections relative to the respective approaches. Figure 4-18 is a tabulation of recommendations for such signing.

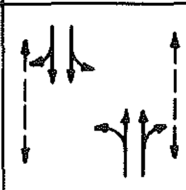
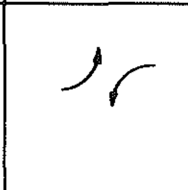
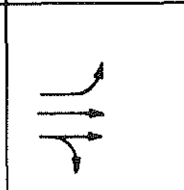
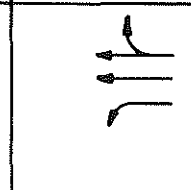
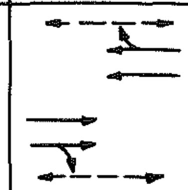
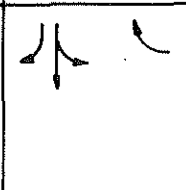
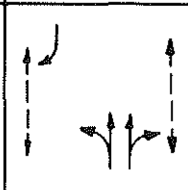
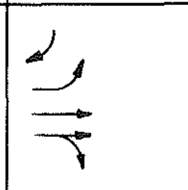
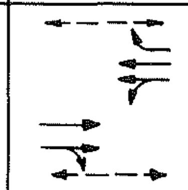
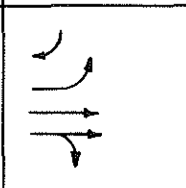
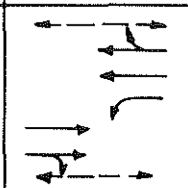
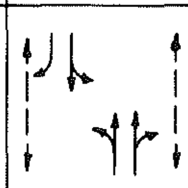
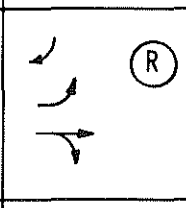
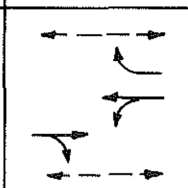
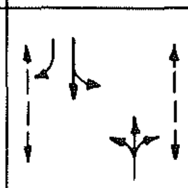
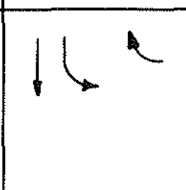
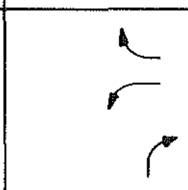
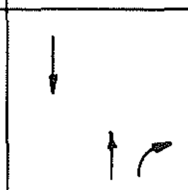
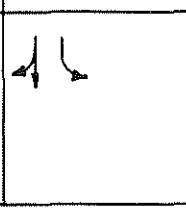
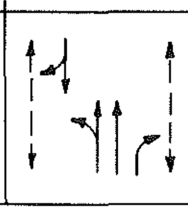
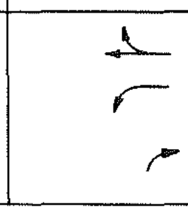
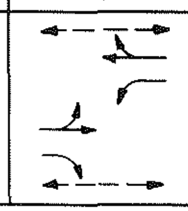
INTERSECTION	TRAFFIC SIGNAL PHASE			
	A	B	C	D
STANGE ROAD AND THIRTEENTH STREET	CONTINUE TURNED OFF			N.A.
STANGE ROAD AND PAMMEL DRIVE				
BISSELL ROAD AND PAMMEL DRIVE				N.A.
BISSELL ROAD AND UNION DRIVE				N.A.
WALLACE ROAD AND UNION DRIVE				
WALLACE ROAD AND OSBORN DRIVE -- SIXTH STREET				

N.A. = NOT APPLICABLE.

←---→ PEDESTRIAN AND/OR BICYCLE MOVEMENTS PERMITTED BY SIGNALIZATION.

(R) RECOMMENDENDED THAT "RECALL" SWITCH BE TURNED TO "ON" POSITION IN CONTROL CABINET FOR PHASE INDICATED.

Fig. 4-16. Suggested Traffic Signal Phasing for Existing Conditions and Recommended Intersection Modifications.

INTERSECTION	TRAFFIC SIGNAL PHASE				
	A	B	C	D	E
STANGE ROAD AND THIRTEENTH STREET					
STANGE ROAD AND PAMMEL DRIVE					N.A.
BISSELL ROAD AND PAMMEL DRIVE				N.A.	N.A.
BISSELL ROAD AND UNION DRIVE				N.A.	N.A.
WALLACE ROAD AND UNION DRIVE					N.A.
WALLACE ROAD AND OSBORN DRIVE--SIXTH STREET					N.A.

N.A. = NOT APPLICABLE.

←---→ PEDESTRIAN AND/OR BICYCLE MOVEMENTS PERMITTED BY SIGNALIZATION.

(R) RECOMMENDED THAT "RECALL" SWITCH BE TURNED TO "ON" POSITION IN CONTROL CABINET FOR PHASE INDICATED.

Fig. 4-17. Suggested Traffic Signal Phasing for Future Conditions, Including Extensions of Roadways.

Intersection	"No Right Turn On Red" Signs			
	Approach			
	N	S	W	E
Stange Road & Thirteenth Street	X*	X*	X*	X*
Stange Road & Pammel Drive	---	X	X	X
Bissell Road & Pammel Drive	N.A. Present	---	X	N.A. Present
Bissell Road & Union Drive	X	---	---	X
Wallace Road & Union Drive	N.A.	X	N.A.	X
Wallace Road & Osborn Drive-Sixth Street	---	X	---	---

"X" indicates recommended sign for approach
* future condition only
N.A. = not applicable

Fig. 4-18. Recommended "No Right Turn On Red" Signs

CHAPTER 5
SUMMARY OF RECOMMENDATIONS

SCOPE

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

SUMMARY OF RECOMMENDATIONS

Traffic Control Devices

Signs:

1. Replace existing "4-Way" stop sign plates to conform with requirements of the MUTCD at the intersection of Union Drive and Knoll Road.
2. Replace existing "Yield" signs at the intersection of Union Drive and Welch Road to conform with requirements of the MUTCD.
3. Remove "Yield" sign at west side of Wallace Road and north of North Richardson Court. Move existing "School Crossing" sign closer to North Richardson Court and provide "School Advance" sign further north on the west side of Wallace Road.
4. Remove portable pedestrian crossing signs along Pammel Drive. Install two-piece "Ped-Xing" signs with yellow hazard identification beacons for each such crosswalk and for each direction of travel along Pammel Drive.
5. Remove special-purpose sign on Union Drive and east of Morrill Road at the division point of one-way and two-way traffic on Union Drive.

Place "Dead End" sign west of Knoll Road relative to westbound Union Drive traffic. Erect "Do Not Enter" signs on both sides of Union Drive relative to westbound traffic and west of the parking lot entrance to the Memorial Union. Place "Left Lane Ends" sign relative to eastbound traffic on Union Drive at a point east of Morrill Road. Install a "Lane Ends Merge Right" sign on Union Drive and east of the west crosswalk to the Memorial Union, relative to eastbound Union Drive traffic. Provide pavement markings for eastbound traffic lane delineation.

6. Provide "One Way" and "Do Not Enter" signs on South Richardson Court, west of Wallace Road.
7. Provide "No Right Turn" and "No Left Turn" signs on Wallace Road, north and south respectively of its intersection with South Richardson Court.
8. Install "One Way" signs at each end of the drop-off lane near the west entrance of the Memorial Union.
9. Erect "One Way" signs on Morrill Road and south of Osborn Drive.
10. Remove existing "Stop" signs at the south side of Osborn Drive relative to northbound traffic on Morrill Road and Knoll Road.
11. Provide "Lane Use" signs in conjunction with pavement arrow markings where mandatory lane usage is recommended.
12. Provide "No Right Turn on Red" signs in accordance with data in Figure 4-18, page 139.
13. Install new speed limit signs relative to speed limits revised as part of this study.

14. Provide signs for each pedestrian push-button detector to clearly indicate which crosswalk is controlled by each such detector.
15. Where medians are added, such as at the intersection of Stange Road and Pammel Drive and at Bissell Road and Pammel Drive, provide two-piece "Divided Highway" signs in advance of the beginning of medians and two-piece "Divided Highway Ends" signs near the termination of such medians.

Pavement Markings:

1. Implement a regular maintenance program to insure good condition for all markings.
2. Enlarge pavement arrow markings, as existing arrows are too small to be effective.
3. For mandatory lane usage, provide pavement arrow markings along with word "Only".
4. Paint new crosswalk lines where pedestrian crossings are moved to different locations.

Traffic Signals:

1. Reduce length of maximum green signal timings to decrease delays.

2. Revise signal phasing in accordance with Figure 4-16, page 137, relative to the short range period and with Figure 4-17, page 138, for long range or future conditions. Also refer to Appendix of report for additional signal phasing and signal head data.

Pedestrian Signals:

1. Provide rectangular "Walk" and "Don't Walk" pedestrian signals at all signalized crosswalks.
2. Install pedestrian signals on separate poles at the southeast corner of Stange Road and Thirteenth Street; at the southwest corner of Bissell Road and Pammel Drive; at the southeast corner of Bissell Road and Union Drive and at the northeast corner of Wallace Road and Osborn Drive-Sixth Street.
3. Install pedestrian push-button detectors for each crosswalk, located to be readily accessible to pedestrian traffic.
4. Time pedestrian signals in accordance with requirements of the MUTCD (See Figure 4-4, page 97). Provide a minimum of seven seconds of "Walk" or "Flashing Walk" indications, except at Stange Road and Thirteenth Street where a five-second interval is recommended.
5. Provide Flashing Walk - Flashing Don't Walk - Steady Don't Walk sequence of pedestrian indications at all signalized intersections, except at Wallace Road and Union Drive. It is recommended that an exclusive pedestrian phase be provided at the latter, whereby a Steady Walk - Flashing Walk - Steady Don't Walk sequence is to be provided.

Speed Studies

1. Increase the speed limit on Sixth Street from the current 25 miles per hour to 30 miles per hour east of Haber Road within the boundaries of Iowa State University.

Road Extensions

Bissell Road (North of Pammel Drive):

1. Extend Bissell Road north of Pammel Drive to a westerly extension of Kooser Drive in the short range period. This will provide relief to Pammel Drive in that an intersectional outlet will be provided for the parking lots north of Pammel Drive.
2. A detailed investigation is recommended to determine the feasibility of extending Bissell Road further north to intersect with Thirteenth Street in the future.

Sheldon Avenue (Northerly to Pammel Drive):

1. Beginning at the curve north of the intersection of West Street-Union Drive, construct Sheldon Avenue north to Pammel Drive.
2. Change Pammel Drive west of such extension (Cemetery Hill) to a one-way westbound facility.
3. Reconstruct the intersection of existing Sheldon Avenue and its junction with the extension of Sheldon Avenue.

Pammel Drive-Sixth Street Connection:

1. Extended Pammel Drive east and then southeasterly of Wallace Road to join with existing Sixth Street. This junction is recommended to be west of the future intersection of Elwood Drive and Sixth Street and may be either at or east of Sixth Street's intersection with Haber Road.
2. Sixth Street is recommended to remain in operation between Wallace Road and the aforementioned new street.

Thirteenth Street:

1. Although not within the jurisdiction of Iowa State University, it is recommended that Thirteenth Street be extended west of Stange Road and north of Iowa State University. Traffic not destined for the University will thereby bypass the University and more particularly Pammel Drive.

Future Crosswalks

1. Consider the following as potential future signalized crosswalk:

   West and south crosswalks at the intersection of Stange Road and Thirteenth Street.

   South and east crosswalks at the intersection of Bissell Road and Pammel Drive.

   West crosswalk at the intersection of Wallace Road and Osborn Drive.

   West crosswalk at the intersection of Wallace Road and Pammel Drive.

Bike Lanes

1. Allow at least two feet of horizontal clearance between the face of curb and any sidewalk or sidewalk-bikeway.
2. Allow at least ten inches horizontal clearance between bicycle traffic and fixed objects. If poles or other like features are located between the bikeway and the street, clearance between bikeway and street should be at least four to six feet.
3. Sidewalk bikeway widths should be at least six feet and preferably nine feet in width.

4. All future on-street bike lanes should be one-way lanes with movement in the same direction as that of vehicular traffic. Such lanes should be at least four feet and preferably six to nine feet in width.
5. Off-set sidewalk-bikeways in the vicinity of intersections to provide at least seventeen feet of clearance between the crosswalk and the near edge of vehicular traffic on the parallel street.

Parking Lot Entrances

1. Restrict the driveway north of Pammel Drive and west of Stange Road to one-way westbound.
2. Close the parking lot entrance north of Pammel Drive and west of Tower Road.
3. Close two of the three entrances to the south of Pammel Drive to the Armory Parking Lot.

Intersection Improvements

Stange Road and Thirteenth Street (See Figure 4-12, Intersection No. 1, page 125):

1. Shift existing east crosswalk approximately 11 feet further east and realign existing sidewalk in the vicinity of the intersection.

Stange Road and Pammel Drive (See Figure 4-12, Intersection No. 3, page 125):

1. Add a right-turn lane on the east approach and a left-turn lane on the west approach relative to Pammel Drive, with the addition

of medians and other pavement modifications. (Also See Figure 4-13, page 126.)

2. Modify sidewalks in vicinity of intersection improvements.

Bissell Road and Pammel Drive (See Figure 4-12, Intersection No. 4, page 125):

1. Remove on-street bike lane from north edge of pavement and relocate to the north of the Pammel Drive pavement by the construction of a sidewalk-bikeway.
2. Construct a left-turn lane and median within the existing pavement on the east approach of Pammel Drive.
3. Construct a left-turn lane and median within the existing pavement on the west approach of Pammel Drive. This median is to line up with the median proposed for the east approach, but will not be used for left-turning movements until such time as Bissell Road is extended north of Pammel Drive.
4. Provide sidewalk-bikeway improvements in the vicinity of the intersection.

Bissell Road and Union Drive (See Figure 4-12, Intersection No. 5, page 125):

1. Provide sidewalk-bikeway improvements in the vicinity of the intersection.

Wallace Road and Union Drive (See Figure 4-14, Intersection No. 6, page 130):

1. Provide sidewalk-bikeway improvements in the vicinity of the intersection at the east and north crosswalks.

Wallace Road and North Richardson Court (See Figure 4-14, Intersection No. 7, page 130):

1. Remove diagonal crosswalk between northwest and southeast corners of intersection.
2. Provide sidewalk-bikeway improvements in the vicinity of the intersection.

Wallace Road and South Richardson Court (See Figure 4-14, Intersection No. 8, page 130):

1. Provide sidewalk-bikeway improvements in the vicinity of the intersection.

Wallace Road and Osborn Drive-Sixth Street (See Figure 4-14, Intersection No. 9, page 130):

1. Add a right-turn lane on the south approach (also see Figure 4-15, page 134).
2. Remove existing on-street bike lane from south side of west approach. Transfer to the proposed off-street sidewalk-bikeway on the south side of Osborn Drive.
3. Provide signing and pavement marking to designate the south lane of the west approach as a mandatory right-turn lane.

CHAPTER 6
ESTIMATED COST AND STAGING OF IMPROVEMENTS

SCOPE

The estimated costs of the recommendations contained in this report are included in this chapter, along with suggested staging of improvements.

ESTIMATED COSTS OF RECOMMENDED IMPROVEMENTS

Cost estimates are included hereinafter relative to individual intersections or special areas. No costs have been included for extensions of the respective roadways nor for modifications associated with such extensions, including traffic signals, signing, marking, sidewalks, street lights, drainage or other such items. Included cost estimates therefore are for modifications necessary for the improvement of traffic flow and safety relative to existing conditions.

Stange Road and Thirteenth Street Intersection

Pedestrian signals, push-button detectors & controls	$ 3,900.00
Sidewalk Improvements	1,100.00
Total Estimated Cost for Intersection	$ 5,000.00

Stange Road and Pammel Drive Intersection

Traffic Signal Modifications	
Mast-arm pole assemblies	$ 10,000.00
Pedestrian signals, push-button detectors & controls	8,000.00
Signal Phasing Modifications	4,000.00
Pavement Improvements	25,000.00
Sidewalk Improvements	10,000.00
"No Right Turn On Red" Signs	100.00
Lane Use Signs	50.00
"Divided Highway" Signs - 2 piece	100.00
"Divided Highway Ends" Signs - 2 piece	100.00
Utility and Drainage Modifications	3,000.00
Landscaping	500.00
Parking Lot Modifications	1,000.00
Pavement Striping and Marking	350.00
Total Estimated Cost for Intersection	$ 62,200.00

Bissell Road and Pammel Drive Intersection

Traffic Signal Modifications	
Pedestrian signals, push-button detectors & controls	$ 6,200.00
Additional signals for westbound lane	500.00
Signal Phasing Modifications	2,000.00
Pavement Improvements - Medians	9,200.00
Sidewalk Improvements	6,000.00
"No Right Turn On Red" Signs	20.00
"Divided Highway" Signs - 2 piece	100.00
"Divided Highway Ends" Signs - 2 piece	100.00
"Right Lane Ends" Sign	30.00
"Pavement Width Transition" Sign	50.00
"Large Double-Arrow" Sign	50.00
Pavement Striping and Marking	150.00
Total Estimated Cost for Intersection	$ 24,400.00

Bissell Road and Union Drive Intersection

Traffic Signal Modifications	
Pedestrian signals, push-button detectors & controls	$ 6,200.00
Signal phasing modifications	2,000.00

Sidewalk Improvements	2,800.00
"No Right Turn On Red" Signs	50.00
Pavement Striping and Marking	150.00
Total Estimated Cost for Intersection	$ 11,200.00

Wallace Road and Union Drive Intersection

Traffic Signal Modifications	
Pedestrian signals, push-button detectors & controls	$ 3,400.00
Signal phasing modifications	2,000.00
Sidewalk Improvements	1,600.00
"No Right Turn On Red" Signs	50.00
Pavement Striping and Marking	150.00
Total Estimated Cost for Intersection	$ 7,200.00

Wallace Road and North Richardson Court Intersection

"School Crossing" Signs	50.00
"School Advance" Signs	50.00
Pavement Striping and Marking	150.00
Sidewalk Modifications	3,000.00
"One-Way" Signs	50.00
Total Estimated Cost for Intersection	$ 3,300.00

Wallace Road and South Richardson Court Intersection

"One-Way" Signs	$ 150.00
"Do Not Enter" Signs	50.00
"No Right Turn" Signs	50.00
"No Left Turn" Signs	50.00
Sidewalk Modifications	1,800.00
Total Estimated Cost for Intersection	$ 2,100.00

Wallace Road and Osborn Drive-Sixth Street Intersection

Traffic Signal Modifications	
Additional Signals for Right-Turn Lane	$ 500.00

Pedestrian signals, push-button detectors & controls	8,000.00
Signal Phasing Modifications	4,000.00
Pavement Improvements	6,000.00
Sidewalk Improvements	9,800.00
"No Right Turn On Red" Signs	100.00
Lane Use Signs	50.00
Utility and Drainage Modifications	750.00
Landscaping	300.00
Pavement Striping and Marking	300.00
Total Estimated Cost for Intersection	$ 29,800.00

Pammel Drive Signing

"Ped Xing" Signs	$ 250.00
Hazard Identification Beacons	750.00
Total Estimated Cost for Pammel Drive Signing	$ 1,000.00

Union Drive Signing at Memorial Union

"Do Not Enter" Signs	$ 100.00
"Left Lane Ends" Sign	50.00
"Lane Ends Merge Right" Sign	50.00
Pavement Striping and Marking	200.00
Total Estimated Cost for Union Drive Signing at Memorial Union	$ 400.00

Union Drive and Morrill Road Intersection

"One-Way" Signs	$ 100.00

Union Drive and Knoll Road Intersection

"4-Way" Plates for existing "Stop" Signs	$ 100.00
"Dead End" Signs	50.00
Total Estimated Cost for Intersection	$ 150.00

Union Drive and Welch Road Intersection

"Yield" Signs	$ 150.00

Osborn Drive and Morrill Road Intersection

"One-Way" Signs	$ 100.00
Total Estimated Cost for Intersection	$ 100.00
TOTAL ESTIMATED COST OF IMPROVEMENTS	$147,100.00

Cost estimates relative to traffic signals, pedestrian signals and traffic signal control are to be considered as very approximate, due to the complex nature of the present traffic signal controllers and the lack of cost data for modifying such control equipment.

STAGING

The following order of priorities, relative to the respective intersections or other specific areas of concern, is suggested, based on need for improvement relative to safety, and efficiency of pedestrian, bicycle and vehicular traffic movements:

1.	Stange Road and Pammel Drive Intersection	$62,200.00
2.	Wallace Road and Osborn Drive-Sixth Street Intersection	$29,800.00
3.	Bissell Road and Union Drive Intersection	$11,200.00
4.	Wallace Road and Union Drive Intersection	$ 7,200.00
5.	Bissell Road and Pammel Drive Intersection	$24,400.00
6.	Stange Road and Thirteenth Street Intersection	$ 5,000.00

7.	Wallace Road and South Richardson Court Intersection	$ 2,100.00
8.	Wallace Road and North Richardson Court Intersection	$ 3,300.00
9.	Union Drive and Morrill Road Intersection	$ 100.00
10.	Pammel Drive Signing	$ 1,000.00
11.	Union Drive Signing	$ 400.00
12.	Union Drive and Knoll Road Intersection	$ 150.00
13.	Osborn Drive and Morrill Road Intersection	$ 100.00
14.	Union Drive and Welch Road Intersection	$ 150.00

In regard to the proposed future roadway extensions, the following order of priorities is considered as being most beneficial to relief of traffic congestion at existing intersections:

1. Extension of Thirteenth Street westerly of Stange Road
2. Extension of Pammel Drive easterly to Sixth Street
3. Extension of Bissell Road to Thirteenth Street extended
4. Extension of Bissell Road to Kooser Drive extended
5. Extension of Sheldon Avenue to Pammel Drive.

APPENDIX

SCOPE

The purpose of this appendix is to provide supplemental traffic signal phasing information and to provide additional traffic signal phasing information for the condition of constructing traffic signal improvements but not constructing pavement widening improvements.

CONDITION OF TRAFFIC SIGNAL IMPROVEMENTS WITHOUT MODIFICATION OF INTERSECTIONS

Figure A-1 is a schematic diagram of signal phasing for the three intersections for which deficiencies have been noted and intersection modifications recommended earlier in this report. This phasing is for the condition that intersection modifications are delayed until sometime later than traffic signal improvements are made.

Figures A-2 through A-4 include additional signal phasing data relative to the condition noted in relation to Figure A-1.

SUPPLEMENTAL TRAFFIC SIGNAL PHASING DATA

Figures A-5 through A-10 refer to Figure 4-16 of this report and provide additional phasing information for the condition of existing conditions and with the construction of recommended intersection modifications.

Figures A-11 through A-16 are in reference to Figure 4-17 of this report and provide additional phasing data for the condition whereby recommended intersection modifications are constructed under future conditions.

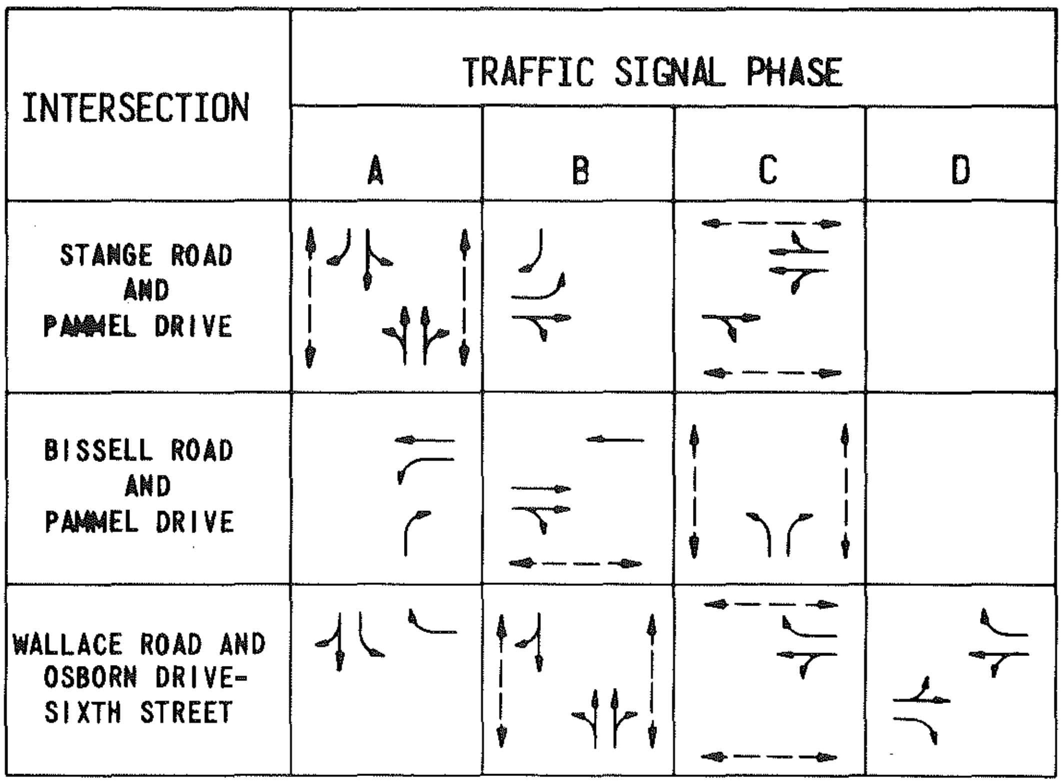
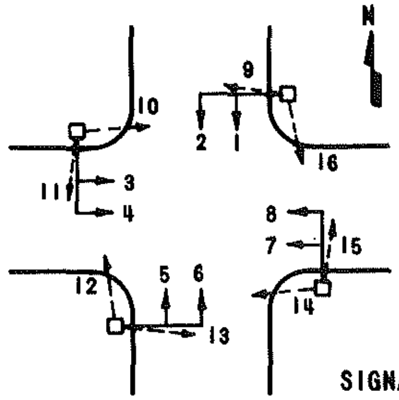
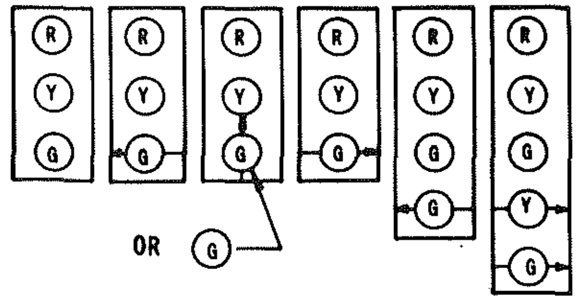


Fig. A-1. Schematic Traffic Signal Phasing for Condition of No Intersection Improvements.

INTERSECTION: STANGE RD. & PAMMEL DR.

REFERS TO FIGURE: A NO INTERSECTION MODIFICATIONS





SIGNAL NO.	SIGNAL TYPE	TRAFFIC SIGNAL PHASE									
		A		B		C		D		E	
		R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.
1	A	G	Y	R	R	R	R				
2	A	G	Y	R	R	R	R				
3	A	R	R	R	R	G	Y				
4	A	R	R	R	R	G	Y				
5	D	→	→[1]	→	Y[2]	R	R				
6	A	G	Y	R	R	R	R				
7	A	R	R	G	G[1]	G	Y				
8	B	R	R	←	Y	R	R				
9	PED. W/DW	DW	DW	DW	DW	FW	FDW				
10	PED. W/DW	DW	DW	DW	DW	FW	FDW				
11	PED. W/DW	FW	FDW	DW	DW	DW	DW				
12	PED. W/DW	FW	FDW	DW	DW	DW	DW				
13	PED. W/DW	DW	DW	DW	DW	FW	FDW				
14	PED. W/DW	DW	DW	DW	DW	FW	FDW				
15	PED. W/DW	FW	FDW	DW	DW	DW	DW				
16	PED. W/DW	FW	FDW	DW	DW	DW	DW				

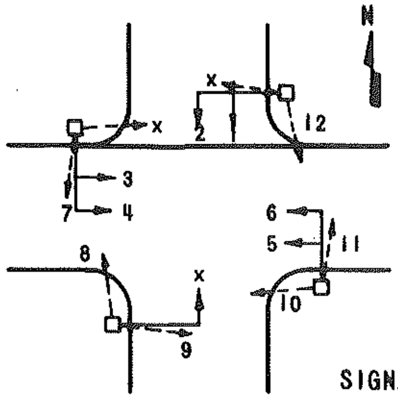
R/W: RIGHT-OF-WAY INTERVAL
CL.: CLEARANCE INTERVAL
FW: FLASHING WALK
FDW: FLASHING DON'T WALK
DW: DON'T WALK
PED. W/DW: PEDESTRIAN WALK/DON'T WALK
←↑→: GREEN ARROW

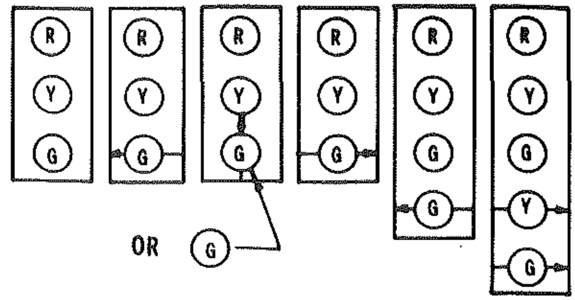
1 CIRCULAR YELLOW IF SUCCEEDING PHASE SKIPPED
2 GREEN ARROW IF PHASE C SKIPPED

Fig. A-2. Traffic Signal Phasing Chart for Intersection of Stange Road and Pammel Drive for Condition of No Intersection Improvements.

INTERSECTION: BISSELL RD. & PAMMEL DR.

REFERS TO FIGURE: A NO INTERSECTION MODIFICATIONS





SIGNAL TYPE A B C D E F

SIGNAL NO.	SIGNAL TYPE	TRAFFIC SIGNAL PHASE									
		A		B		C		D		E	
		R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.
1	D	→	Y[2]	R	R	→	→[1]				
2	B	R	R	R	R	←	Y				
3	C	↑	↑[1]	↑	Y[2]	R	R				
4	B	←	Y	R	R	R	R				
5	A	R	R	G	Y	R	R				
6	C	R	R	G	Y	R	R				
7	PED. W/DW	DW	DW	DW	DW	FW	FDW				
8	PED. W/DW	DW	DW	DW	DW	FW	FDW				
9	PED. W/DW	DW	DW	FW	FDW	DW	DW				
10	PED. W/DW	DW	DW	FW	FDW	DW	DW				
11	PED. W/DW	DW	DW	DW	DW	FW	FDW				
12	PED. W/DW	DW	DW	DW	DW	FW	FDW				

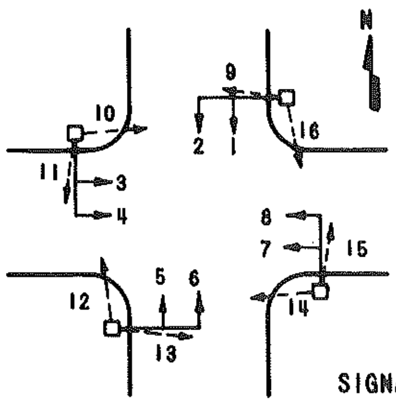
R/W: RIGHT-OF-WAY INTERVAL
CL.: CLEARANCE INTERVAL

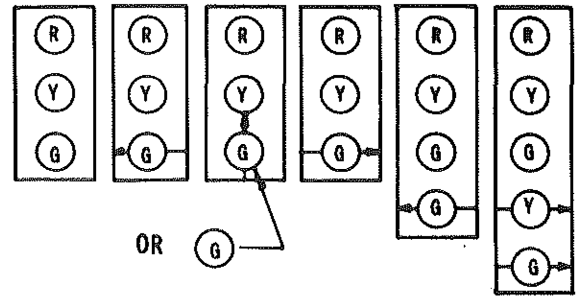
1 CIRCULAR YELLOW IF SUCCEEDING PHASE SKIPPED
2 GREEN ARROW IF SUCCEEDING PHASE SKIPPED

Fig. A-3. Traffic Signal Phasing Chart for Intersection of Bissell Road and Pammel Drive for Condition of No Intersection Improvements.

INTERSECTION: WALLACE RD. & OSBORN DR.-6TH ST.

REFERS TO FIGURE: A NO INTERSECTION MODIFICATIONS





SIGNAL TYPE A B C D E F

SIGNAL NO.	SIGNAL TYPE	TRAFFIC SIGNAL PHASE									
		A		B		C		D		E	
		R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.
1	A	R	R	G	Y	R	R	R	R		
2	A	R	R	G	Y	R	R	R	R		
3	D	→	Y [2]	R	R	→	→ [4]	→	→ [1,5]		
4	A	R	R	R	R	G	G [1]	G	Y [3]		
5	A	G	G [1]	G	Y [3]	R	R	R	R		
6	B	←	Y	R	R	R	R	R	R		
7	A	R	R	R	R	R	R	G	Y		
8	A	R	R	R	R	R	R	G	Y		
9	PED. W/DW	DW	DW	DW	DW	FW	FDW	DW	DW		
10	PED. W/DW	DW	DW	DW	DW	FW	FDW	DW	DW		
11	PED. W/DW	DW	DW	FW	FDW	DW	DW	DW	DW		
12	PED. W/DW	DW	DW	FW	FDW	DW	DW	DW	DW		
13	PED. W/DW	DW	DW	DW	DW	FW	FDW	DW	DW		
14	PED. W/DW	DW	DW	DW	DW	FW	FDW	DW	DW		
15	PED. W/DW	DW	DW	FW	FDW	DW	DW	DW	DW		
16	PED. W/DW	DW	DW	FW	FDW	DW	DW	DW	DW		

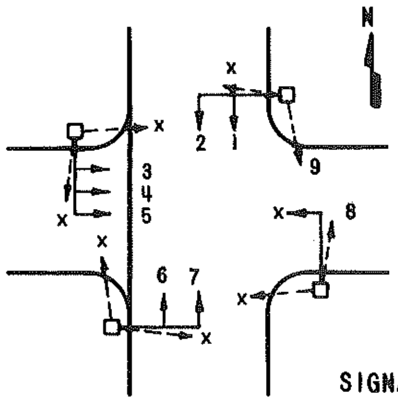
R/W: RIGHT-OF-WAY INTERVAL
CL.: CLEARANCE INTERVAL

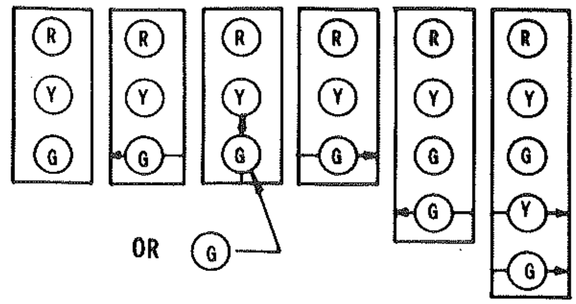
1 CIRCULAR YELLOW IF SUCCEEDING PHASE SKIPPED
2 GREEN ARROW IF SUCCEEDING PHASE SKIPPED
3 CIRCULAR GREEN IF SUCCEEDING 2 PHASES SKIPPED
4 CIRCULAR YELLOW IF SUCCEEDING 2 PHASES SKIPPED
5 REMAINS GREEN ARROW IF SUCCEEDING 2 PHASES SKIPPED

Fig. A-4. Traffic Signal Phasing Chart for Intersection of Wallace Road and Osborn Drive-Sixth Street for Condition of No Intersection Improvements.

INTERSECTION: STANGE RD. & 13TH ST.

REFERS TO FIGURE: 4-16





SIGNAL TYPE A B C D E F

SIGNAL NO.	SIGNAL TYPE	TRAFFIC SIGNAL PHASE									
		A		B		C		D		E	
		R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.
1	F	--	--	G	Y	R[1]	R[2]				
2	A	--	--	G	Y	R	R				
3	D	--	--	R	R	→	Y				
4	B	--	--	R	R	←	Y				
5	B	--	--	R	R	←	Y				
6	A	--	--	G	Y	R	R				
7	A	--	--	G	Y	R	R				
8	PED. W/DW	--	--	FW	FDW	DW	DW				
9	PED. W/DW	--	--	FW	FDW	DW	DW				

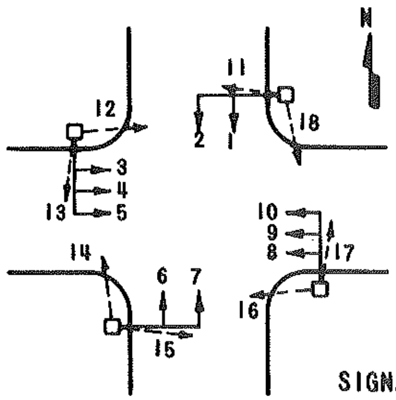
R/W: RIGHT-OF-WAY INTERVAL
CL.: CLEARANCE INTERVAL

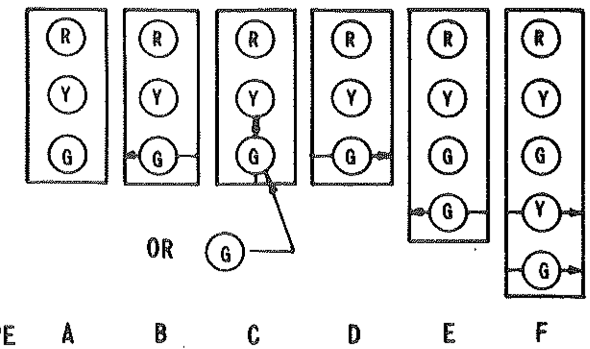
1 CIRCULAR RED WITH GREEN ARROW
2 CIRCULAR RED WITH YELLOW ARROW
NOTE: PHASE "A" TURNED OFF

Fig. A-5. Traffic Signal Phasing Chart for Intersection of Stange Road and Thirteenth Street for Existing Conditions with Intersection Modifications.

INTERSECTION: STANGE RD. & PAMMEL DR.

REFERS TO FIGURE: 4-16





SIGNAL NO.	SIGNAL TYPE	TRAFFIC SIGNAL PHASE									
		A		B		C		D		E	
		R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.
1	A	R	R	G	Y	R	R	R	R		
2	A	R	R	G	Y	R	R	R	R		
3	D	→	Y [3]	R	R	R	R	→	→ [1]		
4	C	R	R	R	R	R	R	↑	Y		
5	A	R	R	R	R	R	R	G	Y		
6	D	→	→ [4]	→	→ [1]	→	Y [2]	R	R		
7	A	G	Y	R	R	R	R	R	R		
8	A	R	R	R	R	G	G [1]	G	Y [3]		
9	C	R	R	R	R	↑	↑ [1]	↑	Y [3]		
10	B	R	R	R	R	←	Y	R	R		
11	PED. W/DW	DW	DW	DW	DW	DW	DW	FW	FDW		
12	PED. W/DW	DW	DW	DW	DW	DW	DW	FW	FDW		
13	PED. W/DW	DW	DW	FW	FDW	DW	DW	DW	DW		
14	PED. W/DW	DW	DW	FW	FDW	DW	DW	DW	DW		
15	PED. W/DW	DW	DW	DW	DW	DW	DW	FW	FDW		
16	PED. W/DW	DW	DW	DW	DW	DW	DW	FW	FDW		
17	PED. W/DW	DW	DW	FW	FDW	DW	DW	DW	DW		
18	PED. W/DW	DW	DW	FW	FDW	DW	DW	DW	DW		

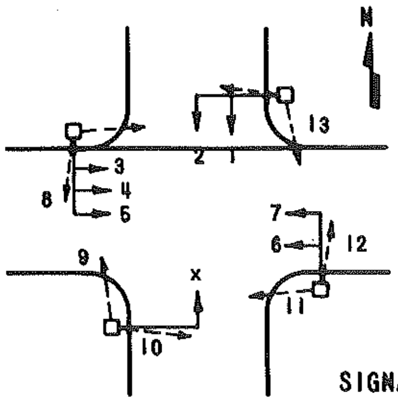
R/W: RIGHT-OF-WAY INTERVAL
CL.: CLEARANCE INTERVAL

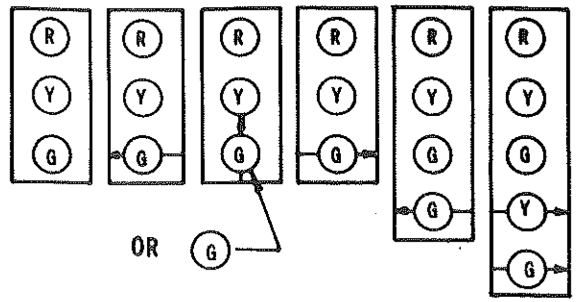
1 CIRCULAR YELLOW IF SUCCEEDING PHASE SKIPPED
2 GREEN ARROW IF PHASE D SKIPPED
3 GREEN ARROW IF SUCCEEDING 2 PHASES SKIPPED
4 CIRCULAR YELLOW IF SUCCEEDING 2 PHASES SKIPPED

Fig. A-6. Traffic Signal Phasing Chart for Intersection of Stange Road and Pammel Drive for Existing Conditions with Intersection Modifications.

INTERSECTION: BISSELL RD. & PAMMEL DR.

REFERS TO FIGURE: 4-16





SIGNAL TYPE A B C D E F

SIGNAL NO.	SIGNAL TYPE	TRAFFIC SIGNAL PHASE									
		A		B		C		D		E	
		R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.
1	D	R	R	→	→┘	→	Y [2]				
2	B	R	R	←	Y	R	R				
3	C	↑	Y [2]	R	R	↑	↑ [1]				
4	C	↑	Y [2]	R	R	↑	↑ [1]				
5	B	R	R	R	R	←	Y				
6	A	G	Y	R	R	R	R				
7	C	↑	Y	R	R	R	R				
8	PED. W/DW	DW	DW	FW	FDW	DW	DW				
9	PED. W/DW	DW	DW	FW	FDW	DW	DW				
10	PED. W/DW	FW	FDW	DW	DW	DW	DW				
11	PED. W/DW	FW	FDW	DW	DW	DW	DW				
12	PED. W/DW	DW	DW	FW	FDW	DW	DW				
13	PED. W/DW	DW	DW	FW	FDW	DW	DW				

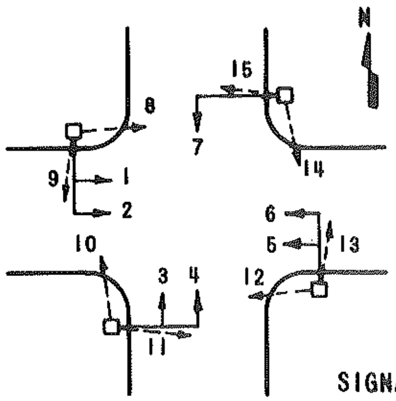
R/W: RIGHT-OF-WAY INTERVAL
CL.: CLEARANCE INTERVAL

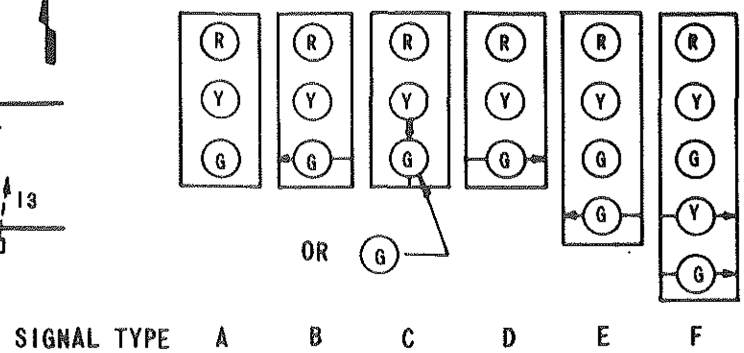
1 CIRCULAR YELLOW IF SUCCEEDING PHASE SKIPPED
2 GREEN ARROW IF SUCCEEDING PHASE SKIPPED

Fig. A-7. Traffic Signal Phasing Chart for Intersection of Bissell Road and Pammel Drive for Existing Conditions with Intersection Modifications.

INTERSECTION: BISSELL RD. & UNION DR.

REFERS TO FIGURE: 4-16





SIGNAL NO.	SIGNAL TYPE	TRAFFIC SIGNAL PHASE									
		A		B		C		D		E	
		R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.
1	D	R	R	→	Y	R	R				
2	A	R	R	G	Y	R	R				
3	D	→	Y [2]	R	R	→	→ [1]				
4	A	R	R	R	R	G	Y				
5	A	G	G [1]	G	Y [3]	R	R				
6	B	←	Y	R	R	R	R				
7	A	R	R	R	R	G	Y				
8	PED. W/DW	DW	DW	FW	FDW	DW	DW				
9	PED. W/DW	DW	DW	DW	DW	FW	FDW				
10	PED. W/DW	DW	DW	DW	DW	FW	FDW				
11	PED. W/DW	DW	DW	FW	FDW	DW	DW				
12	PED. W/DW	DW	DW	FW	FDW	DW	DW				
13	PED. W/DW	DW	DW	DW	DW	FW	FDW				
14	PED. W/DW	DW	DW	DW	DW	FW	FDW				
15	PED. W/DW	DW	DW	FW	FDW	DW	DW				

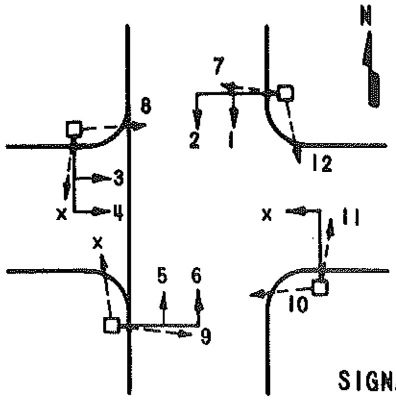
R/W: RIGHT-OF-WAY INTERVAL
CL.: CLEARANCE INTERVAL

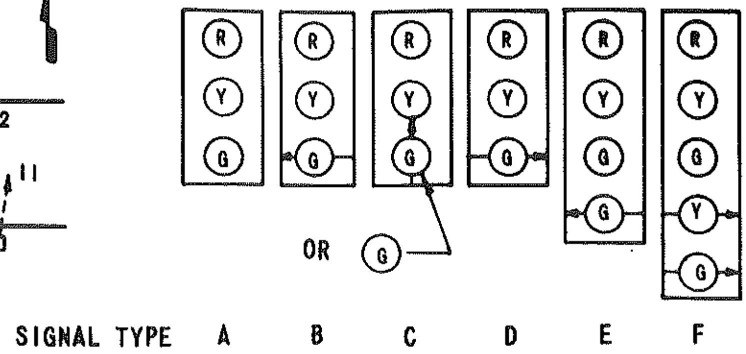
1 CIRCULAR YELLOW IF SUCCEEDING PHASE SKIPPED
2 GREEN ARROW IF SUCCEEDING PHASE SKIPPED
3 CIRCULAR GREEN IF SUCCEEDING PHASE SKIPPED

Fig. A-8. Traffic Signal Phasing Chart for Intersection of Bissell Road and Union Drive for Existing Conditions with Intersection Modifications.

INTERSECTION: WALLACE RD. & UNION DR.

REFERS TO FIGURE: 4-16





SIGNAL NO.	SIGNAL TYPE	TRAFFIC SIGNAL PHASE									
		A		B		C		D		E	
		R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.
1	D	R	R	→	→[1]	→	Y[3]	R	R		
2	C	R	R	R	R	↑	Y	R	R		
3	D	→	→[1]	→	Y[3]	R	R	R	R		
4	B	R	R	←	Y	R	R	R	R		
5	C	↑	Y[2]	R	R	↑	Y[2]	R	R		
6	B	←	Y	R	R	R	R	R	R		
7	PED. W/DW	DW	DW	DW	DW	DW	DW	W	FDW		
8	PED. W/DW	DW	DW	DW	DW	DW	DW	W	FDW		
9	PED. W/DW	DW	DW	DW	DW	DW	DW	W	FDW		
10	PED. W/DW	DW	DW	DW	DW	DW	DW	W	FDW		
11	PED. W/DW	DW	DW	DW	DW	DW	DW	W	FDW		
12	PED. W/DW	DW	DW	DW	DW	DW	DW	W	FDW		

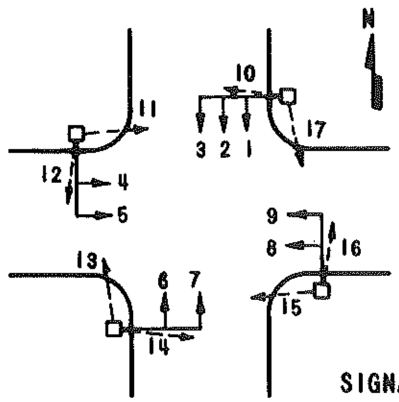
R/W: RIGHT-OF-WAY INTERVAL
CL.: CLEARANCE INTERVAL

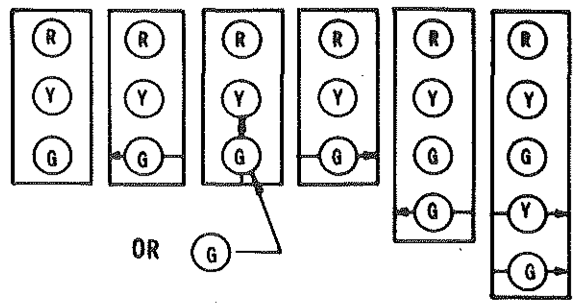
1 CIRCULAR YELLOW IF SUCCEEDING PHASE SKIPPED
2 GREEN ARROW IF SUCCEEDING PHASE SKIPPED
3 GREEN ARROW IF SUCCEEDING 2 PHASES SKIPPED

Fig. A-9. Traffic Signal Phasing Chart for Intersection of Wallace Road and Union Drive for Existing Conditions with Intersection Modifications.

INTERSECTION: WALLACE RD. & OSBORN DR.-6TH ST.

REFERS TO FIGURE: 4-16





SIGNAL TYPE A B C D E F

SIGNAL NO.	SIGNAL TYPE	TRAFFIC SIGNAL PHASE									
		A		B		C		D		E	
		R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.
1	D	R	R	→	→[1]	→	Y[3]	R	R		
2	C	R	R	↑	Y	R	R	R	R		
3	A	R	R	G	Y	R	R	R	R		
4	A	R	R	R	R	G	G[1]	G	Y[2]		
5	E	R	R	R	R	G[4]	G[1]	G	Y		
6	A	G	G[1]	G	Y[3]	R	R	R	R		
7	B	←	Y	R	R	R	R	R	R		
8	D	R	R	R	R	R	R	→	Y		
9	A	R	R	R	R	R	R	G	Y		
10	PED. W/DW	DW	DW	DW	DW	DW	DW	FW	FDW		
11	PED. W/DW	DW	DW	DW	DW	DW	DW	FW	FDW		
12	PED. W/DW	DW	DW	FW	FDW	DW	DW	DW	DW		
13	PED. W/DW	DW	DW	FW	FDW	DW	DW	DW	DW		
14	PED. W/DW	DW	DW	DW	DW	DW	DW	FW	FDW		
15	PED. W/DW	DW	DW	DW	DW	DW	DW	FW	FDW		
16	PED. W/DW	DW	DW	FW	FDW	DW	DW	DW	DW		
17	PED. W/DW	DW	DW	FW	FDW	DW	DW	DW	DW		

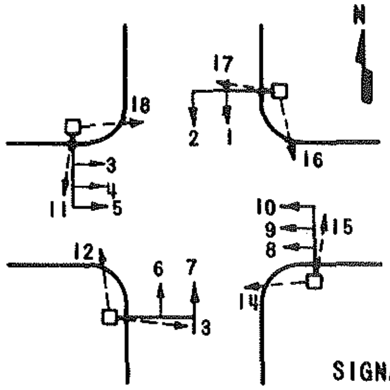
R/W: RIGHT-OF-WAY INTERVAL
CL.: CLEARANCE INTERVAL

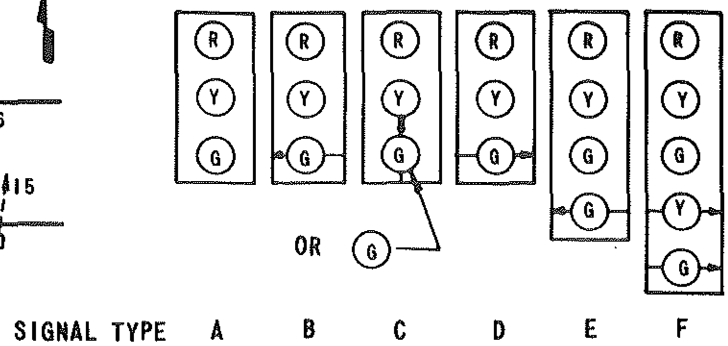
1 CIRCULAR YELLOW IF SUCCEEDING PHASE SKIPPED
2 CIRCULAR GREEN IF SUCCEEDING 2 PHASES SKIPPED
3 GREEN ARROW IF SUCCEEDING 2 PHASES SKIPPED
4 CIRCULAR GREEN WITH GREEN ARROW

Fig. A-10. Traffic Signal Phasing Chart for Intersection of Wallace Road and Osborn Drive-Sixth Street for Existing Conditions with Intersection Modifications.

INTERSECTION: STANGE RD. & 13TH ST.

REFERS TO FIGURE: 4-17





SIGNAL NO.	SIGNAL TYPE	TRAFFIC SIGNAL PHASE									
		A		B		C		D		E	
		R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.
1	A	G	Y	R	R	R	R	R	R	R	R
2	A	G	Y	R	R	R	R	R	R	R	R
3	A	R	R	R	R	R	R	G	G	G	Y
4	C	R	R	R	R	R	R	↑	↑	↑	Y
5	B	R	R	←	Y [1]	R	R	←	Y	R	R
6	A	G	Y	R	R	R	R	R	R	R	R
7	A	G	Y	R	R	R	R	R	R	R	R
8	A	R	R	R	R	G	G	R	R	G	Y
9	C	R	R	R	R	↑	↑	R	R	↑	Y
10	B	R	R	←	← [2]	←	Y	R	R	R	R
11	PED. W/DW	FW	FDW	DW	DW	DW	DW	DW	DW	DW	DW
12	PED. W/DW	FW	FDW	DW	DW	DW	DW	DW	DW	DW	DW
13	PED. W/DW	DW	DW	DW	DW	DW	DW	DW	DW	FW	FDW
14	PED. W/DW	DW	DW	DW	DW	DW	DW	DW	DW	FW	FDW
15	PED. W/DW	FW	FDW	DW	DW	DW	DW	DW	DW	DW	DW
16	PED. W/DW	FW	FDW	DW	DW	DW	DW	DW	DW	DW	DW
17	PED. W/DW	DW	DW	DW	DW	DW	DW	DW	DW	FW	FDW
18	PED. W/DW	DW	DW	DW	DW	DW	DW	DW	DW	FW	FDW

R/W: RIGHT-OF-WAY INTERVAL
CL.: CLEARANCE INTERVAL

NOTE: PHASING SEQUENCE - PHASE B TO EITHER PHASE C, D OR E
PHASE C TO PHASE E WITH PHASE D SKIPPED
PHASE E MUST FOLLOW PHASES C OR D

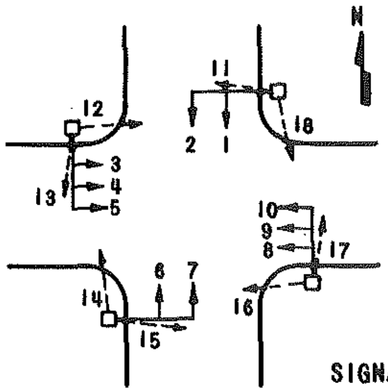
1 GREEN ARROW IF SUCCEEDING PHASE SKIPPED

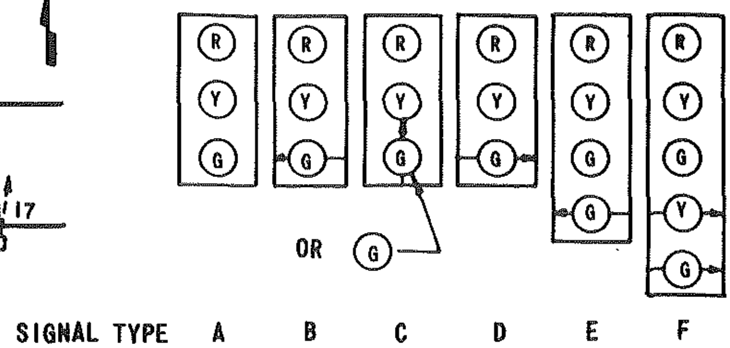
2 CIRCULAR YELLOW IF SUCCEEDING PHASE SKIPPED

Fig. A-11. Traffic Signal Phasing Chart for Intersection of Stange Road and Thirteenth Street for Future Conditions with Intersection Modifications.

INTERSECTION: STANGE RD. & PAMMEL DR.

REFERS TO FIGURE: 4-17





SIGNAL NO.	SIGNAL TYPE	TRAFFIC SIGNAL PHASE									
		A		B		C		D		E	
		R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.
1	A	R	R	G	Y	R	R	R	R		
2	A	R	R	G	Y	R	R	R	R		
3	D	→	Y[4]	R	R	R	R	→	→[1]		
4	C	R	R	R	R	R	R	↑	Y		
5	A	R	R	R	R	R	R	G	Y		
6	D	→	→[2]	→	→[1]	→	Y[3]	R	R		
7	A	G	Y	R	R	R	R	R	R		
8	A	R	R	R	R	G	G[1]	G	Y[5]		
9	C	R	R	R	R	↑	↑[1]	↑	Y[4]		
10	B	R	R	R	R	←	Y	R	R		
11	PED. W/DW	DW	DW	DW	DW	DW	DW	FW	FDW		
12	PED. W/DW	DW	DW	DW	DW	DW	DW	FW	FDW		
13	PED. W/DW	DW	DW	FW	FDW	DW	DW	DW	DW		
14	PED. W/DW	DW	DW	FW	FDW	DW	DW	DW	DW		
15	PED. W/DW	DW	DW	DW	DW	DW	DW	FW	FDW		
16	PED. W/DW	DW	DW	DW	DW	DW	DW	FW	FDW		
17	PED. W/DW	DW	DW	FW	FDW	DW	DW	DW	DW		
18	PED. W/DW	DW	DW	FW	FDW	DW	DW	DW	DW		

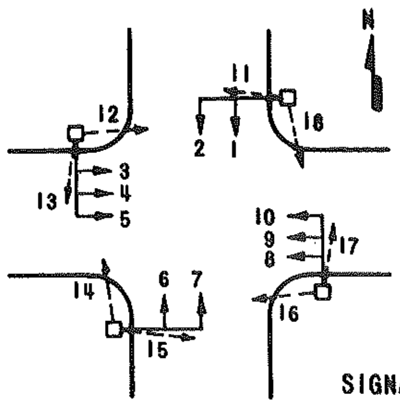
R/W: RIGHT-OF-WAY INTERVAL
CL.: CLEARANCE INTERVAL

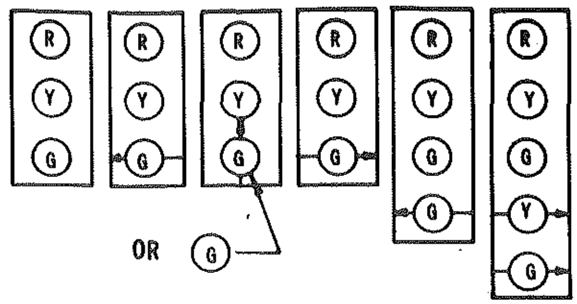
1 CIRCULAR YELLOW IF SUCCEEDING PHASE SKIPPED
2 CIRCULAR YELLOW IF SUCCEEDING 2 PHASES SKIPPED
3 GREEN ARROW IF SUCCEEDING PHASE SKIPPED
4 GREEN ARROW IF SUCCEEDING 2 PHASES SKIPPED
5 CIRCULAR GREEN IF SUCCEEDING 2 PHASES SKIPPED

Fig. A-12. Traffic Signal Phasing Chart for Intersection of Stange Road and Pammel Drive for Future Conditions with Intersection Modifications.

INTERSECTION: BISSELL RD. & PAMMEL DR.

REFERS TO FIGURE: 4-17





SIGNAL TYPE A B C D E F

SIGNAL NO.	SIGNAL TYPE	TRAFFIC SIGNAL PHASE									
		A		B		C		D		E	
		R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.
1	A	R	R	R	R	G	Y				
2	A	R	R	R	R	G	Y				
3	A	R	R	G	Y	R	R				
4	C	R	R	↑	Y	R	R				
5	A	R	R	G	Y	R	R				
6	D	→	Y [2]	R	R	→	→				
7	A	R	R	R	R	G	Y				
8	A	G	G [1]	G	Y [3]	R	R				
9	C	↑	↑ [1]	↑	Y [2]	R	R				
10	B	←	Y	R	R	R	R				
11	PED. W/DW	DW	DW	FW	FDW	DW	DW				
12	PED. W/DW	DW	DW	FW	FDW	DW	DW				
13	PED. W/DW	DW	DW	DW	DW	FW	FDW				
14	PED. W/DW	DW	DW	DW	DW	FW	FDW				
15	PED. W/DW	DW	DW	FW	FDW	DW	DW				
16	PED. W/DW	DW	DW	FW	FDW	DW	DW				
17	PED. W/DW	DW	DW	DW	DW	FW	FDW				
18	PED. W/DW	DW	DW	DW	DW	FW	FDW				

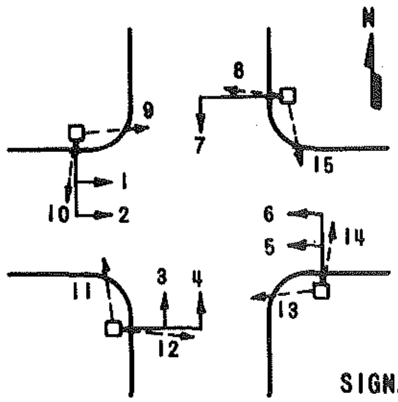
R/W: RIGHT-OF-WAY INTERVAL
CL.: CLEARANCE INTERVAL

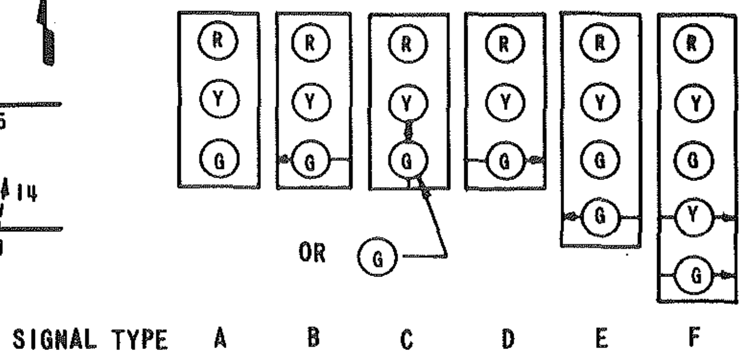
1 CIRCULAR YELLOW IF SUCCEEDING PHASE SKIPPED
2 GREEN ARROW IF SUCCEEDING PHASE SKIPPED
3 CIRCULAR GREEN IF SUCCEEDING PHASE SKIPPED

Fig. A-13. Traffic Signal Phasing Chart for Intersection of Bissell Road and Pammel Drive for Future Conditions with Intersection Modifications.

INTERSECTION: BISSELL RD. & UNION DR.

REFERS TO FIGURE: 4-17





SIGNAL NO.	SIGNAL TYPE	TRAFFIC SIGNAL PHASE									
		A		B		C		D		E	
		R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.
1	D	R	R	→	Y	R	R				
2	A	R	R	G	Y	R	R				
3	D	→	Y[2]	R	R	→	→[1]				
4	A	R	R	R	R	G	Y				
5	A	G	G[1]	G	Y[3]	R	R				
6	B	←	Y	R	R	R	R				
7	A	R	R	R	R	G	Y				
8	PED. W/DW	DW	DW	FW	FDW	DW	DW				
9	PED. W/DW	DW	DW	FW	FDW	DW	DW				
10	PED. W/DW	DW	DW	DW	DW	FW	FDW				
11	PED. W/DW	DW	DW	DW	DW	FW	FDW				
12	PED. W/DW	DW	DW	FW	FDW	DW	DW				
13	PED. W/DW	DW	DW	FW	FDW	DW	DW				
14	PED. W/DW	DW	DW	DW	DW	FW	FDW				
15	PED. W/DW	DW	DW	DW	DW	FW	FDW				

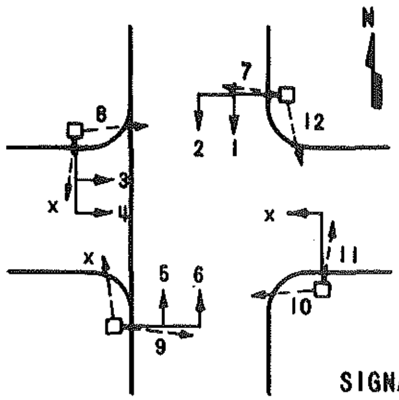
R/W: RIGHT-OF-WAY INTERVAL
CL.: CLEARANCE INTERVAL

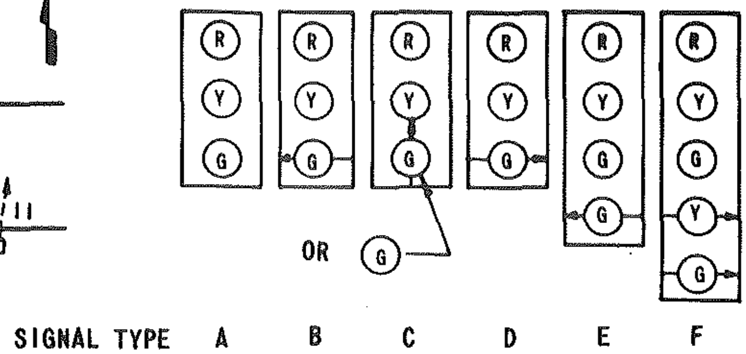
1 CIRCULAR YELLOW IF SUCCEEDING PHASE SKIPPED
2 GREEN ARROW IF SUCCEEDING PHASE SKIPPED
3 CIRCULAR GREEN IF SUCCEEDING PHASE SKIPPED

Fig. A-14. Traffic Signal Phasing Chart for Intersection of Bissell Road and Union Drive for Future Conditions and Intersection Modifications.

INTERSECTION: WALLACE RD. & UNION DR.

REFERS TO FIGURE: 4-17





SIGNAL NO.	SIGNAL TYPE	TRAFFIC SIGNAL PHASE									
		A		B		C		D		E	
		R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.
1	D	R	R	→	→[1]	→	Y[2]	R	R		
2	C	R	R	R	R	↑	Y	R	R		
3	D	→	→[1]	→	Y[2]	R	R	R	R		
4	B	R	R	←	Y	R	R	R	R		
5	C	↑	Y[3]	R	R	↑	Y[3]	R	R		
6	B	←	Y	R	R	R	R	R	R		
7	PED. W/DW	DW	DW	DW	DW	DW	DW	W	FDW		
8	PED. W/DW	DW	DW	DW	DW	DW	DW	W	FDW		
9	PED. W/DW	DW	DW	DW	DW	DW	DW	W	FDW		
10	PED. W/DW	DW	DW	DW	DW	DW	DW	W	FDW		
11	PED. W/DW	DW	DW	DW	DW	DW	DW	W	FDW		
12	PED. W/DW	DW	DW	DW	DW	DW	DW	W	FDW		

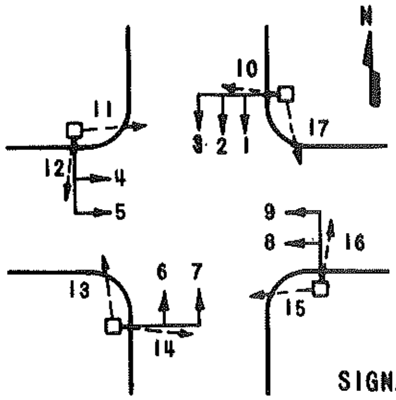
R/W: RIGHT-OF-WAY INTERVAL
CL.: CLEARANCE INTERVAL

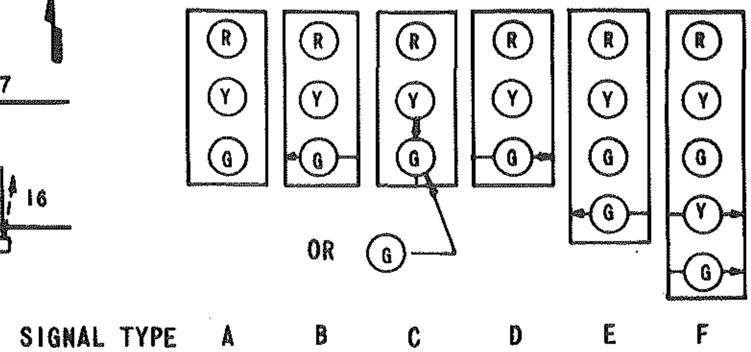
1 CIRCULAR YELLOW IF SUCCEEDING PHASE SKIPPED
2 GREEN ARROW IF SUCCEEDING 2 PHASES SKIPPED
3 GREEN ARROW IF SUCCEEDING PHASE SKIPPED

Fig. A-15. Traffic Signal Phasing Chart for Intersection of Wallace Road and Union Drive for Future Conditions with Intersection Modifications.

INTERSECTION: WALLACE RD. & OSBORN DR.-6TH ST.

REFERS TO FIGURE: 4-17





SIGNAL NO.	SIGNAL TYPE	TRAFFIC SIGNAL PHASE									
		A		B		C		D		E	
		R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.	R/W	CL.
1	D	R	R	→	→[1]	→	Y[2]	R	R		
2	C	R	R	↑	Y	R	R	R	R		
3	A	R	R	G	Y	R	R	R	R		
4	A	R	R	R	R	G	G[1]	G	Y[3]		
5	E	R	R	R	R	G[4] ←	G[1]	G	Y		
6	A	G	G[1]	G	Y[3]	R	R	R	R		
7	B	←	Y	R	R	R	R	R	R		
8	D	R	R	R	R	R	R	→	Y		
9	A	R	R	R	R	R	R	G	Y		
10	PED. W/DW	DW	DW	DW	DW	DW	DW	FW	FDW		
11	PED. W/DW	DW	DW	DW	DW	DW	DW	FW	FDW		
12	PED. W/DW	DW	DW	FW	FDW	DW	DW	DW	DW		
13	PED. W/DW	DW	DW	FW	FDW	DW	DW	DW	DW		
14	PED. W/DW	DW	DW	DW	DW	DW	DW	FW	FDW		
15	PED. W/DW	DW	DW	DW	DW	DW	DW	FW	FDW		
16	PED. W/DW	DW	DW	FW	FDW	DW	DW	DW	DW		
17	PED. W/DW	DW	DW	FW	FDW	DW	DW	DW	DW		

R/W: RIGHT-OF-WAY INTERVAL
CL.: CLEARANCE INTERVAL

1 CIRCULAR YELLOW IF SUCCEEDING PHASE SKIPPED

2 GREEN ARROW IF SUCCEEDING 2 PHASES SKIPPED

3 CIRCULAR GREEN IF SUCCEEDING 2 PHASES SKIPPED

4 CIRCULAR GREEN WITH GREEN ARROW

Fig. A-16. Traffic Signal Phasing Chart for Intersection of Wallace Road and Osborn Drive-Sixth Street for Future Conditions with Intersection Modifications.