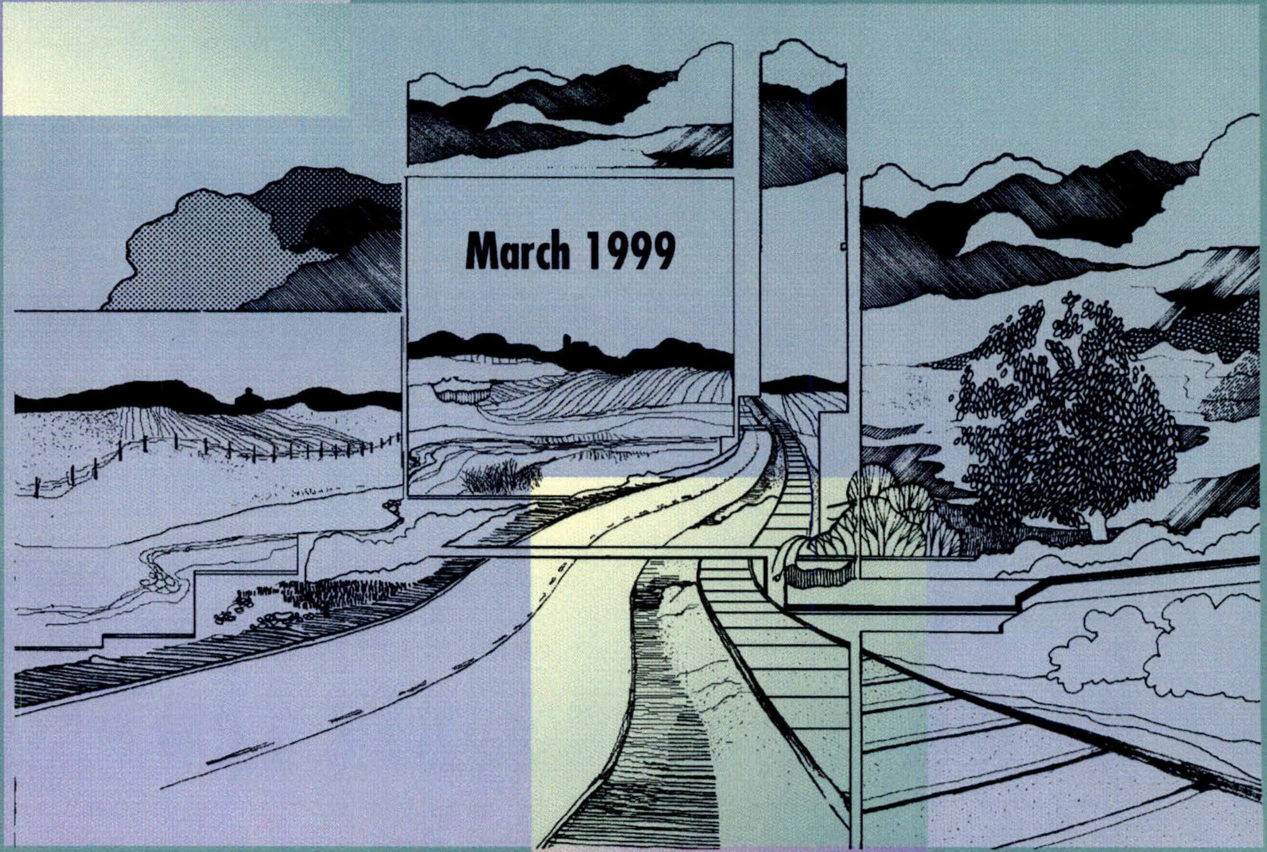
Corridor Traffic Management Study

U.S. 61 MUSCATINE BYPASS CORRIDOR

Prepared For:
Iowa Department of Transportation
City of Muscatine



March 1999

Prepared by:

SRF CONSULTING GROUP, INC.

In Association with:
Howard R. Green Company
Consulting Engineers

US 61 MUSCATINE BYPASS CORRIDOR TRAFFIC MANAGEMENT STUDY

INDEX

Page No.

INDEX
List of Figures

INDEX
List of Figures

I. INTRODUCTION

This report was prepared for the Iowa Department of Transportation to document the results of a comprehensive study of the US 61 bypass corridor in Muscatine, Iowa. The focus of the study was to address community concerns regarding traffic safety and traffic operations. In completing the study, accident and traffic volume data was collected and analyzed. Input from the public and elected officials of the Muscatine community was also obtained. The goals of the project were to:

(1) Accurately identify the nature of the types of problems and the locations where the problems were occurring,

(2) Formulate a range of possible remedial measures,

(3) Analyze and test those proposed measures,

(4) Inform the community of the nature of the traffic problems and of the proposed remedies,

(5) Seek feedback from the community on those proposed remedies,

(6) Develop a comprehensive list of recommended improvements,

(7) Develop cost estimates and assign priorities to those possible improvements.

An additional goal of this project was to identify possible Intelligent Transportation System (ITS) measures that could be used to address the safety and operations problems that have developed along this corridor. The proposed ITS measures were also to be analyzed to determine their likely benefits and their likely success if used at other locations elsewhere in Iowa.

The study area follows the US 61 bypass, from the intersection of US 61 and Grandview Avenue in the southwest, to the intersection of US 61 and the Wal-Mart access in the northeast (see Figure 1). During the time of the preparation of this study, plans were announced for the extension of University Avenue northward to connect to US 61 east of the original eastern end of the project. This new intersection will most likely be controlled by a permanent traffic signal at some point in the future. This segment of US 61 will be the first completed portion of the constructing of an eastward extension of existing four-lane divided roadway all the way to the Quad Cities area. Intersection improvements at University Avenue are scheduled for construction in 1999.

The total length of the corridor that was studied for this project is approximately 8 miles.

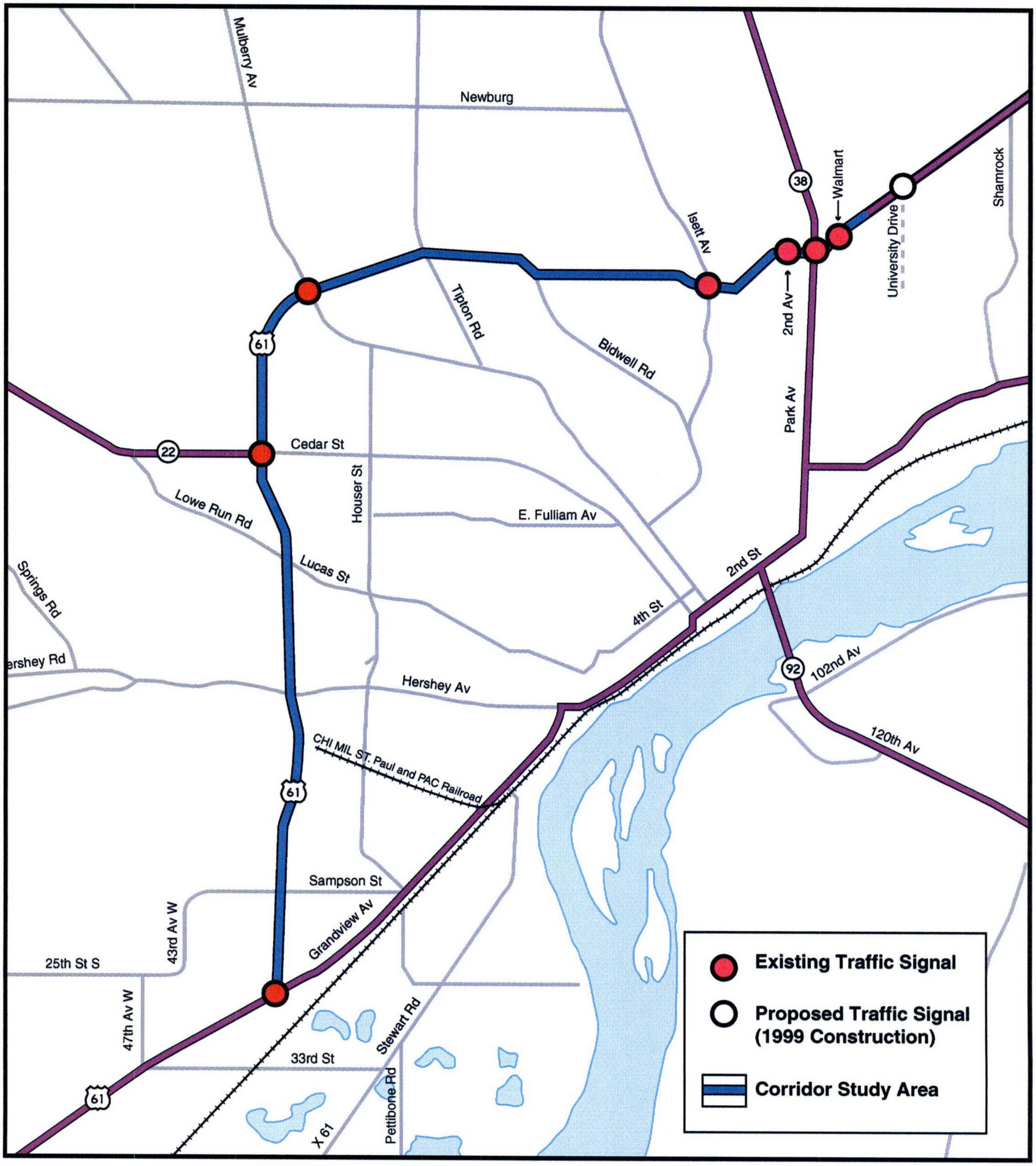


FIGURE 1
STUDY AREA

II. EXISTING CONDITIONS

A. Geometrics, Access

Along the length of the study corridor, US 61 is a four-lane divided facility. It has exclusive left turn lanes at major intersections and a semi-rural typical section with a raised grass median, but with gravel shoulders. The mainline does not have right turn lanes, with the exception of the southbound approach at Grandview Avenue and the eastbound approach at 2nd Avenue. The median is approximately 16 to 18 feet wide, not wide enough to comfortably store a vehicle to allow a two step crossing of the mainline. Figure 2 shows a typical roadway section of US 61 on the approach to a typical intersection, at a point where a full width left turn lane has been developed. Beyond the study area on either end of the bypass, US 61 is a rural two-lane highway but is programmed for four lane construction in 1999 and 2000.

Over the corridor's eight-mile length, there are twelve at-grade intersections with local roadways (including the Wal-Mart access). The three intersections at the east end (2nd Avenue, Park Avenue and Wal-Mart access) are closely spaced. The majority of commercial development along the corridor is concentrated in that area. There is no direct driveway access to commercial properties along US 61 in the area. Rather, commercial accesses are consolidated on the cross-streets and enter/exit US 61 via the three aforementioned intersections. The remainder of the corridor has a residential/rural appearance. One business north of Sampson Street has direct access to US 61, and there are a number of field entrances that have median openings, but no turn lanes.

Between Grandview Avenue and 2nd Avenue, the typical cross-street approach to US 61 has a shared left turn/through lane separated from the right turn by a raised paved island. In advance of this island, there is typically one lane of approach. The mainline approaches to the major intersections typically have left turn lanes but do not have right turn lanes. Exceptions exist at Grandview Avenue and the three intersections at the eastern end of the corridor where left turn lanes are provided on the side street approaches (2nd Avenue, Park Avenue and Wal-Mart access). Figure 3 summarizes mainline and cross street turn lane provisions at each intersection.

There is one significant mainline grade within the corridor limits, a 4 percent grade through the Hershey Avenue intersection. Northbound US 61 is the uphill direction.

B. Traffic Control

Of the twelve intersections along the US 61 corridor mentioned in the previous section, seven are currently controlled by traffic signals. Five have permanent installations: (1) Grandview Avenue, (2) Cedar Street (Iowa 22), (3) 2nd Avenue, (4) Park Avenue (Iowa 38), and (4) the Wal-Mart access. Two are temporary installations with signal indications mounted on span wires: (1) Mulberry Avenue (County Road X54), and (2) Isett Avenue. The remaining five intersections are controlled by stop signs on the cross-street.

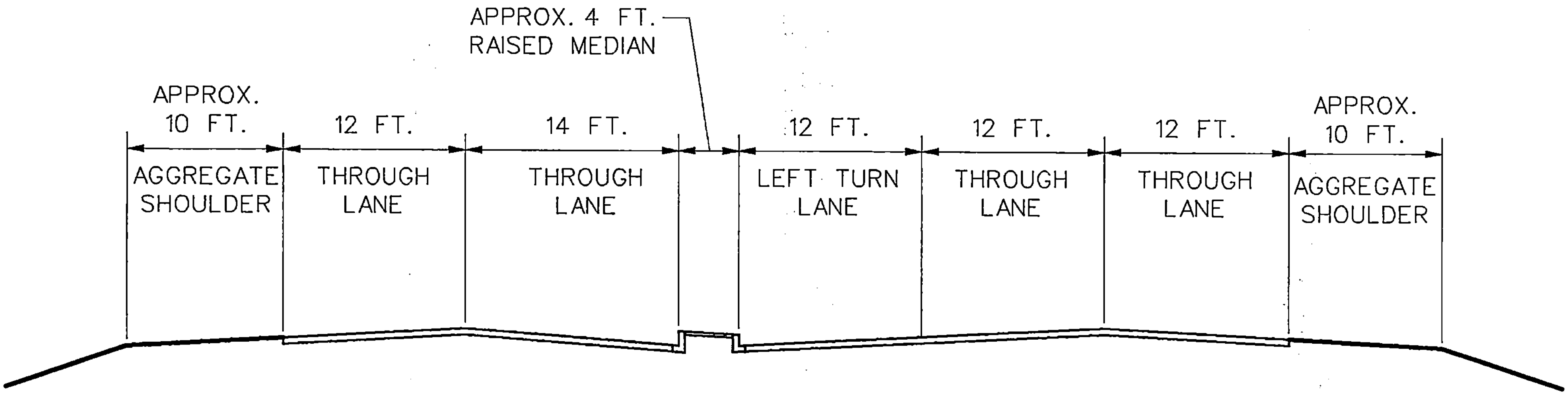


FIGURE 2

EXISTING U.S. 61 ROADWAY SECTION ON THE APPROACH TO A TYPICAL INTERSECTION

Intersection	Mainline	Cross Street
Wal-Mart Entrance	Left Turn Lanes	Left Turn Lanes Right Turn Lane on Southbound Approach
Park Avenue / Hwy. 38	Left Turn Lanes	Left Turn Lanes Right Turn Lane on Northbound Approach
2nd Avenue	Left Turn Lanes Right Turn Lane on Eastbound Approach	Left Turn Lanes
Isett Avenue	Left Turn Lanes	No Turn Lanes
Bidwell Road	Left Turn Lanes	No Turn Lanes
Tipton Road	Left Turn Lanes	No Turn Lanes
Mulberry Avenue	Left Turn Lanes	No Turn Lanes
Cedar Street / Hwy. 22	Left Turn Lanes	No Turn Lanes
Lucas Street	Left Turn Lanes	No Turn Lanes
Hershey Avenue	Left Turn Lanes	No Turn Lanes
Sampson Street	Left Turn Lanes	No Turn Lanes
Grandview Avenue	Left Turn Lanes Right Turn Lanes on Southbound and Eastbound Approaches	Left Turn Lanes Right Turn Lane on Westbound Grandview

FIGURE 3
EXISTING TURN LANE PROVISIONS

Each of the seven signal systems provides protected/permissive left turn signals for turning from the mainline. Cross-street protected/permissive left turn signals are also provided at Grandview Avenue, 2nd Avenue and Park Avenue. At the remaining signalized intersections, cross-street movements are handled on the normal green interval. This means that left turning vehicles must yield to oncoming traffic. There is also a right turn arrow overlap movement for the northbound approach at the Park Avenue intersection that is green when the westbound left turn arrow is green. The five permanent signal systems are full-traffic-actuated, while the two temporary wood pole signal systems are semi-actuated, with no detection of mainline through vehicles.

A new permanent signal system at University Drive is under consideration. The signal could be constructed in conjunction with the reconstruction of US 61 to a four-lane divided roadway through this area, which will take place in 1999. If a signal system is not in place when the new University Drive intersection opens, the intersection should be monitored very closely for signal justification. This is discussed in more detail elsewhere in this report.

At each intersection the appropriate pavement markings are generally present and in reasonably good condition. Street name signs are typically ground mounted along US 61 in advance of the intersection.

C. Operational Characteristics

Information on existing operation of the corridor was gathered from several sources. The Iowa Department of Transportation (IDOT) provided accident records, speed and volume data. Muscatine Power and Water provided traffic signal plans and the current signal timing parameters. Representatives of the City provided insight into local concerns, including information on future development and locations of significant traffic generators. Residents of Muscatine provided personal insights through a series of community meetings/technical workshops held by IDOT. Useful information was also gathered by the consultant, through observations of the operation of several of the key intersections along the corridor. In addition travel time runs were made along the length of the corridor during the peak hours of traffic flow.

1. Accidents

Accident records were obtained from IDOT for the period from 1993 through early 1998. They were analyzed in an attempt to ascertain collision patterns along the bypass corridor as a whole, and to identify the alternative safety improvements that might be beneficial at specific locations. The following conclusions were drawn from this analysis:

- When broken out by month of the year, day of the week, and time of day, corridor-wide accidents were distributed for the most part, as one would expect. Accident numbers were greatest in the winter months of November, December and January, when holiday travel occurs and when road conditions tend to deteriorate with snow and ice. Over the course of the week, the largest percentage of accidents occurred on weekdays, when traffic volumes are greatest. More accidents occurred on Friday than any other day. Typically, volumes are higher on Fridays because of the combination of work trips and weekend travel. Accidents were most prevalent during the afternoon hours, with the largest peak between 4:00 and 5:00 p.m. when many people are returning home from work and when the adjacent commercial properties have their greatest levels of activity.

- From 1994 through 1997, a slight but consistent downward trend in total accidents along the corridor was noticed (see Figure 4). Upon closer examination, the entire reduction in accidents was attributable to one intersection: US 61 at Hershey Avenue. The total number of accidents at all the remaining intersections was stable from year to year.

- The accident rates at selected intersections along the US 61 bypass are consistent with accident rates at intersections elsewhere having similar entering volumes and speeds (see Figure 5). Therefore, the accident rates could be considered to not be excessive. However, based on Iowa statewide data from similar intersections the accident rates are approximately 30 percent higher. In addition, the average monetary loss per accident appears to be unusually high at the intersections along the Muscatine bypass (see Figures 6 and 7). A high monetary loss rate is an indication of severe crashes. It is this accident severity that has been a concern to the community.

- The accidents at each intersection were broken out by type. By doing this, the type of safety improvements that could be effective for each intersection could be identified. Figure 8 presents a breakdown of accidents by type at each intersection, and categorizes them as property damage, personal injury or fatal accidents. Figure 9 provides a summary, listing the two most prevalent types of accidents at each intersection.

As an example, one could expect that installing traffic signals at an intersection that is currently controlled by stop signs on the cross street will reduce the number of right angle accidents. However, traffic signals will interrupt high-speed traffic flow and could cause an increase in the number of rear end accidents. Drivers on the main roadway may not notice traffic signals placed in a rural environment. As a result, even though the number of right angle collisions would be reduced, some could still occur. Those remaining right angle collisions would be severe. This is of particular concern along a high-speed corridor like the Muscatine bypass.

Number of Accidents By Location (1994-1998)

* Derived from the accident reports provided by the Iowa Department of Transportation

Intersection	Total Number of Accidents	1994	1995	1996	1997	1998*
2nd Avenue	12	1	3	4	4	0
Bidwell Road	13	2	3	2	6	0
Cedar St./Hwy. 22	26	9	4	6	6	1
Cleveland Street	7	0	0	2	3	2
Grandview Avenue	11	4	2	4	1	0
Hershey Avenue	43	16	13	8	3	3
Isett Avenue	33	9	6	7	10	1
Lowe Run/Lucas St.	12	4	2	4	1	1
Mulberry Avenue	31	5	7	11	7	1
Park Ave./Hwy. 38	72	13	24	16	17	3
Sampson Avenue	8	4	2	1	1	0
Tipton Road	17	5	5	3	3	1
	Total Accidents by Year	72	71	68	62	13*

* 1998 accident data from January through March

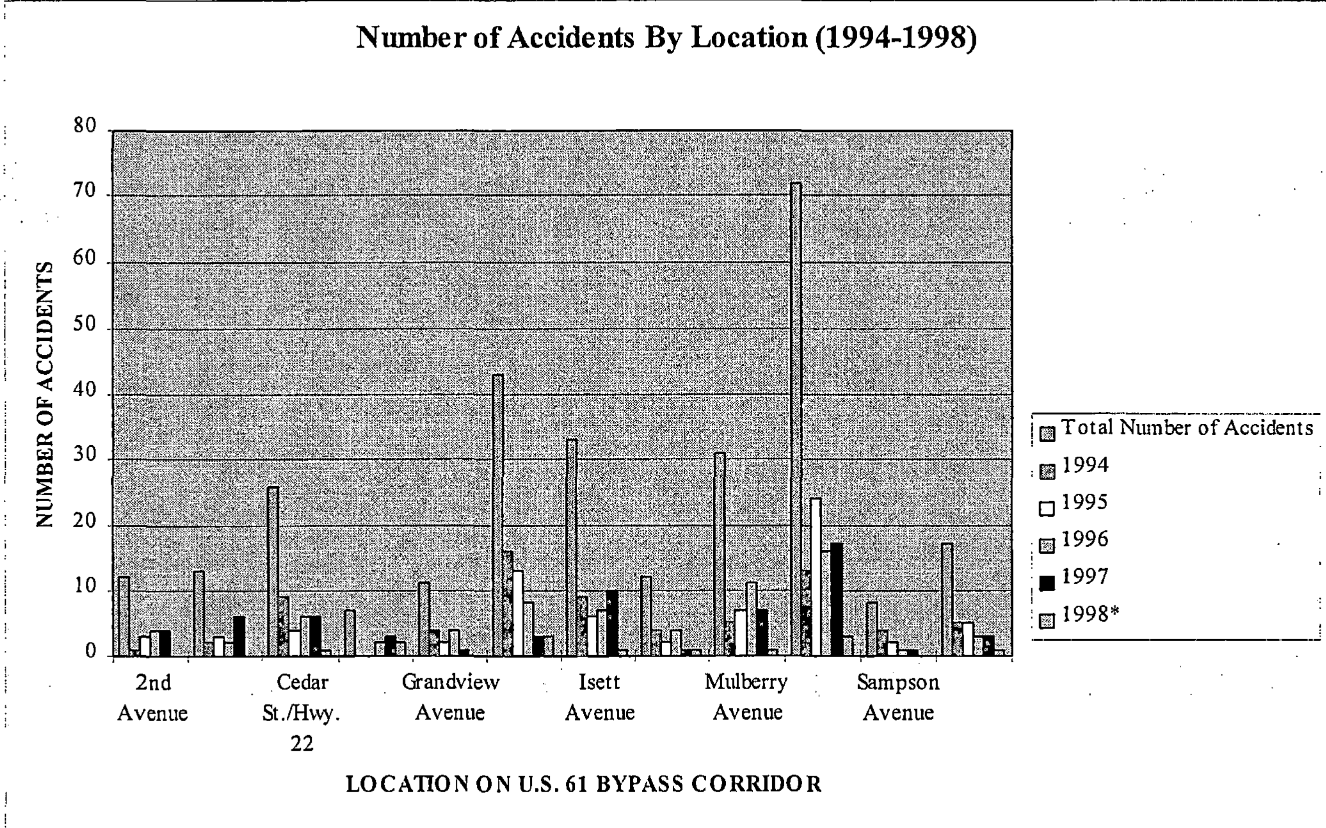


FIGURE 4
TOTAL ACCIDENTS BY LOCATION

Location	Entering Vehicles/Day	Accident Rate *
US 61 / Cedar-Muscatine	12,628	1.16
US 61 / Mulberry-Muscatine	12,300	1.12
US 61 / Hershey-Muscatine	14,700	0.75
US 61 / Isett-Muscatine	11,000	1.33
TH 169 / CSAH 4-Zimmerman, MN	16,908	1.60
TH 65 / CSAH 30-Cambridge, MN	16,600	0.80
TH 65 / CSAH 5-Isanti, MN	16,093	1.60
TH 10 / TH 25-Becker, MN	10,900	1.00
TH 10 / TH 24-Clear Lake, MN	12,591	1.00

* Accident Rates are in Accidents per Million Vehicles Entering the Intersection

FIGURE 5

COMPARISON OF ACCIDENT RATES WITH SIMILAR INTERSECTIONS IN MINNESOTA

Location	Entering Vehicles/Day	Accident Rate *	1993-1995 Accidents	Average Loss Per Accident	Number of Fatal & Injury Accidents
US 61 / Cedar-Muscatine	12,628	1.16	16	$ 35,113.00	10
US 61 / Mulberry-Muscatine	12,300	1.12	15	$ 112,000.00	13
US 61 / Hershey-Muscatine	14,700	0.75	11	$ 35,000.00	6
US 61 / Isett-Muscatine	11,000	1.33	19	$ 29,000.00	7
US 69 / IA 160-Ankeny	23,500	1.52	39	$ 2,646.00	12
IA 415 / IA 160-Ankeny	15,700	1.27	22	$ 18,400.00	12
IA 58 / Ridgeway-Cedar Falls	8,400	1.41	13	$ 17,400.00	8
IA 58 / Greenhill-Cedar Falls	12,000	0.53	7	$ 7,100.00	3
IA 58 / Viking Road-Cedar Falls	9,250	0.49	5	$ 4,300.00	1
US 218 / Mitchell-Waterloo	20,900	0.44	10	$ 2,800.00	3
US 218 / 11th-Waterloo	29,447	1.49	48	$ 11,055.00	15
US 63 / Airline-Waterloo	10,800	1.18	14	$ 3,843.00	7
IA 141 / 54th-Grimes	26,800	1.47	43	$ 24,732.00	19

* Accident Rates are in Accidents per Million Vehicles Entering the Intersection. Average accident rate for similar intersections in Iowa is 0.9 accidents per million entering vehicles

FIGURE 6
COMPARISON OF ACCIDENT RATES AND SEVERITY WITH INTERSECTIONS IN IOWA

	1993 - 1995 Average Accident Rate (accidents/million vehicles)	Average Loss Per Accident	Percentage of Major Injury and Fatal Accidents
Iowa Signalized (11 intersections)	1.04	$ 15,663.00	8%
Muscatine US 61 Unsignalized *	1.06	$ 58,000.00	37%
Muscatine US 61 Signalized at Cedar	1.16	$ 35,000.00	25%

*** Mulberry & Isett Intersections before Temporary Signalization, and Hershey Intersection**

FIGURE 7
IOWA RURAL 55 MPH INTERSECTION ACCIDENT RATES AND SEVERITY - 4 LANE CORRIDORS

Muscatine, Iowa / U.S. 61 Bypass Corridor - Accident Report Information

* Derived from the accident reports provided by the Iowa Department of Transportation

		Property Damage	Personal Injury	Fatalities	Total
Wal-Mart	Total Accidents (1994-1998)	6	1	0	7
	Left Turn Accidents	1	0	0	1
	Right Angle Accidents	0	1	0	1
	Rear End Collisions	0	0	0	0
	Other Types of Accidents	5	0	0	5
Park Ave. / TH 38	Total Accidents (1994-1998)	44	27	1	72
	Left Turn Accidents	17	11	0	28
	Right Angle Accidents	4	3	0	7
	Rear End Collisions	11	10	0	21
	Other Types of Accidents	12	3	1	16
2nd Avenue	Total Accidents (1994-1998)	4	8	0	12
	Left Turn Accidents	0	2	0	2
	Right Angle Accidents	2	3	0	5
	Rear End Collisions	2	2	0	4
	Other Types of Accidents	0	1	0	1
Isett Avenue	Total Accidents (1994-1998)	21	12	0	33
	Left Turn Accidents	1	2	0	3
	Right Angle Accidents	4	5	0	9
	Rear End Collisions	4	2	0	6
	Other Types of Accidents	12	3	0	15
Bidwell Road	Total Accidents (1994-1998)	8	5	0	13
	Left Turn Accidents	0	0	0	0
	Right Angle Accidents	1	1	0	2
	Rear End Collisions	0	3	0	3
	Other Types of Accidents	7	1	0	8
Tipton Road	Total Accidents (1994-1998)	13	4	0	17
	Left Turn Accidents	0	2	0	2
	Right Angle Accidents	2	1	0	3
	Rear End Collisions	1	0	0	1
	Other Types of Accidents	10	1	0	11
Mulberry Avenue	Total Accidents (1994-1998)	9	20	2	31
	Left Turn Accidents	2	3	0	5
	Right Angle Accidents	4	13	2	19
	Rear End Collisions	1	3	0	4
	Other Types of Accidents	2	1	0	3
Cedar St. / TH 22	Total Accidents (1994-1998)	13	13	0	26
	Left Turn Accidents	3	9	0	12
	Right Angle Accidents	0	3	0	3
	Rear End Collisions	1	1	0	2
	Other Types of Accidents	9	0	0	9

FIGURE 8 (SHEET 1 OF 2)
ACCIDENTS BY TYPE

		Property Damage	Personal Injury	Fatalities	Total
Lucas Street	Total Accidents (1994-1998)	9	3	0	12
	Left Turn Accidents	1	0	0	1
	Right Angle Accidents	5	2	0	7
	Rear End Collisions	2	0	0	2
	Other Types of Accidents	1	1	0	2
Hershey Avenue	Total Accidents (1994-1998)	22	20	1	43
	Left Turn Accidents	2	0	0	2
	Right Angle Accidents	4	14	1	19
	Rear End Collisions	1	0	0	1
	Other Types of Accidents	15	6	0	21
Grandview Avenue	Total Accidents (1994-1998)	3	8	0	11
	Left Turn Accidents	1	1	0	2
	Right Angle Accidents	0	3	0	3
	Rear End Collisions	1	3	0	4
	Other Types of Accidents	1	1	0	2

FIGURE 8 (SHEET 2 OF 2)
ACCIDENTS BY TYPE

Location	Intersection Control	Most Frequent Accident Types
Wal-Mart Entrance	Signalized	Single Vehicle, Left Turn
Park Avenue / Hwy. 38	Signalized	Left Turn, Rear End
2nd Avenue	Signalized	Right Angle, Rear End
Isett Avenue	Signalized, semi-actuated	Right Angle, Rear End
Bidwell Road	Unsignalized	Rear End, Right Angle
Tipton Road	Unsignalized	Right Angle, Left Turn
Mulberry Avenue	Signalized, semi-actuated	Right Angle, Left Turn
Cedar Street / Hwy. 22	Signalized	Left Turn, Right Angle
Lucas Street	Unsignalized	Right Angle, Rear End
Hershey Avenue	Unsignalized	Right Angle, Single Vehicle
Grandview Avenue	Signalized	Rear End, Right Angle

FIGURE 9

KEY ACCIDENT TYPES AT EACH BYPASS LOCATION

There are measures that can be taken to counter the rear end and right angle accident potential at signal controlled intersections. The rear end accident and, to some extent, the right angle accident potential could be addressed by adding the appropriate main line vehicle detectors or advance warning flashers. A left turn accident problem would be reduced by providing more restrictive left turn control, such as allowing left turns only on the green arrow. However, this type of signal control typically results in significant increases left turn delay and increases in overall intersection delay.

2. Traffic Volumes, Speeds

The posted speed limit along US 61 is 55 miles per hour between Grandview Avenue and a point west of 2nd Avenue, at which point it becomes 45 miles per hour through the Wal-Mart access intersection. East of Wal-Mart, the posted speed limit returns to 55 miles per hour. IDOT recently proposed reducing the posted speed limit to 45 mph to the west of Isett Avenue, but the Muscatine City Council opposed the change.

Figure 10 shows actual mainline 85th percentile speeds surveyed by IDOT at various locations along the corridor in 1996 and 1998. The 85th percentile speed is the speed below which 85 percent of vehicles travel, and is the speed most commonly used to set posted speed limits on roads where state statutes permit variability based on local conditions. The actual vehicle speeds appear to be within the bounds of expectations for this type of roadway.

Traffic volumes are usually represented on traffic flow maps as Average Daily Traffic (ADT's). Figure 11 shows ADT's on US 61 and the major cross-streets. The numbers are taken from the IDOT preliminary 1998 Traffic Flow Map and the IDOT 1994 Traffic Flow Map, and represent the average ADT's over the course of the year. 1994 ADT's on the US 61 bypass ranged from 7,800 north of Grandview Avenue to 13,000 east of Isett Avenue. 1998 ADT's ranged from 9,600 south of Hershey Avenue to 18,100 between Park Avenue and the Wal-Mart access. These volumes are well below the capacity of a typical four-lane divided roadway.

3. Traffic Mix

The percentage of trucks in the traffic stream on US 61 is very high when compared to other roads similar in nature. The corridor wide average for trucks is nearly 25 percent while 10 percent would be considered normal for many arterial roadways. This high truck percentage is a result of many factors. US 61 is a significant trucking route along the west side of the Mississippi River. Muscatine also has a relatively large number of businesses that generate over-the-road truck trips. In addition there is a relatively low volume of automobile traffic present to reduce those truck percentages. Auto travel patterns in the Muscatine area tend to be radial to the center of the city rather than in a circumferential pattern.

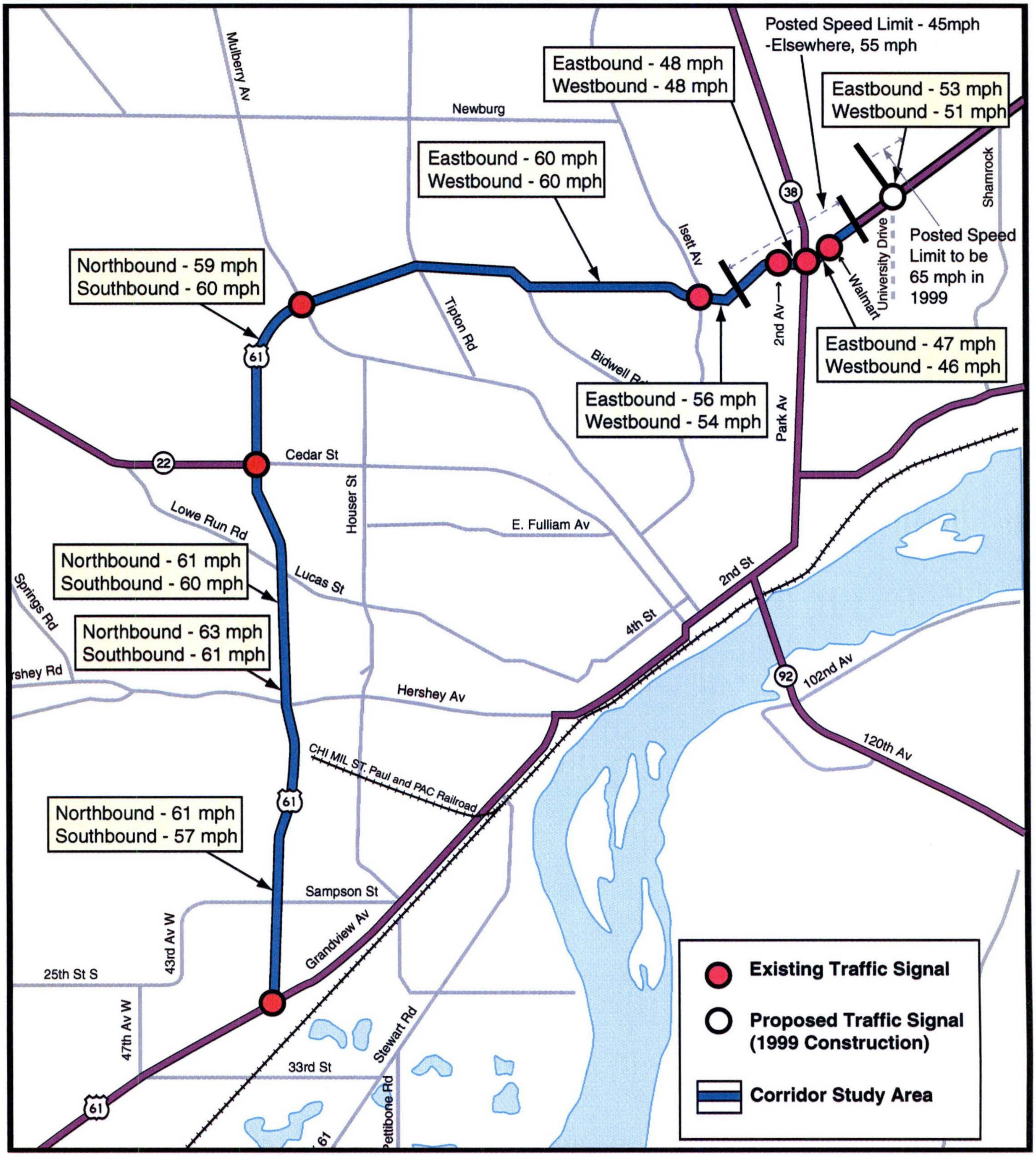


FIGURE 10
EXISTING 85TH PERCENTILE VEHICLE SPEEDS

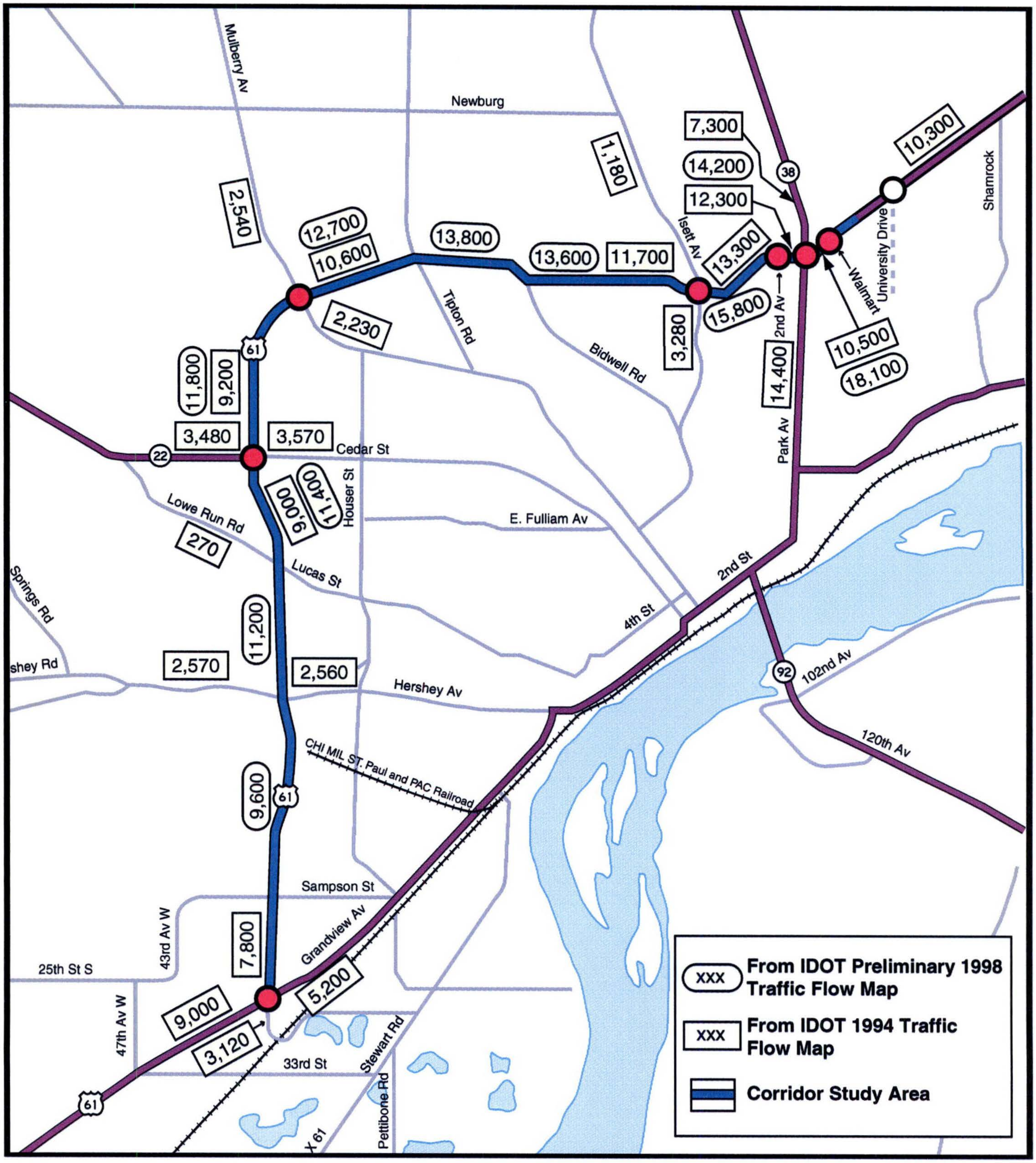


FIGURE 11
ANNUAL AVERAGE DAILY TRAFFIC

The presence of large percentages of trucks creates significant problems for the operation of a high-speed arterial such as US 61. The limited acceleration rates for trucks and their need to keep large separations between them and other vehicles causes the dispersion of traffic platoons which are needed for effective signal coordination. Trucks also create turbulent traffic flow when auto traffic changes lanes to avoid being behind trucks. There are also large numbers of trucks turning left at many intersections along the corridor. The left turning trucks must cross the higher speed left though lane to reach the left turn lane. This lane changing also adds turbulence to the traffic flow.

The added turbulence from truck movements and their physical size effectively means that each truck requires the same amount of roadway capacity as 3 or 4 automobiles. Figure 12 shows percentages of trucks on US 61 at intersections along the corridor.

4. <u>Existing Operation Issues</u>

Local residents expressed concerns about a variety of operational and geometric issues at the community meetings, including the following:

- The radius in the northwest quadrant of the Wal-Mart intersection is inadequate. Right turning vehicles drive off the paved surface.
- At the Park Avenue intersection, drivers of left turning vehicles often have difficulty judging gaps in oncoming traffic during the permissive interval of the protected/permissive left turn operation. Residents also mentioned that the leading green arrow times out before the left turning queue has been cleared during peak periods.
- There is no provision for pedestrians at the 2nd Avenue intersection, yet pedestrians are occasionally seen crossing US 61 between the commercial developments on either side of the highway.
- The position of the afternoon sun in summer makes it difficult to see vehicles on the eastbound approach to the Isett Avenue and Mulberry Avenue intersections.
- Drivers of southbound vehicles don't expect a traffic signal at Cedar Street. Vehicles occasionally proceed through the intersection when the red signal indications are displayed. In particular, trucks have difficulty stopping.
- At the Lucas Street intersection, the crest of the hill to the south creates a sight distance problem. Northbound vehicles approaching the intersection cannot be seen until they are relatively close.
- The soccer/baseball/softball complex east of the Hershey Avenue intersection creates peaks, particularly in turning traffic, at that intersection. The proximity of the nursing home to the west means that more elderly people traverse the intersection.

Location	Percentage of Trucks
Park Avenue / Hwy. 38	22.6%
2nd Avenue	11.3%
Isett Avenue	11.5%
Bidwell Road	13.0%
Tipton Road	13.0%
Mulberry Avenue	14.0%
Cedar Street / Hwy. 22	22.1%
Lucas Street	19.9%
Hershey Avenue	24.6%
Grandview Avenue	23.2%

FIGURE 12
MAINLINE TRUCK PERCENTAGES AT INTERSECTIONS

5. Operational Analysis

Two microcomputer models, SYNCHRO and CORSIM, were used to conduct a mathematical analysis of the operation of the network with existing traffic volumes, vehicle mixes, traffic signal timing parameters, etc. for the a.m. and p.m. peak hour conditions. This was done to create a baseline for determining the effect of various improvements on the operation of specific intersections, as well as the overall operation of the corridor. The roadway network was replicated in SYNCHRO. Running the SYNCHRO model gave a substantial number of outputs representing measures of effectiveness (MOE's) for individual intersections, and arterial MOE's for individual segments and for the entire length of the US 61 bypass. The CORSIM model created a computer simulation of the corridor, and provided its own calculated MOE's. It was useful for determining the number of dilemma zone occurrences at a given intersection.

The following conclusions about the operation of the corridor under existing conditions were drawn from the SYNCHRO and CORSIM outputs:

- The average speed for a vehicle traveling the entire length of the corridor, accounting for stopped delays at intersections, is approximately 44 miles per hour (mph) in the a.m. peak hour and 42 mph in the p.m. peak hour.

- The most congested part of the corridor is naturally the area around the Park Avenue intersection where two highways intersect and where the majority of the commercial development is concentrated. At the US 61/Park Avenue intersection the average stopped delay per vehicle is approximately 16 seconds in the a.m. peak hour and 25 seconds in the p.m. peak hour. This suggests intersection level of service (LOS) B/C in the morning peak period and LOS C/D in the afternoon peak period. A signal system having LOS D or better is generally regarded as acceptable.

- The most significant queuing problem occurs at the US 61/Park Avenue intersection in the p.m. peak period, when at times the computer model (as was also reported by the community) suggests that queues spill back out of the westbound left turn lane.

- When compared to many other arterial roadways with traffic signal controlled intersections, the US 61 bypass corridor performs reasonably well from a traffic operations standpoint. There are, however, improvements that can and should be made strictly with the intent to improve traffic operations but priority should be given to those improvements that will improve safety. Most of those improvements will benefit traffic operations as well.

III. DEFICIENCIES

As data were gathered, information was examined, and the operational analyses performed, a list of deficiencies was created. Some are considered corridor-wide, while others are location-specific. In the context of this report, a deficiency is defined as a condition that can be improved with a reasonable amount of effort and expenditure. The improvements would also be consistent with established design and operational criteria for the roadway's functional classification. These criteria are based on IDOT standards and practices, as well as the experience of the consultant with similar roadways in other states. The identified deficiencies have been divided into three categories: intersection and roadway geometrics, traffic control devices and techniques, and overall quality of roadway operation.

A. Geometrics, Access

The following geometric deficiencies that are noted were generally observed throughout the corridor. Where a deficiency relates to a specific location, that location and that deficiency are mentioned individually.

1. Mainline left turn lane lengths are inadequate. The design of the current left turn lanes assumes that as much as the first 10-mph of deceleration occurs in the through lane, before the left turning vehicle enters the taper for the left turn lane. The short turn lanes also require a deceleration rate of 10 feet per second per second. This rate can be considered high. A rate of 7 feet per second per second is more comfortable and appropriate for this type of facility. There is also no provision for storing waiting vehicles in the left turn lanes. This deficiency becomes even more critical when the high percentage of trucks using the roadway is considered.

   The requirement to begin deceleration while still in the through lane may not be a terrible inconvenience to through traffic when traffic volumes are low and well distributed. However, on a roadway such as US 61 where the volumes are moderate and traffic signals create platooned flows, the lack of adequate deceleration space outside of the through lane creates turbulence and reduces capacity. This is especially true where truck percentages are high, as they are on US 61 in Muscatine. The impedance caused if a truck following the turning vehicle is forced to decelerate 10 mph and then accelerate is much more significant than it is for a passenger car.

   For a 55 mph roadway, a left turn lane that has 300 feet of full lane width and 180 feet of taper (assuming a 15:1 taper of a 12 foot wide lane) provides enough distance for the entire deceleration to comfortably occur in the taper and full width turn lane. This assumes, of course, that queued vehicles aren't claiming a portion of the turn lane length. However, unless the volume of left turning vehicles is routinely very high (see discussion below), the return on the investment into an even longer turn lane might be prohibitive.

The westbound left turn at the US 61/Park Avenue intersection has a large enough volume that storage length is a definite issue. The volume in the p.m. peak hour is currently 320 left turns. The threshold volume above which consideration should be given to dual left turn lanes is 300 turning vehicles.

Other locations where residents have expressed specific concerns about inadequate left turn lane lengths are the eastbound approach at Park Avenue, and both mainline approaches at Isett Avenue. At these locations, residents have witnessed queues spilling into the adjacent through lane.

2. The lack of mainline right turn lanes is also a serious deficiency. One right turning vehicle at the front end of a platoon forces all the vehicles in the right through lane to decelerate to the turning speed, which is likely to be as low as 15 mph. This creates delay, an increased risk of rear end accidents, and potential for tremendous turbulence (as some drivers attempt to change lanes), as well as breakup of the platoon of vehicles.

   Citizens claim that some right turning vehicles use the gravel shoulder to decelerate. These vehicles often have difficulty decelerating to the speed necessary to safely negotiate the turn, and occasionally slide through the intersection. Right turning vehicles also often deposit gravel in the intersection.

   Southbound Park Avenue (Iowa 38) at US 61 certainly has volumes and speeds to warrant a right turn lane, as well.

   The same design considerations that apply to left turn lanes should apply to right turn lanes.

3. The lack of adequate median width is a concern particularly at unsignalized intersections, where crossing or left turning traffic from the cross-street must find a simultaneous gap in the traffic streams of both directions of US 61 traffic.

4. The signalized intersections at Cedar Street, Mulberry Avenue and Isett Avenue do not have exclusive left turn lanes on the cross-street, but rather shared left turn/through lanes. One benefit of having facing exclusive left turn lanes is that the driver of a left turning vehicle has a better line of sight past an opposing left turning vehicle, in order to pick a gap in opposing through traffic. The line of sight can be improved even more by overlapping the opposing left turn lanes by two to four feet. The other benefit of exclusive left turn lanes with permissive left turning movements is that a through vehicle won't get trapped behind a left turning vehicle that must yield to opposing traffic.

5. The current typical design provides a raised "porkchop" island on the cross-streets. This gives the look of a free right turn condition. However, there are generally no acceleration lanes or reaction offsets with generous tapers along the mainline. Therefore, a driver turning right onto the mainline must wait for a large enough gap that he can merge directly into the through traffic from a stopped condition. With this design, delay is incurred by right turning vehicles. The lack

of an acceleration lane on northbound US 61 from the Hershey Avenue intersection creates a more significant problem because of the four percent uphill grade. It takes longer for a turning vehicle to accelerate. Either the driver must wait for a larger gap to make the maneuver, or the turning vehicle creates turbulence in the traffic flow, thereby reducing capacity and compromising safety.

6. At the Isett Avenue intersection, grades are such that southbound left turning drivers momentarily lose sight of lower profile northbound vehicles. This condition creates an unsafe environment.

7. Access restrictions are generally good along the corridor. However, with the speeds that are prevalent and the increasing traffic volumes, the remaining field entrances are likely to become a more significant safety concern over time.

B. Traffic Control

The following deficiencies are related to traffic signal design and signing.

1. The two temporary wood pole traffic signal systems at Mulberry Avenue and Isett Avenue are semi-actuated; that is, there is no detection of mainline through vehicles. After a minimum green time for the mainline is satisfied, the signal will cycle to serve the cross-street whenever a call is placed via the cross-street detection. This could happen when a mainline through vehicle is in the middle of its dilemma zone. By not having extend detectors on US 61, there is no dilemma zone protection whatsoever. This is a serious safety concern on a high speed road such as US 61.

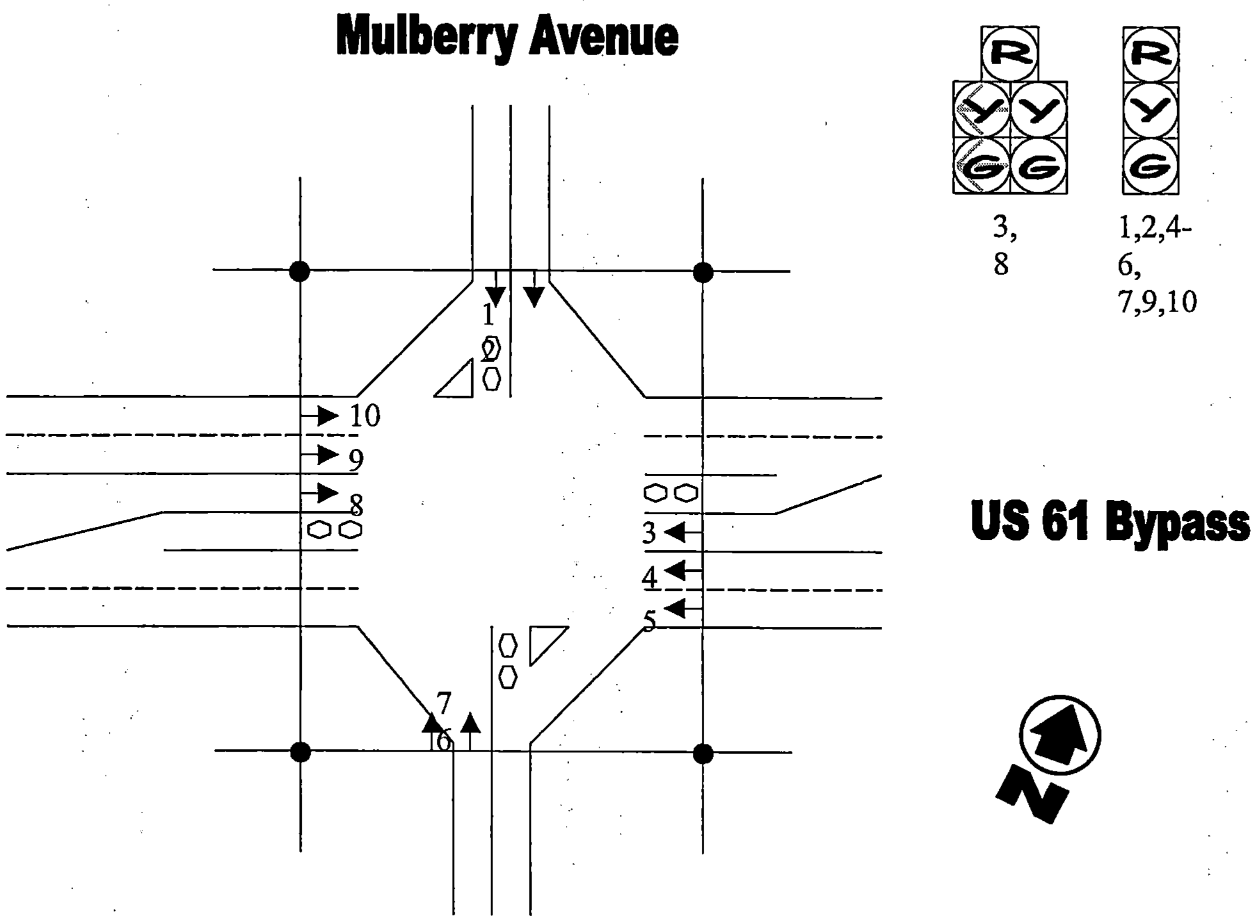
   One would expect to see a relatively large number of right angle and rear end accidents at a signalized intersection with semi-actuated control on a high speed roadway. This is borne out at Mulberry Avenue and Isett Avenue. Right angle accidents are by far the most prevalent at the former, while right angle and rear end accidents are the two most common types at the latter intersection.

Detailed Analysis of Mulberry Avenue and US 61 Intersection

The existing intersection of Mulberry Avenue with the US 61 Bypass is currently controlled by a temporary, semi-actuated traffic signal system. The signal system consists of a box span-wire configuration connected to a temporary controller. Protected/permissive left turn phasing is utilized on the US 61 Bypass, while Mulberry is strictly permissive phasing only. Two loop detectors are present in each of the left turn lanes on US 61 and on both of the single lane approaches for Mulberry Avenue.

The current intersection geometry consists of two through lanes and a left turn lane in each direction on the US 61 Bypass. Mulberry Avenue has a single, combination through/left turn lane, as well as a large radius and a small triangular raised island to separate right turning traffic. This section is typical for both approaches. Neither the

US 61 Bypass nor Mulberry Avenue has exclusive right turn lanes, and the shoulders on the US 61 Bypass are aggregate which limits their use for vehicles turning right off of the highway. The current posted speed limit on US 61 is 55 miles per hour (mph), though 85th percentile speeds have been noted at or above 60 mph. The current posted speed limit on Mulberry Avenue is 35 mph. A sketch of the intersection geometry and signal locations is shown below.



An analysis of the intersection was conducted using CORSIM microscopic traffic simulation software. The purpose of this analysis was to determine the effect of adding mainline detection (advance loop detectors in the through lanes – approximately 475 feet from the stop bar) to the US 61 Bypass. The results of this analysis are summarized on the following pages. The intersection performed well under the peak hour and future traffic volumes with the additional detectors. In both cases, the safety (measured by number of mainline dilemma zone occurrences) and operation of the intersection were improved. The analysis also showed benefits to reducing the minimum/maximum green times, and the vehicle extension for Mulberry Avenue and the left turn phases of the US 61 Bypass.

Four alternatives were considered during the analysis. Each of the four alternatives was run utilizing peak hour traffic volumes, 8th highest hour traffic volumes, and future traffic volumes. Therefore, a total of 12 runs/simulations were made. The peak hour traffic volumes were taken from recent (1998) manual traffic counts conducted by the Iowa Department of Transportation (IDOT). Eighth-highest hour or off-peak traffic volumes were estimated by reducing the peak hour traffic volumes by one-half (0.5). The future traffic volumes were determined by multiplying the peak hour traffic volumes by one and one-half (1.5). The intersection geometry did not change for any of the alternatives. The only changes made were the addition of mainline loop detectors and adjustments to the signal controller settings. The four alternatives were as follows:

Alternative 1: Existing geometry, traffic signal controller settings and loop detector locations.

Alternative 2: Existing geometry, traffic signal controller settings, loop detector locations + ***mainline loop detectors placed 475 feet from the stop bar on both approaches (and both lanes) of the US 61 Bypass.***

Alternative 3: Existing geometry, ***revised traffic signal controller settings,*** existing loop detector locations.

Alternative 4: Existing geometry, ***revised traffic signal controller settings,*** existing loop detector locations + ***mainline loop detectors placed 475 feet from the stop bar on both approaches (and both lanes) of the US 61 Bypass.***

The CORSIM microscopic simulation software provided a detailed summary of the measures of effectiveness (MOE's) for each alternative. The summaries for each run/simulation are included in the appendix of this report. The MOE's that were obtained from the output of each simulation in order to compare each Alternative included percent stopping, delay time (seconds per vehicle), stopped delay (cumulative vehicle-minutes), deceleration/acceleration delay (cumulative vehicle-minutes), and also stopping and delay costs.

The latter two were computed based upon the following assumptions:

Decel/accel delay (veh-min) =>	**<u>30-second</u>** decel/accel delay per stopped mainline thru-vehicle **<u>15-second</u>** decel/accel delay per stopped cross street thru-vehicle **<u>10-second</u>** decel/accel delay per stopped turning vehicle – all approaches
Stopped Delay Costs =>	**<u>8 cents</u>** per stop – mainline through vehicles **<u>6.5 cents</u>** per stop – mainline turning vehicles **<u>5 cents</u>** per stop – cross street vehicles **<u>$10/hour</u>** for vehicle delay

The current intersection operates at Level of Service (LOS) B, which is well above the generally accepted value of LOS C for this type of corridor. LOS is used to identify the condition of traffic flow for intersections and basic roadway segments. It can also be used as a measure of congestion. LOS ranges from LOS A (very low traffic volumes – no congestion or delays) to LOS F (very high traffic volumes – intense congestion, long delays). Based on the CORSIM results, a slight operational (LOS) improvement would occur for motorists traveling on the US 61 Bypass if mainline detection was provided. Total peak hour delay costs for the intersection would decrease from $110.71 to $104.47, though total stopping costs would increase from $55.51 to $56.04.

Further operational improvements were obtained by making minor changes to the minimum/maximum green times and the vehicle extension for Mulberry Avenue and the left turn phases of the US 61 Bypass. Minimum green times for the cross-street phases were reduced from 15 seconds to 10 seconds. US 61 Bypass left turn phase minimum green times were reduced from 10 seconds to 7 seconds. The vehicle extensions for the cross-street phases were also reduced from 3.5 seconds to 2.5 seconds. These changes were applied to the simulation with and without the mainline detection. The result was a significant reduction in total delay and stopping delay costs. These results for the peak hour are shown in the table below.

Alternative	Total Delay Cost	Total Stopping Cost
1	$ 110.71	$ 55.51
2	$ 104.47	$ 56.04
3	***$ 94.39***	***$ 55.36***
4	***$ 86.80***	***$ 50.07***

The addition of mainline detection would provide little benefit to the motorist approaching the intersection on Mulberry. In fact, it is possible that the motorist could expect to experience additional delays and be more likely to stop. This is due to the extension of the green time by the mainline detection on the US 61 Bypass. Additional delay may also occur in the off-peak periods for all approaches. These drawbacks are minor and do not offset the benefits provided by the improvements of Alternatives 2, 3 and 4.

In addition to the operational improvement, the addition of mainline detection provides important dilemma zone protection for the motorist traveling through on the US 61 Bypass. The dilemma zone is defined as the segment of roadway on the approach to a traffic signal bounded by the two points where, when the signal indications turn yellow: 1) 95 percent of drivers will continue through the intersection, and 2) 95 percent of drivers will stop. The dilemma zone assumed for the analysis extended from 150' to 420' from the stop bar on through lanes of the US 61 bypass. Alternatives 3 and 4 were compared to determine the significance of mainline detection on the dilemma zone. The results were as expected, as Alternative 4 provided considerably fewer dilemma zone occurrences and fewer vehicles caught in the middle of the dilemma zone. During the peak hour, the number of dilemma zone occurrences was reduced from 73 to 43, or a 41 percent reduction. The percentage of cycles where vehicles were found in the dilemma zone dropped from 77 percent to 55 percent, and the percentage of cycles where vehicles were caught near the center of the dilemma zone (the "gray area") was reduced from 48 percent to 22 percent. Alternative 4 provided similar benefits in the off-peak and under future traffic volumes. The graphics on the following page are intended to represent the dilemma zone occurrences noted when viewing the simulation. The numbers shown represent the location of the vehicle and the total number of vehicles at the time when the signal indications turned yellow.

The addition of mainline detection on the US 61 Bypass at the intersection of Mulberry Avenue will provide not only operational benefits, but also essential protection of the dilemma zone. This should result in safer driving conditions for the motorists and possibly a reduction in the number of rear end collisions. Further adjustment of the traffic signal controller settings will be necessary to account for actual field conditions and possible anomalies in the simulation software. These may be accomplished during the installation of the permanent traffic signal system and mainline loop detectors.

PEAK HOUR DILEMMA ZONE

ALT 3	7	12	17	18	15	4
ALT 4	2	5	5	12	14	5

420' **285'** **150'**

	Total Veh.	In Gray Area	Cycles w/DZ Occurrence
ALT 3:	73	48 %	77 %
ALT 4:	43	22 %	55 %

OFF- PEAK DILEMMA ZONE

ALT 3	3	13	12	5	6	0
ALT 4	0	0	0	2	6	4

420' **285'** **150'**

	Total Veh.	In Gray Area	Cycles w/DZ Occurrence
ALT 3:	39	24 %	52 %
ALT 4:	12	4 %	24 %

FUTURE DILEMMA ZONE

ALT 3	3	26	23	27	19	11
ALT 4	5	5	6	21	18	11

420' **285'** **150'**

	Total Veh.	In Gray Area	Cycles w/DZ Occurrence
ALT 3:	109	58 %	92 %
ALT 4:	43	41 %	78 %

2. At other signalized intersections where back detection is present in the mainline through lanes, it is often too close to the stop line to protect the entire dilemma zone. For a 55 mph road, the recommended detector location is approximately 475 feet from the stop line. For a 45 mph road, it is 350 feet. At Cedar Street (55 mph posted), the mainline back detectors are located 405 feet from the stopline. As mentioned previously, residents have suggested that trucks often have difficulty stopping at this intersection, and there is a tendency to proceed through the intersection after the signal indications have turned red. At the Wal-Mart access (45 mph posted), the signal plans show the eastbound detectors 240 feet back and the westbound detectors 300 feet back.

3. Pole mounted signal heads as a supplement to mast arm mounted indications are not used as a matter of practice along the Muscatine bypass. In the author's experience, it is often beneficial to have an indication at a different height from the overhead indications. Accident reports indicated that on several occasions drivers said the signal indications were lost in the glare from the sun. In these instances, it's possible that a pole-mounted signal indication might have been visible.

4. Where protected/permissive signal operation is used, it is typical to have one 5-section signal head mounted over the left turn lane. The view of this signal face is often obscured for the driver of a left turning vehicle, particularly if that vehicle is queued behind a truck, bus or van. Often the vehicle is into the intersection before the signal face comes into view, at which time the driver discovers whether the protected left turn arrow is still on. Having a second 5-section signal head pole-mounted in the far left corner of the intersection helps visibility of the indications considerably.

5. It is evident that pedestrians occasionally cross US 61 between the commercial developments on either side of the highway at the 2nd avenue intersection. At present, there is no pedestrian signal here. This results in an unduly hazardous environment for pedestrians.

6. The cross-street free right islands that appear at several intersections generally do not have any delineation. They must be difficult to see, especially in winter after a snowfall.

7. The guide signs (white text on green background) on the approaches to cross-streets appear to have been replaced somewhat recently. The legibility of the text is better than it previously was, but the letter sizes could be increased to make the signs even more legible.

C. Operation

This section describes the deficiencies related to operation of the active traffic control features; namely, the traffic signal systems. Deficiencies associated with the location of or lack of signal equipment are discussed in the previous section. The focus here is on how the signal systems are programmed to operate.

1. The use of protected/permissive phasing, when compared to protected-only phasing, tends to reduce vehicular delay to varying degrees depending on the characteristics of the specific intersection, as it is less restrictive. However, if left turn accidents are prevalent, the benefit of reduced delay must be weighed against the greater exposure of left turning vehicles to conflicting traffic movements. This is especially true on higher speed roadways, where accidents tend to be more severe.

   In the case of the US 61 Muscatine bypass, left turn accidents represent the most frequent accident type at the intersections with Park Avenue and Cedar Street. Intersections where left turn accidents are the second most common type are the Wal-Mart access, Tipton Road (unsignalized) and Mulberry Avenue. As mentioned earlier, residents have expressed concerns about the ability of drivers to select gaps during permissive left turn operation at the Park Avenue intersection.

   As a point of information, the Minnesota Department of Transportation (Mn/DOT) has a policy that left turn phasing shall be protected-only on all roads with posted speed limits of 45 mph or higher. This is primarily because gap selection is more difficult at higher speeds, especially for older drivers.

   A bimodal left turn control option, where left turns are protected-only during periods of higher volumes and protected/permissive in lower volume conditions is discussed in detail in the Recommendations section of this report.

2. Presently, each of the traffic signal systems along the US 61 bypass operates as an isolated signalized intersection. In other words, none of the signal systems are coordinated. Coordinated operation (where cycle lengths are fixed between two or more signal systems, and splits and offsets are invoked by a master controller) can improve operations along an arterial corridor substantially, if the proper conditions exist. If through movements on the mainline are relatively high volume, and the spacing between signals is not too great, it is possible to gain operational benefit by creating platoons of vehicles that progress through the series of signals in a green band. This can increase average mainline travel speeds by reducing mainline through vehicle stopped delay and, under the right volume conditions, reduce total intersection delay.

   The northeast end of the US 61 bypass appears to have volume and signalized intersection spacing characteristics that would allow operation to benefit from signal coordination. The SYNCHRO model was run with existing conditions, and then was allowed to coordinate any group of signals where it saw a benefit in terms of operation. SYNCHRO selected the following intersections for coordination: Wal-Mart access, Park Avenue, 2nd Avenue and Isett Avenue. Figure 13 shows a comparison of peak hour operation without and with coordination. In the p.m. peak hour, the average stopped delay for all approaches at the US 61/ Park Avenue intersection was reduced by 11 seconds per vehicle when coordinated. The total corridor travel time was reduced by 47 seconds in the northbound/eastbound direction, and by 41 seconds in the westbound/southbound direction. Similar, although less dramatic, results were obtained in the a.m. peak hour.

3. The detectors in the mainline left turn lanes currently only extend the left turn phase. It is possible to program these detectors to also extend the mainline through phase after the left turn arrow terminates in protected/permissive operation. This can help left turning vehicles find a gap in opposing traffic and initiate their maneuver before the mainline signal indications turn yellow.

PM Peak Hour	Park Ave. Intersection Percentile Stopped Delay(s)	NB/EB Travel Time(s)	NB/EB Arterial Speed (mph)	WB/SB Travel Time(s)	WB/SB Arterial Speed (mph)
Existing Conditions	25.4	710	41	655	44
Existing Conditions - Coordinated*	14.5	663	44	614	47
Add Mainline detection @ Isett and Mulberry - Coordinated*	13.4	662	44	614	47
Add signals @ Bidwell and Tipton - Coordinated*	13.8	659	44	613	47
Mainline Protected Only LT's* (no signals at Bidwell, Tipton)	17.4	682	43	620	46
2 Westbound LT lanes at Park*	14.3	675	43	627	46

AM Peak Hour	Park Ave. Intersection Percentile Stopped Delay(s)	NB/EB Travel Time(s)	NB/EB Arterial Speed (mph)	WB/SB Travel Time(s)	WB/SB Arterial Speed (mph)
Existing Conditions	15.7	670	44	638	45
Add Mainline detection @ Isett and Mulberry - Coordinated*	11.4	654	45	625	46
Add signals @ Bidwell and Tipton - Coordinated*	11.6	650	45	622	46
Mainline Protected Only LT's* (no signals at Bidwell, Tipton)	15.7	665	44	623	46
2 Westbound LT lanes at Park*	15.5	660	44	625	46

FIGURE 13

COMPARISON OF SYNCHRO OUTPUTS

IV. RECOMMENDATIONS

This section of the report is organized as follows:

- Recommended improvements are described under headings representing categories of improvements (Geometrics, Development and Access, Traffic Control and Operation). Along with the description of the improvement, its estimated cost, relationship to other recommended improvements, and priority are discussed. Recommended improvements are prioritized on the basis of their ease of implementation, relative benefit and engineering/construction cost. Each improvement is given one of the following four priorities:

  1) Immediate Priority – an improvement that can be done with very little cost aside from the commitment of staff time, that can provide immediate benefit. These improvements primarily fall under the category of Operation.

  2) High Priority – an improvement that requires the commitment of more resources, but which will provide significant enough benefit that it should be considered in the short term.

  3) Medium Priority – an improvement that is associated with the development of a corridor management policy, or an improvement the benefits of which are viewed as being less critical to the enhancement of corridor operation than the high priority improvements. The value of some of these improvements might increase as traffic volumes grow. Some should be considered for the short term if other high priority improvements are being made at a specific location.

  4) Low Priority – an improvement that would be beneficial, but is not viewed as a critical element in the operation of the corridor. These improvements would be made as resources permit, most likely after high priorities have been addressed.

  5) ITS - There are several Intelligent Transportation System (ITS) techniques that could be used on the US 61 corridor that would provide additional driver information, provide operational benefits or improve safety. These recommended improvements can be viewed as optional and are not required to address a specific existing problem, but their use on this project could be viewed as a test.

A. Recommended Improvements by Type of Work

1. Geometric Improvements

Geometric improvements include all physical improvements to the roadways. Those that apply to more than one location are described first, followed by those applicable to isolated locations. Some geometric improvements will necessitate other work such as traffic signal modifications. Where this is the case, costs for this other work are included in the estimated engineering and construction cost for that geometric improvement, unless stated otherwise.

- Lengthen mainline left turn lanes

  The recommended length at all locations except for the westbound approach to Park Avenue and the eastbound approach to University Drive is 300 feet of full bay width plus additional length for capacity at individual locations as needed, and 180 feet of 15:1 taper. As discussed in the Deficiencies section, this is viewed as an important improvement for maintaining laminar flow in the through lanes, because it allows the turning vehicle to decelerate without adversely affecting the through traffic flow. Lengthening left turn lanes is considered to be a high priority.

  It is recommended that dual left turn lanes be installed on the westbound approach to the Park Avenue intersection (see later discussion). As an interim measure, the existing left turn lane could be lengthened to 480 feet of full bay width with 180 feet of 15:1 taper. This would provide badly needed additional vehicle storage, and would allow a future extension of the 15:1 taper to create a second 300 foot turn lane.

  The north leg of the University Drive intersection will be a private driveway, and doesn't warrant the expenditure for a full length left turn lane on the eastbound approach. However, a shorter left turn lane should be provided. It would be very undesirable from an operational and safety perspective for the occasional left turning vehicle to block the left through traffic lane. Without a left turn lane, it would be necessary to operate the eastbound approach with permissive left turns at all times, once a traffic signal has been installed. This is contrary to the recommended use of bi-modal left turn phasing found later in this section.

  A left turn lane consisting of 100 feet of full bay width and a 10:1 taper over 120 feet is recommended for the eastbound approach at University Drive.

  The estimated cost to lengthen mainline left turn lanes as described above is $470,000.

- Add mainline right turn lanes

  The problems with vehicles decelerating to make right turns out of a through lane, or using the existing gravel shoulders as defacto right turn lanes are documented in the Deficiencies section. Mainline right turn lanes should be added on all approaches that currently do not have them. Exceptions are the southbound approach to Grandview Avenue, the eastbound approach to 2nd Avenue (which already has a right turn lane, although it should be lengthened to the standards below), and the westbound approach to University Drive (a westbound right turn only accesses a private driveway). A minimum full width bay of 250 feet with a 15:1 taper over 180 feet is recommended for all mainline right turn lanes. This provides adequate length for a right turning vehicle to decelerate to 15 miles per hour before executing its turn, with all the deceleration occurring in the taper and full width turn bay. This is considered a high priority improvement because of its safety and operational benefits.

There appears to be some reluctance in Iowa to build parallel right turn lanes because of a perceived safety concern related to occlusion of mainline through vehicles by the vehicle in the right turn lane, when a stopped cross-street driver is attempting to select a gap. On a road with two or more lanes in one direction and no mainline right turn lane, however, the same occlusion occurs when, as a vehicle in the right lane decelerates to make a right turn, the vehicle behind it changes lanes to avoid having to decelerate. With mainline right turn lanes, sightlines for stopped cross-street vehicles can be improved in most cases by moving the stop line forward. Offsetting the mainline right turn lane from the adjacent through lane can further improve sightlines. Another advantage of mainline right turn lanes is that the cross-street driver can be much more certain whether a vehicle approaching on the mainline will be turning or traveling through the intersection.

The estimated cost to add mainline right turn lanes as described above is $690,000.

- Change cross-street geometrics

At the Isett Avenue, Mulberry Avenue and Cedar Street intersections this involves reconfiguring the cross-street to have opposing left turn lanes and a through/right turn lane in each direction. The benefits of doing this are discussed in the Deficiencies section. At Isett and Mulberry Avenues, this work can be done in conjunction with replacing the temporary traffic signal system with a new permanent signal system. At Cedar Street a major revision to the existing permanent signal system will be necessary.

At 2nd Avenue, the lane configuration is adequate, but the south leg of the intersection should be reconstructed to improve on the existing narrow lanes, sharp horizontal curvature and concrete joints that run diagonally across the lanes.

The above improvements are considered high priority.

Estimated costs are $120,000 each at Isett and Mulberry Avenues (not including replacement of the traffic signal systems), $270,000 at Cedar Street (including signal revision) and $100,000 at 2nd Avenue.

- Improve cross-street grades

  This is recommended at the Isett Avenue intersection to ensure that drivers on Isett Avenue don't lose sight of opposing vehicles, as sometimes happens with the existing roadway grades. This is a high priority improvement.

  Assuming that the profile on Isett Avenue must be changed over a length of 500 feet, the estimated cost of this improvement is $90,000.

- Remove right turn island

  This recommendation applies to the Isett and Mulberry Avenue intersections, and would be done as part of a revision of cross-street geometrics discussed earlier. However, if cross-street geometrics are not modified initially, it is suggested that, at a minimum, the islands be removed from these two intersections. Both have temporary signals, but the poles are not on the islands; rather, they are in the corners beyond the channelized right turns. Thus, the right turns technically don't bypass the signal and are not truly "free rights." The islands are therefore not serving a useful purpose, and could be difficult to see in certain weather conditions because of a lack of definition.

  Although this is not considered a serious safety hazard, the removal of the islands at these two intersections is given high priority because it can provide benefit at relatively little cost.

  The estimated cost for this work is $5,000 at each intersection for a total of $10,000.

- Park Avenue turn lanes

  Some north-south left turn accidents have been attributed to "poor alignment" of the left turn lanes on Park Avenue. The existing geometrics on Park Avenue feature a wide median on the north leg and a narrow median on the south leg. This arrangement creates a situation where the opposing north-south left turns are offset and block the view of oncoming through traffic. To reduce the visibility problem, the median on the north side of the intersection should be narrowed. This change will create a left turn lane that would be aligned to face the existing northbound left turn lane. The existing southbound left turn lane would then become the left hand through lane (see Figure 14).

RECOMMENDED IMPROVEMENTS BY LEG

NORTH LEG
- CHANGE EXISTING SOUTHBOUND LEFT TURN LANE TO A THROUGH LANE.
- ADD SOUTHBOUND LEFT TURN LANE.
- ADD SOUTHBOUND RIGHT TURN LANE.
- ADD 50:l LANE DROP TAPER OF SECOND NORTHBOUND THROUGH LANE.
- PULL BACK MEDIAN NOSE.

SOUTH LEG
- CHANGE EXISTING NORTHBOUND RIGHT TURN LANE TO A THROUGH LANE.
- ADD NORTHBOUND RIGHT TURN LANE.
- PULL BACK MEDIAN NOSE.

WEST LEG
- ADD EASTBOUND RIGHT TURN LANE.
- WIDEN MEDIAN AND PUSH WESTBOUND LANES TO THE NORTH.
- PULL BACK MEDIAN NOSE.

EAST LEG
- ADD SECOND WESTBOUND LEFT TURN LANE.
- ADD WESTBOUND RIGHT TURN LANE.
- PULL BACK MEDIAN NOSE.

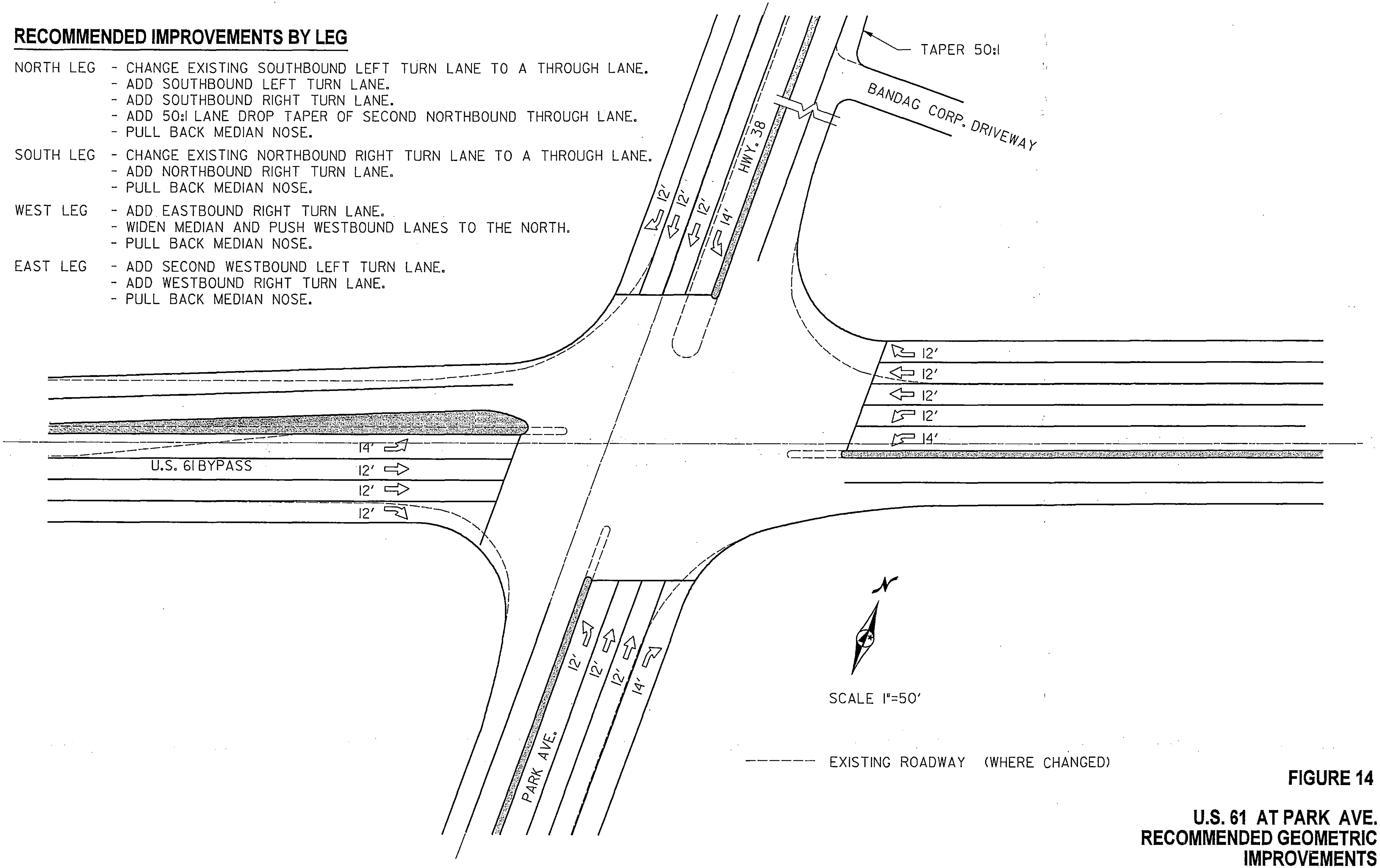


FIGURE 14

U.S. 61 AT PARK AVE. RECOMMENDED GEOMETRIC IMPROVEMENTS

The estimated cost of this high priority improvement is $40,000.

Currently, the northbound approach to the US 61/Park Avenue intersection consists of one left turn lane, one through lane and one right turn lane. The northbound departing leg has two lanes that align with the aforementioned through and right turn lanes. Accidents have been attributed to northbound through vehicles using the right turn lane as a through lane, and residents have witnessed this misuse of the lane fairly often. It is recommended that the right turn lane be redesignated a through lane, and a new right turn lane be added (see Figure 14). In addition to eliminating lane misuse, this will increase the capacity of the intersection. In order to accommodate the second northbound through lane, two northbound lanes departing the intersection must be provided, followed by a 50:1 lane reduction transition taper. Currently, a second northbound through lane ends at the Bandag Corporation driveway. This is a high priority improvement.

The estimated cost is $80,000.

The southbound approach to the same intersection has a wide concrete shoulder with rumble strips, and no exclusive right turn lane. A medium priority recommendation is to remove the rumble strips and stripe the shoulder as a right turn lane (see Figure 14). This will also increase intersection capacity.

The estimated cost for this work is $10,000.

- Add a second westbound left turn lane at Park Avenue

The existing left turn lane frequently fills up and queues spill into the adjacent through lane in peak periods. With an existing p.m. peak hour left turning volume of 320 vehicles, of which a relatively large percentage are trucks, this recommendation should receive strong consideration. A dual left turn will improve signal operation, both by significantly reducing the potential for queues to spill out of the turn bay, and by reducing the percent of the signal cycle length that must be devoted to this movement. Westbound dual left turn lanes are shown in Figure 14.

Adding a second left turn lane is considered a medium priority only because it is an expensive proposition, requiring extensive work associated with the realignment of through lanes and associated signal revisions. This option should be taken into consideration before any other work is performed at this intersection, however.

The estimated cost is $360,000. This figure does not include the cost of any right-of-way acquisition that may be necessary.

- Add reaction offset and taper for right turns onto mainline

  This is recommended at all unsignalized intersections (except on northbound US 61 at Hershey Avenue and westbound US 61 at University Drive) as well as the signalized intersections at Cedar Street, Mulberry Avenue and Isett Avenue (southbound to westbound right turn only), to allow vehicles turning right onto the mainline to reach a higher speed before merging with mainline through traffic, thereby reducing the size of gap needed. This design is intended to replicate the features of a freeway entrance ramp. It provides a safer environment for through vehicles, particularly when cross-street vehicles accept inadequate gaps, because the driver of the mainline vehicle has more time to adjust his speed if necessary. The offset and taper will permit right turning vehicles to accelerate at a rate that will allow them to fit into a gap when they merge with through traffic. The recommended design consists of a right turn island, a reaction offset of 10 feet at the point where the free right becomes tangent to the mainline, and a 50:1 taper of the outside edge line (see Figure 15). This is considered a medium priority recommendation.

  The estimated cost for this work is $1,200,000.

- Add acceleration lane to northbound US 61 from Hershey Avenue intersection

  Because of the four percent uphill grade on northbound US 61 north of Hershey Avenue, a free right turn island and acceleration lane should be added to help vehicles entering from Hershey accelerate before merging with through traffic. Assuming typical acceleration characteristics of a passenger car on this type of an upgrade, approximately 1600 feet are needed to accelerate from 15 mph (assumed turning speed) to 45 mph. A full-width acceleration lane of approximately this length, followed by a 50:1 taper over a length of 600 feet, is recommended. This is a medium priority improvement.

  Its estimated cost is $150,000.

- Vehicles turning right onto westbound US 61 from the Wal-Mart parking lot regularly drive off the paved surface at the corner. It is therefore recommended that the northwest corner radius be increased. The estimated cost of this low priority improvement is $30,000.

- A corridor-wide recommendation is to place bituminous pavement on mainline shoulders. Gravel is not as safe when a vehicle needs to pull off to the shoulder in an emergency. If a gravel shoulder is not maintained properly, drop-offs from the paved surface, ruts, and depressions can develop. Maintenance itself is a burden with a gravel shoulder. Gravel is sometimes deposited on the driving lanes by vehicles using the shoulder. This is listed as

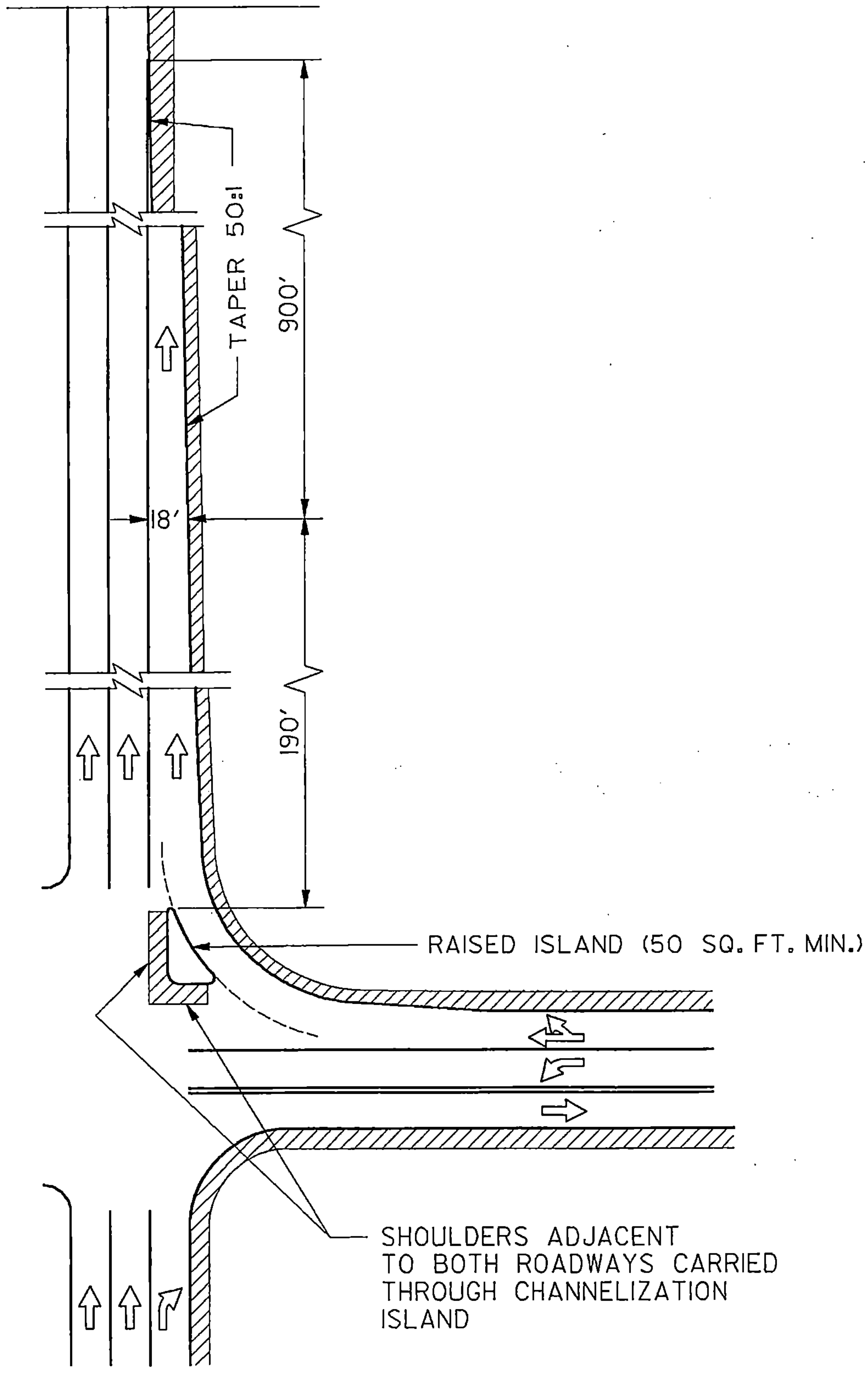


FIGURE 15

TYPICAL LAYOUT
REACTION OFFSET AND TAPER

a low priority item, because it appears to be contrary to standard IDOT practice and because of the significant capital expenditure involved, but it is recommended nonetheless. The estimated cost of paving the outside shoulders in both directions is approximately $460,000 per mile, or $3,600,000 for the entire corridor. If shoulders are paved in stages, it is suggested that the busiest area between Isett Avenue and the Wal-Mart access be completed first.

2. Traffic Control Improvements

Traffic control improvements include physical improvements associated with traffic signals, signing and striping.

- Replace temporary traffic signal with permanent signal system

  The existing temporary span wire traffic signal systems at the Isett and Mulberry Avenue intersections should be replaced with permanent full-traffic-actuated signal systems having mainline back detection and left turn lane detection. See the Deficiencies section for further discussion of the need for back detection. This is a high priority improvement. Along with the new signal systems, cross-street geometric revisions should be made as outlined in the Geometric Improvements section. These are not included in the estimated cost of $170,000 for each intersection.

- Add delineation to cross-street right turn islands

  This is a temporary improvement at those intersections where it is recommended that the islands be removed. However, it is suggested as an immediate improvement because of its low cost. The leading edge of each island on the cross-street approach should have a nine-button delineator.

  The estimated cost is $1,000.

- Relocate mainline back detectors

  As discussed in the Deficiencies section, moving loop detectors back to sufficient distance from the stop line to provide complete dilemma zone protection will create safer operation at the Cedar Street and Wal-Mart access signals. At Cedar Street, the back detectors should be relocated to 475 feet from the stop line. At Wal-Mart, they should be 350 feet from the stop line. This is a high priority improvement with a total estimated cost of $20,000.

- Add far left pole-mounted signal heads where there is left turn phasing

  The reasons behind this recommendation are stated in the Deficiencies section. It is applicable to the mainline at all signals, as well as the cross-street at Wal-Mart, Park Avenue, 2nd Avenue and Grandview Avenue. These signal heads would be included as part of the new permanent signals systems at Isett and Mulberry Avenues, and the revised signal system at Cedar Street. This improvement is designated as medium priority, and has an estimated cost of $40,000.

- Add far right pole-mounted signal heads

  As discussed in the Deficiencies section, accident reports suggested that occasionally drivers were not able to see overhead signal indications because of glare from the sun. Adding far right pole-mounted heads might help alleviate this situation. It is recommended, for the sake of consistency through the corridor, that far right heads be added in all locations where they don't currently exist, both on the mainline and the cross-street. These heads would be included as part of our new permanent signal systems at Isett and Mulberry Avenues, and a revised signal system at Cedar Street. This is a medium priority improvement with an estimated cost of $20,000.

- Study reducing posted speed limit through University Drive intersection

  The IDOT plans for the summer 1999 widening of US 61 to four lanes through the University Drive intersection show a posted speed limit of 65 miles per hour from the east to a point west of the intersection, where the speed limit is reduced. The proposed extension of University Drive, creating this new intersection, and the anticipated installation of a traffic signal at this location reflects the extension to the east of the Muscatine urbanized area. A signalized intersection at University Drive will most likely operate in a safer manner if the posted speed limit of 55 mph is extended to the east through the intersection. It is recommended that a speed study be conducted to determine the appropriate speed limit in this area. If the speed study suggests a reduced speed limit, changing the signing becomes a high priority improvement with an estimated cost of $2,000.

- Replace advance guide signs

  Replacement of the ground-mounted intersection advance guide signs with new signs having larger, more visible lettering is considered a low priority improvement. The estimated cost to replace these signs throughout the corridor is $25,000.

- Monitor University Drive intersection for signal justification, install traffic signal

If the University Drive intersection is initially constructed without a traffic signal (which should only be done if the median is designed with enough width to store a crossing vehicle), it should be monitored very closely. The warrant analysis based on projected traffic volumes that appears in the Appendix suggests that, upon opening of the intersection, the volume thresholds for Warrant 8 (Combination of Warrants) and Warrant 11 (Peak Hour Volume) will be exceeded. The City also has received a proposal for a commercial development at this location. In monitoring the intersection, particular attention should be given to the number of trucks making turns.

Monitoring the University Drive intersection for signal justification is a high priority item that should begin as soon as the intersection is opened to traffic. A new traffic signal system, which could probably be installed fairly rapidly by Muscatine Power and Water, is estimated to cost $150,000.

- Install traffic signals at Bidwell and Tipton

The traffic volumes at Bidwell and Tipton do not currently meet signal installation warrants. However, an operational analysis was performed which assumed that the signals were installed and coordinated with the other signal systems along the corridor. The results of that analysis showed an overall improved operation of the corridor with the installation of these two signals. See Figure 13.

The reason for this improvement is that with these two intersections in the coordinated system, the intersections at Mulberry and Cedar also performed better in coordination. A case could be made, therefore, for justifying the signals on the basis of the progressive movement warrant. The addition of signals at these two intersections will also help to establish the more suburban character, rather than rural, of this section of the Muscatine Bypass. The presence of the additional signalized intersections may create the impression for the driver that this is a cohesive and consistent corridor rather than a collection of isolated intersections with a variety of traffic control devices. Improved driver awareness may produce a safer environment.

The proposed signal systems would be full-traffic-actuated and would only leave the mainline green when there are vehicles waiting on the side streets or left turn lanes and the change of the signal fits with the coordination pattern. Therefore, the only significant negative aspect of the installation of these signals at this time would be the cost of construction and maintenance. The installation of these two signal systems, along with hardwire interconnect from Isett Avenue to Cedar Street, would be classified as medium priority. The estimated cost is $550,000 ($170,000 for each signal system and $210,000 for interconnect).

- Monitor remaining unsignalized intersections for signal justification

  At present, signalization is not warranted at the Lucas or Sampson intersections. Approach volumes at these intersections should be checked periodically against the volume thresholds for traffic signal warrants, particularly if substantial volume increases are evident. The cost for this low priority item is negligible.

- Add pedestrian crossing at 2nd Avenue

  As discussed in the Deficiencies section, there is pedestrian demand at this intersection. To satisfy that demand by providing a safer environment for pedestrians, a pedestrian crossing of US 61 at the 2nd Avenue signal is recommended. This includes the addition of a marked crosswalk, and pedestrian signal indications and push buttons. The signal timing plan will need to be modified to include pedestrian timing.

  This is a high priority item with an estimated cost of $10,000.

3. Development, Access Improvements

As stated earlier, access control is generally good along the corridor. As development is proposed in the future, it will be important to maintain this good access control to ensure that the performance of the US 61 bypass remains satisfactory.

- Close field entrances

  The City is currently controlling field entrances in an adequate manner. As a matter of policy, whenever the opportunity presents itself, existing field entrances should be closed. Maintaining this policy will promote a safer operating environment along the corridor over time, and will help to better define access control along the bypass. This is considered to be low priority, but should be a continuing effort. Cost is negligible.

4. Operational Improvements

Operational improvements are specific to the signalized intersections. They are either modifications to be made to the signal controller programming or signal hardware or software additions/revisions that modify the operation of the traffic signal system.

- Reduce cross-street minimum greens

  Longer cross-street minimum green times increase the potential for unnecessary delays to mainline vehicles, especially during off-peak periods.

As long as cross-street detection is adequate, as it appears to be on the plans for the in place signals, cross-street vehicle extensions are reasonable, and cross-street truck percentages are not too high, there should be no need for cross-street minimum greens of more than 10 seconds at the signals with lower cross-street volumes (Park Avenue and Grandview Avenue excluded).

See further discussion under **Detailed Analysis of Mulberry Avenue and US 61 Intersection** in the Deficiencies section.

Any adjustments to minimum greens should be observed in the field to make sure there are no intersection-specific characteristics that result in adverse impacts to operation.

This is considered an immediate priority improvement because it only involves a controller programming adjustment at each traffic signal. Cost is negligible.

- Make mainline left turn lane detectors extend through phase in protected/ permissive operation

  By extending the through phase when left turns are being made during the permissive interval, left turning drivers are more likely to find a gap in opposing through traffic while the green circular indication is still displayed. Without the through phase extension, its more likely that the left turn will be made on the yellow clearance interval. A computer simulation will not display a tremendous improvement in signal performance, particularly if left turning volumes are relatively light. However, this operation provides a safer environment for left turners.

  This is another immediate priority because it involves only a controller programming change at each traffic signal. Cost is negligible.

- Insert time-based signal coordination

  This is an immediate priority recommendation that is considered a temporary measure until hardwire interconnect can be installed (see discussion below). The signals along US 61 that are recommended to be coordinated are University, Wal-Mart, Park, 2nd and Isett. These signals are spaced closely enough that operational benefit can be gained by promoting mainline progression through signal coordination.

  The estimated cost for this work is $2,000 per intersection, or $10,000 total. This estimate covers the cost to develop and implement a series of time-based coordinated timing plans.

- Install hardwire interconnect and coordinate US 61 signals

  Interconnecting the signals mentioned in the previous section will allow their controllers to be kept in sync by a master controller with an internal time clock. The operating agency won't need to worry about checking the clocks on individual controller units to verify that they are displaying exactly the same time, as they would with time-based coordination. The system will be assured of operating with the cycle lengths and offsets as programmed into the controllers.

  This is a high priority item, in that it has the potential to significantly improve mainline progression, and consequently overall system operation. The estimated cost is $90,000.

- Install hardwire interconnect on Park Avenue between US 61 and Cleveland Street

  Park Avenue has a coordinated signal system that extends from Fifth Street at the south end to Cleveland Street at the north end. Cleveland Street is the first signalized intersection south of US 61 on Park Avenue, approximately 800 feet south of US 61. It is recommended that, once the US 61 traffic signals have been interconnected and coordinated, interconnect cable be placed along Park Avenue between the US 61 and Cleveland Street signals, thereby tying the two systems together.

  Operation should be set up as follows:

  The two systems should not be continuously coordinated, since it would not be prudent to force undue delay upon US 61 vehicles because of traffic conditions on Park Avenue, and vice versa. Rather, each master controller should pick its own appropriate timing plans. The timing plan libraries for the two signal systems should contain one or more like cycle lengths. When both master controllers call for the same cycle length, the two signal systems can be synched up and run as one system, with the US 61 master controller temporarily becoming the master controller for the entire system. The Park Avenue master controller would temporarily operate as a subordinate, until the cycle length changes for one of the corridors.

  This is a medium priority item, although it might make sense to install this interconnect at the same time as the US 61 interconnect. The estimated cost is $20,000.

- Install mainline bi-modal left turn phasing

  The advent of light-emitting diode (LED) signal displays has made this recommendation possible. Currently, mainline left turns are handled exclusively with protected/permissive phasing (5-section signal heads). With the high speeds on US 61 and increasing traffic volumes, this type of operation will cause greater safety concerns over time. While protected-only left turn operation provides a safer environment for drivers, it generally has more overall intersection delay than protected/permissive operation, particularly in off-peak hours.

  Bi-modal left turn phasing would gain the safety benefits of protected-only operation in peak volume periods when the left turn accident potential has been shown to be greatest, and the operational efficiency of the existing protected/permissive operation in off-peak periods when the accident potential is low.

  Existing red lenses would be replaced with red LED indications, which are capable of displaying either a circular or an arrow indication. In the off-peak periods, the signals would operate as they do now, with protected/permissive left turns and red circular indications. In peak periods, the red indications would become arrows, and would be utilized in conjunction with only the green and yellow arrows, creating effectively a three-section signal head and protected-only left turn operation.

  A dual message, blank-out fiber optic sign would be placed adjacent to the left turn signals. The two messages would be: (1) "LEFT ON GREEN YIELD" or (2) "NO LEFT TURN ON RED ARROW".

  Alternatively, the red circular indication could be used in both modes of operation. A dual message sign similar to the one above would present one of the following two messages:

  (1) "LEFT ON GREEN YIELD" when in protected/permissive operation, and
  (2) "LEFT TURN SIGNAL" when in protected only operation.

  In the case of the 170 signal controllers in use in Muscatine, bi-modal left turn phasing will require some software work to inform the controller how and when to switch between the two types of operation, and how to tell the signal equipment to change displays. It will also require cabinet wiring associated with load switch terminations and possibly reprogramming of conflict monitors.

  If a second westbound left turn lane is added at the Park Avenue intersection (see recommendation under Geometric Improvements), that signal will need to run in protected-only mode at all times, and will not have bi-modal left turn phasing. Bi-modal phasing is also not recommended for the Grandview Avenue intersection because of the lower speeds and the fact that US 61 turns there.

This is considered a medium priority item. If this recommendation is pursued, time should be allowed for the development of the software and conflict monitor modifications. The estimated cost to change to bi-modal left turn phasing at all the remaining signals along the corridor is $60,000.

- Install Advance Warning Flashers

  Advance Warning Flasher (AWF) installations are recommended at the following locations:

  - Westbound approach to University Drive
  - Eastbound approach to Isett Avenue
  - Both approaches to Mulberry Avenue
  - Both approaches to Cedar Street.

  The recommended AWF design for a 55 mph approach includes flashing devices with warning signs on either side of the approach at a distance of 600 feet upstream of the stopline, and a loop detector in each through lane at a distance of 800 feet upstream of the stopline. In a coordinated signal system, the mainline detectors serve two purposes: they provide dilemma zone protection if the signal runs uncoordinated for parts of the day or if communication to the master controller is disrupted, and they allow the signal to be operated such that the mainline can gap out in coordinated operation. With this layout, the flashers are activated for a period of 8 seconds before the mainline green indications change to yellow.

  The purpose behind the AWF installations is twofold. They will warn drivers that they are approaching a traffic signal where one might not be expected, and, if designed correctly, will create an area on the roadway where drivers have a heightened sense of awareness that the signal is about to change, thereby decreasing reaction times. See the Appendix for a time-space diagram for advance warning flasher operation.

  Installation of AWF's at the locations noted above is considered a medium priority improvement. The estimated cost is $25,000 per installation, or $150,000 for all six installations.

5. <u>ITS Applications</u>

The use of the bi-modal left turn signal and the advance warning flashers could be considered to be ITS applications. However, those two items are definitely recommended to address clearly stated problems. Other ITS applications could be considered that would be classified as further enhancements.

- The Speed Funnel

  The term "speed funnel" can be described as providing advisory speed information to a driver approaching an isolated signal system or the first intersection in a group of interconnected signal systems along an arterial roadway. The advised speed is displayed on a changeable message sign tied to the operation of the signal systems. The sign legend would basically consist of the message "DRIVE XX MPH TO REACH SIGNAL ON GREEN". The changeable message sign would ideally be placed at a location where the advisory speeds fall within a 10-mile per hour range of the operating speed of the roadway. It would not be prudent to suggest driving more than 10 miles per hour below the speed limit.

  The sign would be placed far enough away from the intersection that if the driver followed the sign's advice they would arrive at the intersection during the green. If the driver did not follow the first advisory sign, there would also be an intermediate sign to reconfirm the speeds of those obeying the first sign and to alert the other drivers to be prepared to stop.

  However, this would mean that for US 61 the sign would need to be placed over a mile from the signalized intersections. Therefore, because of the level of roadside development and other distractions, it is recommended that rather than providing a true "Speed Funnel" a modified version would be used instead. The approach to the signal group would feature ground mount "static" signs with a possible legend that would read "10 TRAFFIC SIGNALS IN NEXT 9 MILES". These static signs would be located about 600 feet before a hybrid dynamic and static sign that would read: "SIGNAL ADVISORY" (static) with the following dynamic messages: (1) MAINTAIN <u>*55, 50 OR 45*</u> MPH FOR GREEN SIGNAL, (2) BE PREPARED TO STOP, (3) <u>*FOG, SNOW, ICE, RAIN, ACCIDENT,*</u> REDUCE SPEED or when the system is not fully operational the dynamic portion of the sign would be blank. See the Appendix for a time-space diagram for the operation of the speed funnel.

  A speed funnel installation is estimated to cost $70,000.

- Advisory speed signs between signals

  At a location a few hundred feet past each signal system an auxiliary dynamic display could be provided that would read SIGNALS SET FOR <u>*XX*</u> MPH.

This type of sign has been mentioned in the Manual on Uniform Traffic Control Devices. This type of system has been used at several locations in the U.S.A. and in Europe. It could help to keep platoons together, and thereby improve operation.

- Detection of weather conditions

  There are a variety of weather responsive systems in use today. These systems range from pavement temperature sensors to sophisticated visibility measuring devices to detect fog conditions. An automated weather condition sensing system could be installed and used to drive some of the messages on the signal advisory signs.

- Remote and or automated monitoring

  The remote monitoring of the operation of the Muscatine bypass can take several forms.

  The first application is the arterial master signal controller. A 170-type signal controller can be configured through software to operate as a "closed loop" type traffic responsive master controller. As a master controller it would not only analyze traffic patterns in order to select system wide timing plans, it would also serve as a communications hub and an equipment-monitoring device. It would have telephone dial in and dial out capability. The master could be accessed from the power company shop, the district office, the central office or the consultant's office. The master would report malfunctions and real time displays of the current operation could be viewed at the remote locations. New timing plans could be installed remotely. Traffic data collection could also be automated.

  The second application would be the use of machine vision to monitor the operation of one of the ITS techniques that could be utilized on the corridor. For example, machine vision could be used to monitor the performance and violation rates of the proposed protected only left turn operation. Or machine vision could measure vehicle speeds that should have been influenced by one of the dynamic displays.

  The third application would be in the form of live video images being brought back to the power company shop or an Iowa DOT office to show traffic or weather conditions at key locations.

B. Prioritized Improvements by Intersection

Following is a compilation of recommendations for the entire corridor and for each intersection, in order of priority. Refer to the previous section of this report for details about each improvement. Estimated costs include construction and engineering.

		Estimated Cost
1.	Corridor-Wide	
	Immediate Priority	
	• None	
	High Priority	
	• None	
	Medium Priority	
	• None	
	Low Priority	
	• Pave shoulders on mainline	$3,600,000
	• Close field entrances	Negligible
	• Replace ground-mounted advance guide signs	$25,000
2.	University Drive*	
	Immediate Priority	
	• Time-based signal coordination	$2,000 per intersection
	High Priority	
	• Monitor for signal justification, install full-traffic-actuated traffic signal system	$150,000
	• Lengthen westbound left turn lane, add short eastbound left turn lane	$30,000
	• Add eastbound right turn lane	$30,000
	• Reduce posted speed limit through intersection	$2,000
	• Install hardwire interconnect to west, and coordinate signal when constructed	$15,000
	Medium Priority	
	• Add mainline bi-modal left turn phasing when signal is constructed	$10,000
	• Install advance warning flasher on westbound approach, when signal is constructed	$25,000

	Estimated Cost
• Add reaction offset and taper for right turns onto eastbound mainline	$80,000

Low Priority

- None

* This intersection is scheduled to be constructed along with the extension of a four-lane section to the east along US 61 in the summer of 1999. The recommended improvements contained herein are based on the roadway construction plans only. Therefore, recommendations regarding traffic control and operation are not comprehensive.

3. Wal-Mart Access

Immediate Priority

• Reduce cross-street minimum greens	Negligible
• Make left turn lane detectors extend through phase during permissive operation	Negligible
• Time-based signal coordination	$2,000 per intersection

High Priority

• Lengthen mainline left turn lanes	$40,000
• Add mainline right turn lanes	$60,000
• Relocate mainline back loop detectors	$10,000
• Install hardwire interconnect and coordinate signal	$20,000

Medium Priority

• Add far left pole-mounted signal heads for all approaches	$10,000
• Add far right pole-mounted signal heads on mainline	$5,000
• Add mainline bi-modal left turn phasing	$10,000

Low Priority

• Improve radius in northwest corner	$30,000

		Estimated Cost
4.	Park Avenue/Highway 38	
	Immediate Priority	
	• Make left turn lane detectors extend through phase during permissive operation	Negligible
	• Time-based signal coordination	$2,000 per intersection
	High Priority	
	• Lengthen mainline left turn lanes	$40,000
	• Add mainline right turn lanes	$60,000
	• Change existing southbound left turn lane to a through lane, add southbound left turn lane	$40,000
	• Change existing northbound right turn lane to a through lane, add northbound right turn lane	$80,000
	• Install hardwire interconnect along US 61 and coordinate signal	$20,000
	Medium Priority	
	• Convert paved shoulder on southbound approach into right turn lane	$10,000
	• Add a second westbound left turn lane	$360,000
	• Add far left pole-mounted signal heads for all approaches	$10,000
	• Add far right pole-mounted signal heads on all approaches	$10,000
	• Install hardwire interconnect south to Cleveland Street	$20,000
	Low Priority	
	• None	
5.	2nd Avenue	
	Immediate Priority	
	• Reduce cross-street minimum greens	Negligible
	• Make left turn lane detectors extend through phase during permissive operation	Negligible
	• Time-based signal coordination	$2,000 per intersection

	Estimated Cost
High Priority	
• Lengthen mainline left turn lanes	$40,000
• Add a westbound mainline right turn lane, lengthen eastbound right turn lane	$60,000
• Revise cross-street geometrics, including redoing concrete joint layout on northbound approach	$100,000
• Install hardwire interconnect and coordinate signal	$20,000
• Add a pedestrian crossing of US 61	$10,000
Medium Priority	
• Add far left pole-mounted signal heads for all approaches	$10,000
• Add far right pole-mounted signal heads on mainline	$5,000
• Add mainline bi-modal left turn phasing	$10,000
Low Priority	
• None	

6. Isett Avenue

Immediate Priority	
• Add delineation to cross-street right turn islands	$300
• Reduce cross-street minimum greens	Negligible
• Time-based signal coordination	$2,000 per intersection

	Estimated Cost
High Priority	
• Lengthen mainline left turn lanes	$40,000
• Add mainline right turn lanes	$60,000
• Remove cross-street right turn islands	$5,000
• Change cross-street geometrics to a left turn lane and a through/right turn lane	$120,000
• Replace temporary signal with a full-actuated permanent signal. Include mainline left turn detectors that extend the through phase during protected/permissive operation, far left signal heads on mainline, and far right pole-mounted signal heads on all approaches.	$170,000
• Install hardwire interconnect to east, and coordinate signal	$15,000
• Improve cross-street grades to ensure satisfactory sight distance	$90,000
Medium Priority	
• Add mainline bi-modal left turn phasing	$10,000
• Install advance warning flasher on eastbound approach	$25,000
• Add reaction offset and taper for right turns onto westbound mainline	$80,000
Low Priority	
• None	

7. Bidwell Road

Immediate Priority

- None

High Priority	
• Lengthen mainline left turn lanes	$40,000
• Add mainline right turn lanes	$60,000

Estimated Cost

Medium Priority

- Add reaction offset and taper for right turns onto mainline – both directions — $160,000
- Install full-traffic-actuated traffic signal system and hardwire interconnect between Isett and Tipton — $270,000

Low Priority

- None

8. Tipton Road

Immediate Priority

- None

High Priority

- Lengthen mainline left turn lanes — $40,000
- Add mainline right turn lanes — $60,000

Medium Priority

- Add reaction offset and taper for right turns onto mainline – both directions — $160,000
- Install full-traffic-actuated traffic signal system and hardwire interconnect between Tipton and Cedar — $280,000

Low Priority

- None

9. Mulberry Avenue

Immediate Priority

- Add delineation to cross-street right turn islands — $300
- Reduce cross-street minimum greens — Negligible

	Estimated Cost
High Priority	
• Lengthen mainline left turn lanes	$40,000
• Add mainline right turn lanes	$60,000
• Remove cross-street right turn islands	$5,000
• Change cross-street geometrics to a left turn lane and a through/right turn lane	$120,000
• Replace temporary signal with a full-actuated permanent signal. Include mainline left turn detectors that extend the through phase during protected/permissive operation, far left signal heads on mainline, and far right pole-mounted signal heads on all approaches.	$170,000
Medium Priority	
• Add mainline bi-modal left turn phasing	$10,000
• Install advance warning flashers on both mainline approaches	$50,000
• Add reaction offset and taper for right turns onto mainline – both directions	$160,000
Low Priority	
• None	

10. Cedar Street

Immediate Priority	
• Add delineation to cross-street right turn islands	$300
• Reduce cross-street minimum greens	Negligible
• Make left turn lane detectors extend through phase during permissive operation	Negligible

	Estimated Cost
High Priority	
• Lengthen mainline left turn lanes	$40,000
• Add mainline right turn lanes	$60,000
• Change cross-street geometrics to a left turn lane and a through/right turn lane. This will necessitate removing the right turn islands and reconstructing the majority of the signal system. Include mainline left turn detectors that extend the through phase during protected/ permissive operation, far left signal heads on mainline, and far right pole mounted signal heads on all approaches.	$270,000
• Relocate mainline back loop detectors	$10,000
Medium Priority	
• Add mainline bi-modal left turn phasing	$10,000
• Install advance warning flashers on both mainline approaches	$50,000
• Add reaction offset and taper for right turns onto mainline – both directions	$160,000
Low Priority	
• None	

11. Lucas Street

Immediate Priority	
• None	
High Priority	
• Lengthen mainline left turn lanes	$40,000
• Add mainline right turn lanes	$60,000
Medium Priority	
• Add reaction offset and taper for right turns onto mainline – both directions	$160,000

	Estimated Cost
Low Priority	
• Monitor for signal justification	Negligible

12. Hershey Avenue*

Immediate Priority

- None

High Priority	
• Lengthen mainline left turn lanes	$40,000
• Add mainline right turn lanes	$60,000

Medium Priority	
• Add uphill (northbound) acceleration lane	$150,000
• Add reaction offset and taper for right turns onto southbound mainline	$80,000

Low Priority

- None

* See "Section V. Hershey Avenue Alternatives" for discussion of possibilities for modified at-grade intersections and interchanges at this location.

13. Sampson Street

Immediate Priority

- None

High Priority	
• Lengthen mainline left turn lanes	$40,000
• Add mainline right turn lanes	$60,000

Medium Priority	
• Add reaction offset and taper for right turns onto mainline – both directions	$160,000

	Estimated Cost
Low Priority	
• Monitor for signal justification	Negligible

14. Grandview Avenue*

Immediate Priority	
• Make left turn lane detectors extend through phase during permissive operation	Negligible
High Priority	
• None	
Medium Priority	
• Add far left pole-mounted signal heads for all approaches	$10,000
Low Priority	
• None	

* IDOT plans on widening US 61 to four lanes to the west from this intersection in the future. When this is done, it is recommended that the southbound right turn lane becomes the second westbound lane (an add-lane) departing the intersection. It is further recommended that consideration be given to an eastbound dual left turn.

C. Improvements and Corresponding Costs by Priority

In this section, recommended improvements are arranged according to the priority categories established previously. Estimated construction and engineering costs are attributed to each improvement, and are totaled for each category of priority. The cost for each improvement represents the total of the estimated costs for that improvement at all the locations for which it is recommended. Note that references to traffic signal improvements at the University Drive intersection assume that a signal is installed when the intersection is opened to traffic.

Immediate Priority		Estimated Cost
1.	Add delineation to cross-street right turn islands (Isett, Mulberry, Cedar intersections)	$1,000
2.	Reduce cross-street minimum greens (Wal-Mart, 2nd, Isett, Mulberry, Cedar signals)	Negligible
3.	Make left turn lane detectors extend through phase during protected/permissive operation (Wal-Mart, Park, 2nd, Cedar, Grandview signals)	Negligible
4.	Install time-based signal coordination (University, Wal-Mart, Park, 2nd, Isett signals)	$10,000
High Priority		
1.	Lengthen mainline left turn lanes (University - westbound only, Wal-Mart, Park, 2nd, Isett, Bidwell, Tipton, Mulberry, Cedar, Lucas, Hershey, Sampson intersections). Add short eastbound left turn lane at University.	$470,000
2.	Add mainline right turn lanes (University - eastbound only, Wal-Mart, Park, 2nd-westbound only, Isett, Bidwell, Tipton, Mulberry, Cedar, Lucas, Hershey, Sampson intersections). Lengthen existing eastbound right turn lane at 2nd Avenue.	$690,000
3.	Change cross-street geometrics to a left turn lane and a through/right turn lane. Includes removing right turn islands. At Cedar Street, requires a major signal revision (Isett, Mulberry, Cedar intersections).	$520,000
4.	Revise cross-street geometrics, including redoing concrete joint layout on northbound approach (2nd Avenue intersection).	$100,000
5.	Change existing southbound left turn lane to a through lane, add southbound left turn lane (Park intersection)	$40,000
6.	Change existing northbound right turn lane to a through lane, add northbound right turn lane (Park intersection)	$80,000

High Priority (continued)		Estimated Cost
7.	Improve cross-street grades to ensure satisfactory sight distance (Isett intersection)	$90,000
8.	Replace temporary signals with full-actuated permanent signals. Include mainline left turn detectors that extend the through phase during protected/permissive operation (Isett, Mulberry signals).	$340,000
9.	Relocate mainline back loop detectors (Wal-Mart, Cedar signals).	$20,000
10.	Conduct speed study, reduce posted speed limit through intersection if appropriate (University intersection).	$2,000
11.	Install hardwire interconnect and coordinate signals (University, Wal-Mart, Park, 2nd, Isett signals).	$90,000
12.	Add a pedestrian crossing of US 61 (2nd Avenue signal)	$10,000
13.	Monitor for signal justification, install full-traffic-actuated traffic signal system (University intersection)	$150,000

Medium Priority

1.	Add a second westbound left turn lane (Park intersection)	$360,000
2.	Convert paved shoulder on southbound approach to a right turn lane (Park intersection).	$10,000
3.	Add uphill (northbound) acceleration lane (Hershey intersection).	$150,000
4.	Add reaction offset and taper (University-eastbound, Isett-westbound, Bidwell, Tipton, Mulberry, Cedar, Lucas, Hershey-southbound, Sampson intersections).	$1,200,000
5.	Add far left pole-mounted signal heads for all approaches (Wal-Mart, Park, 2nd, Grandview signals).	$40,000

Medium Priority (continued)	Estimated Cost
6. Add far right pole-mounted signal heads (Wal-Mart, Park, 2nd Avenue signals).	$20,000
7. Install hardwire interconnect on Park Avenue between US 61 and Cleveland Street (Park signal).	$20,000
8. Add mainline bi-modal left turn phasing (University, Wal-Mart, 2nd, Isett, Mulberry, Cedar signals).	$60,000
9. Install mainline advance warning flashers (University-westbound, Isett-eastbound, Mulberry-both approaches, Cedar-both approaches).	$150,000
10. Install signals at Bidwell and Tipton with interconnect between Isett and Cedar.	$550,000

Low Priority

1. Pave shoulders on mainline (entire corridor).	$3,600,000
2. Improve radius in northwest corner (Wal-Mart intersection).	$30,000
3. Replace ground-mounted advance guide signs (entire corridor).	$25,000
4. Monitor for signal justification (Lucas, Sampson intersections).	Negligible
5. Close field entrances (entire corridor).	Negligible

If all the recommended improvements in this section are made, the total estimated cost for each priority is as follows:

Immediate Priority	$ 11,000
High Priority	$2,602,000
Medium Priority	$2,560,000
Low Priority	$3,655,000

The total estimated cost for all improvements is $8,828,000.

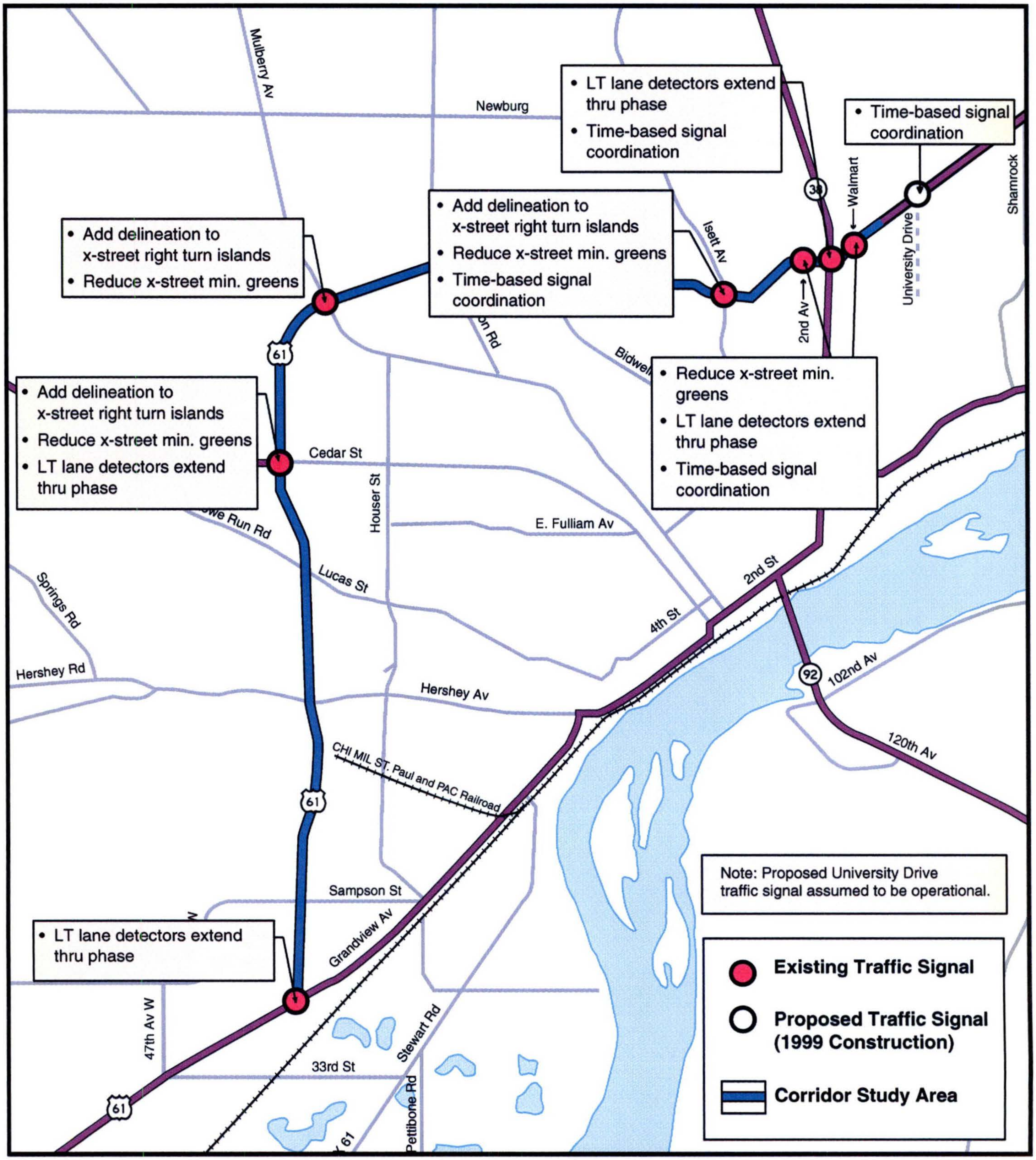


FIGURE 16
RECOMMENDATIONS – IMMEDIATE PRIORITY

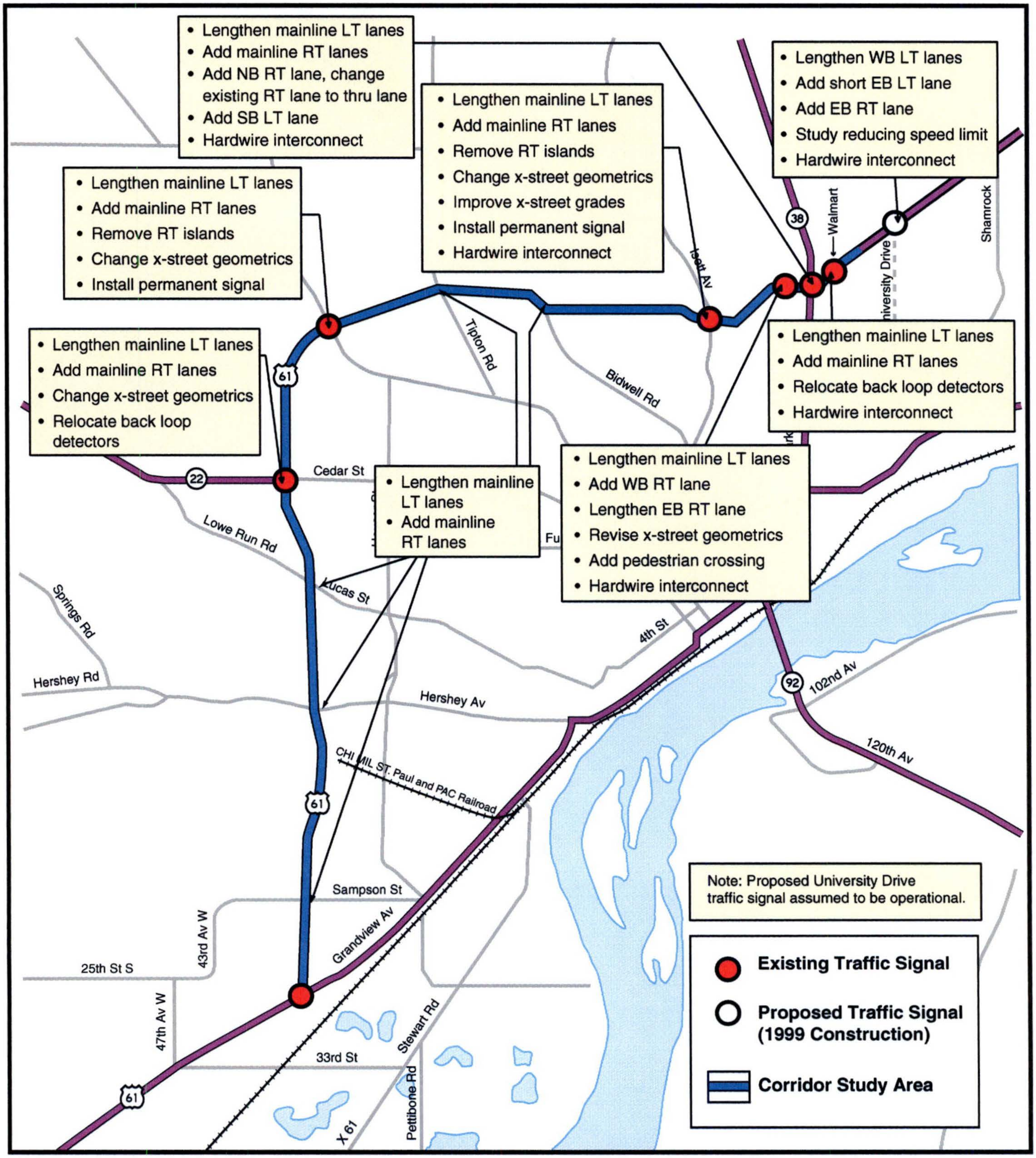


FIGURE 17
RECOMMENDATIONS – HIGH PRIORITY

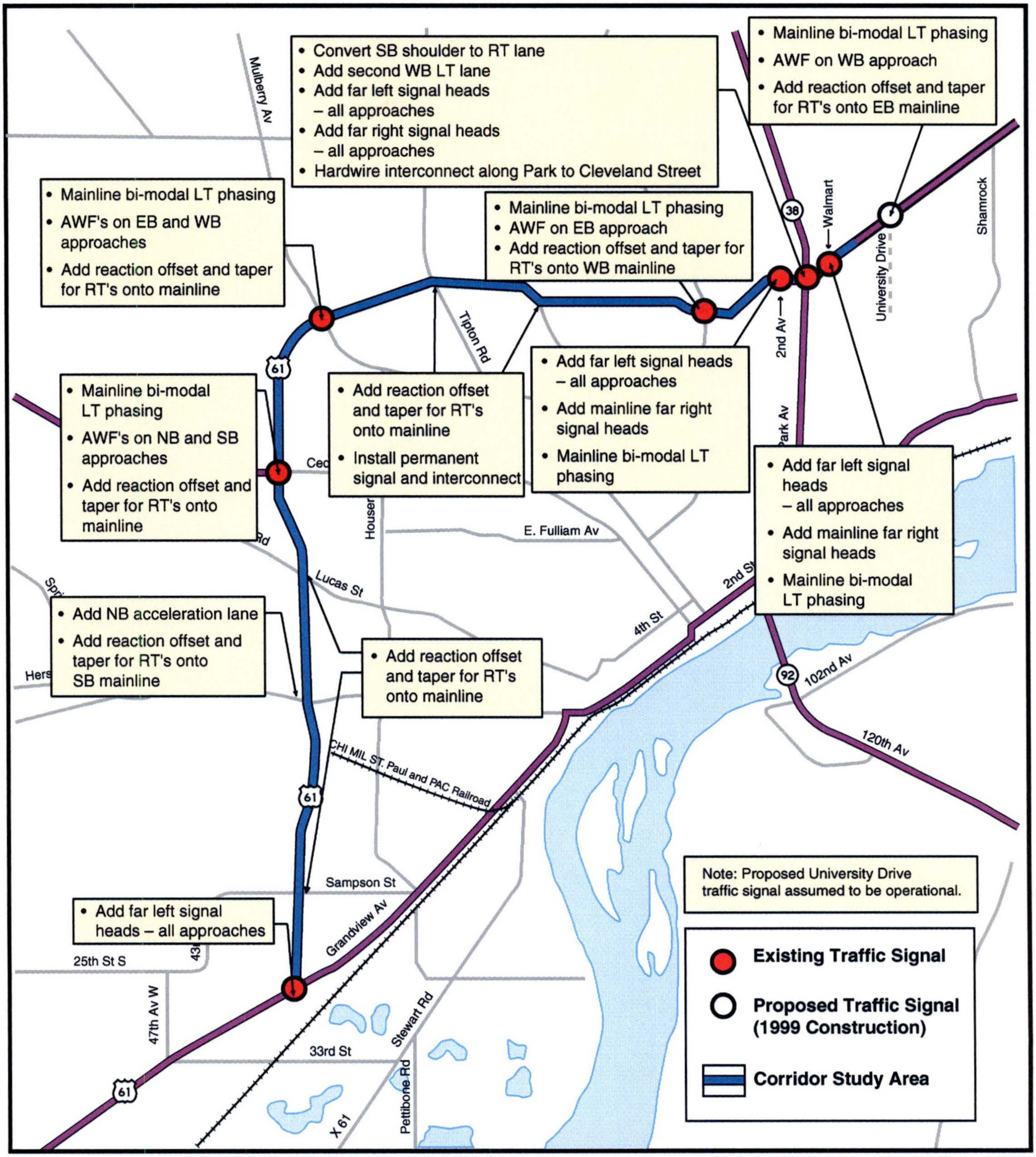


FIGURE 18
RECOMMENDATIONS – MEDIUM PRIORITY

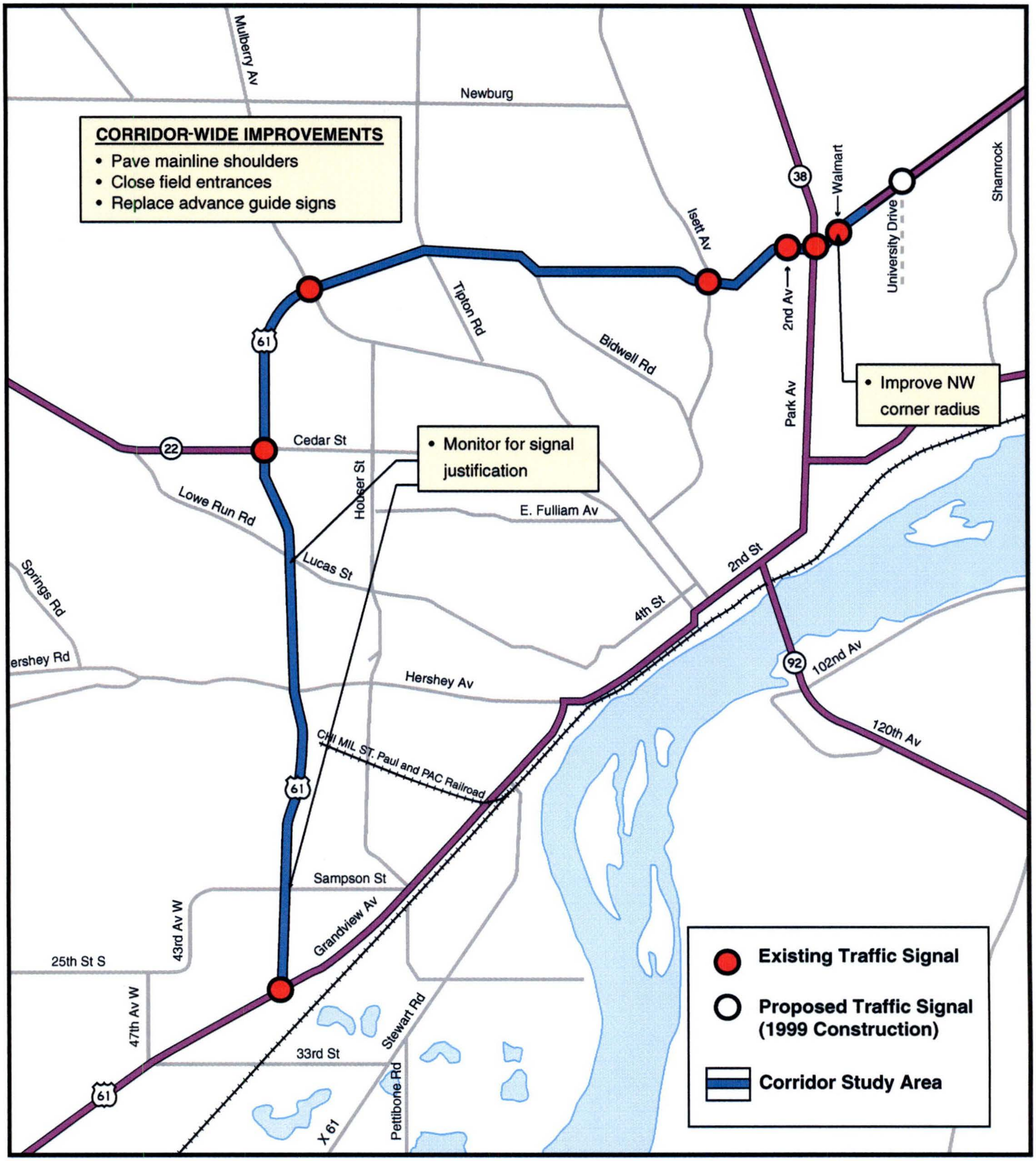


FIGURE 19
RECOMMENDATIONS – LOW PRIORITY

V. HERSHEY AVENUE ALTERNATIVES

The intersection of US 61 and Hershey Avenue has been the scene of several serious accidents over the past few years. Fortunately, the most recent accident data indicates that there has been a trend toward fewer accidents in the last two years. In 1994 there were 16 accidents, including a fatal accident; in 1995, 13 accidents; in 1996, 8 accidents and in 1997 there were 3 accidents. However, there is still concern about the accident potential and in fact, during the first few months of 1998 there were 3 accidents.

It is the concern over the past high accident numbers and the severity of those accidents that has prompted IDOT to ask what would be the best long range improvement to make at this location. The fact that the intersection is located in the middle of a very long and relatively steep (four percent) grade adds to the complexity of selecting the appropriate improvement measures. The presence of this grade raises serious questions about the advisability of leaving any type of at-grade intersection at this location if traffic signal control were to be added. The high percentage of truck traffic on US 61 was also a concern.

A traffic operations analysis was performed using the existing intersection geometry and existing volumes with stop signs on Hershey Avenue as the traffic control. This analysis showed that the annual benefits that could be gained from grade separating Hershey Avenue from US 61 would not be sufficient to offset the annualized cost of the grade separation. The reason for this is that the only movements receiving benefit are the relatively low through and left turn volumes going to and from Hershey Avenue. A relatively low cost design was assumed for those calculations. The design featured a bridge offset to the north of Hershey and the existing intersection remaining open but restricted to allow only right turns to and from US 61.

The assumption was then made that if Hershey were to be signalized, what then would be the economic benefits of replacing the signal with a grade separation. The proposed signal system was assumed to be fully traffic actuated for this analysis. The comparison of the signal versus grade separation still did not indicate that there would be sufficient savings in delay and vehicle operating costs to offset the higher cost of the grade separation with the current traffic volumes.

The forecast volumes for the year 2018 were then analyzed with the assumption that 30 percent of main line vehicles would have to stop and that 25 percent of the traffic would consist of trucks. Using those figures, but using today's user costs, would indicate that a project with an estimated cost in 1999 of five million dollars could be economically justified. If the expected savings from accident reduction were also considered, then a grade separation would be clearly justified in the future to replace a traffic signal. Further justification for a grade separation at Hershey could be gained if the intersection at Lucas Avenue could then have its median closed and be restricted to right turns only.

An alternative design was evaluated that provided a bridge to carry Hershey Avenue over US 61. With this design the existing intersection was retained as an access point, but restricted to only right turns. This design had an estimated cost of about $2.5 million. With this estimated cost, this alternative would be cost effective when compared to traffic signal control and assuming continued traffic growth in 5 to 10 years.

If a traffic signal were installed as an interim measure, in order to improve safety and existing traffic operations, then that signal system should be designed with added features. These features would include advance warning flashers and added main line detection. The intersection should be operated in a manner that minimizes the negative impacts of trying to stop large numbers of trucks.

Several possible improvements for Hershey Avenue were developed and analyzed. These alternatives are described below and are shown in Figures 20 through 27.

DESCRIPTIONS OF ALTERNATIVES AND CONSTRUCTION COST ESTIMATES

1. Basic improvements to intersection geometry – This alternative would provide geometric improvements to help optimize the operation of the existing intersection with the side street "STOP" controls. These recommended geometric changes would also be needed if signals were to be installed at the intersection. This alternative would provide:

   - Right turn lanes -$60,000
   - Longer left turn lanes with provision for downhill braking and truck storage $40,000
   - An uphill acceleration lane for westbound right turns onto northbound U.S. 61 $150,000
   - Total Cost - $250,000

   This alternative would be appropriate if a full movement intersection is to remain in operation.

2. Traffic signals – Traffic signals would be installed if needed to reduce accidents. The signal installation would be done in conjunction with the geometric improvements of item 1. –

   - Cost of signals with special detection and advance warning flashers - $170,000
   - Total cost - signals with improvements from item 1. - $420,000

   The recent accident experience has shown a reduction in the numbers and severity of the crashes. This may mean that the installation of traffic signals could be delayed. The intersection should be closely monitored for any possible accident increase or changes to traffic volumes and patterns. The reduction in the number of accidents occurring in recent years indicates a condition where the installation of traffic signals may increase the number of accidents at this location.

3. Intersection revisions to eliminate side street through and left turn movements – The side street left turns onto U.S. 61 and straight through movements across U.S. 61 on Hershey Avenue would be eliminated by intersection geometric changes. This alternative would eliminate those movements that have the greatest conflicts with other traffic and are most likely to be involved in accidents. Vehicles desiring to make the prohibited movements would have to find other routes. The traffic that is re-routed by these restrictions would have more than a mile added to their trips, may use another intersection that is currently not signal controlled and may be enticed to make "U" turns at a field entrance median opening. Right turns to and from U.S. 61 and left turns from U.S. 61 would be permitted. By allowing both the left turn and right turns from the main line, drivers seeking a destination on Hershey Avenue, who may be unfamiliar with the area, would not experience any difficulty. See Figure 20. The following improvements would be needed:

   - Right turn lanes - $60,000
   - Longer left turn lanes - $40,000
   - An uphill acceleration lane for the right turns onto northbound U.S. 61 - $150,000
   - An acceleration lane for right turns onto southbound U.S. 61 - $80,000
   - Median modifications to restrict movements - $40,000
   - Median islands on the Hershey Avenue approaches to help enforce the restrictions - $40,000
   - Total Cost - $410,000

4. Intersection revisions to eliminate side street through and all left turn movements The side street left turns onto U.S. 61, the straight through movements across U.S. 61 on Hershey Avenue and the left turns from U.S. 61 would all be eliminated by intersection geometric changes. This alternative would eliminate those movements that conflict with other traffic and would thereby create a safe intersection. Vehicles desiring to make the prohibited movements would have to find other routes. Only right turns to and from U.S. 61 would be permitted. The traffic that is re-routed by these restrictions would have more than a mile added to their trips, may use another intersection that is currently not signal controlled and may be enticed to make "U" turns at a field entrance median opening. In addition, a driver who is unfamiliar with the area and who is seeking a destination on Hershey Avenue that requires a left turn may get confused and drive slowly in the left lane and would be likely to make a "U" turn at the next median opening. See Figure 21. The following improvements would be needed:

   - Right turn lanes - $60,000
   - An uphill acceleration lane for the right turns onto northbound U.S. 61 - $150,000
   - An acceleration lane for right turns onto southbound U.S. 61 - $80,000
   - Median modifications to restrict movements - $40,000
   - Median islands on the Hershey Avenue approaches to help enforce the restrictions - $40,000
   - Total Cost - $370,000

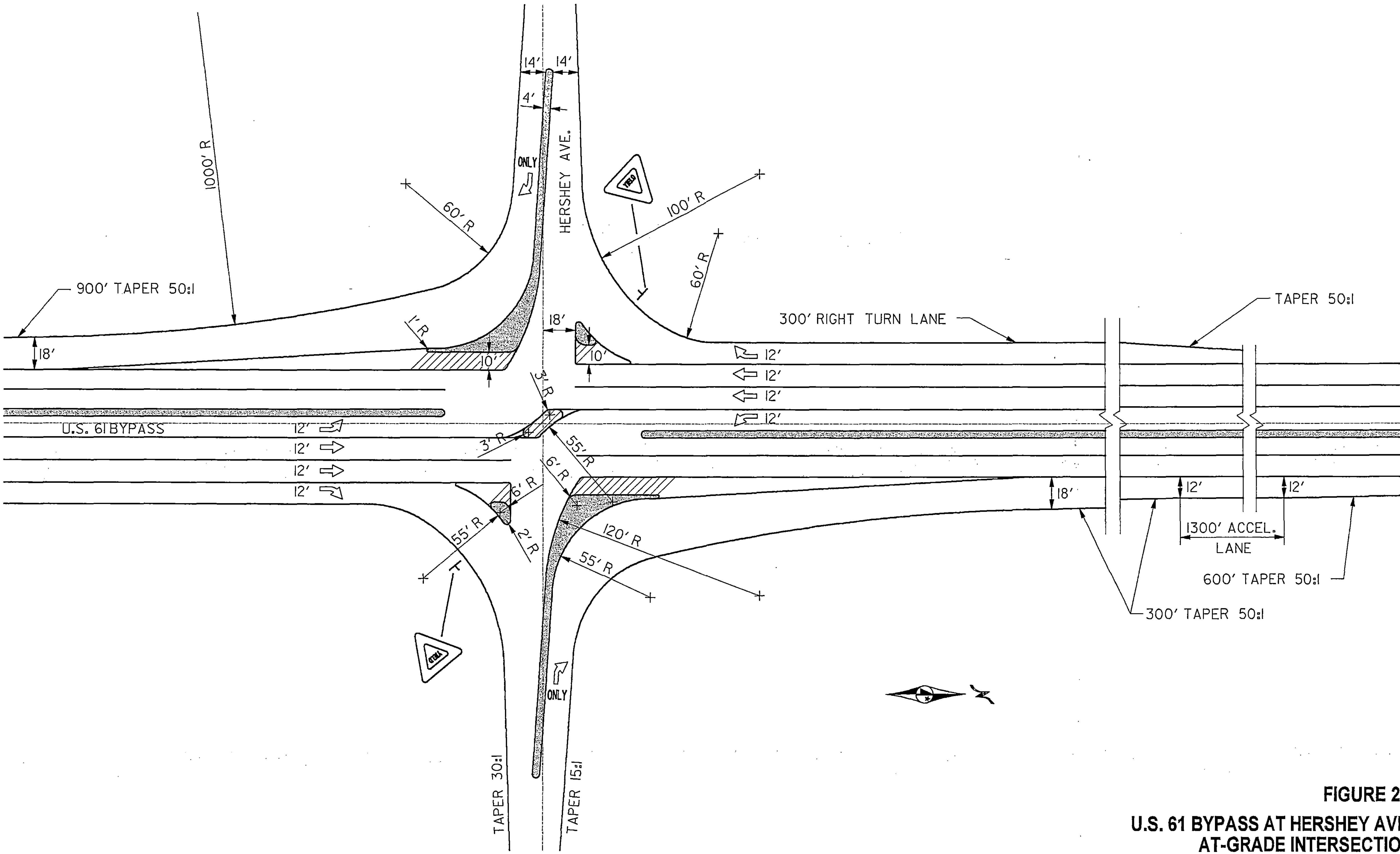


FIGURE 20

U.S. 61 BYPASS AT HERSHEY AVE. AT-GRADE INTERSECTION CROSS-STREET LEFT TURNS AND THROUGH MOVES PROHIBITED

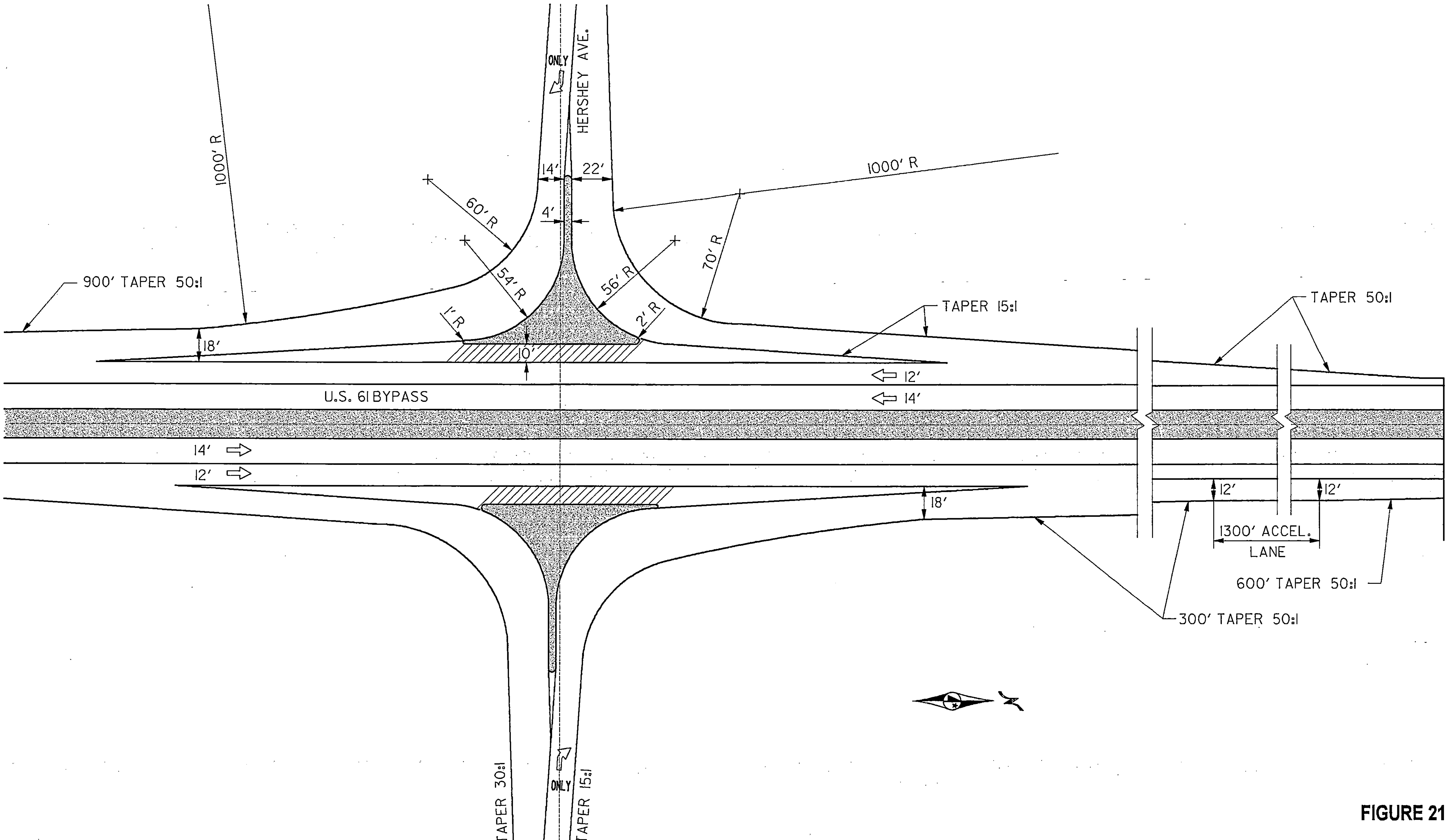


FIGURE 21

U.S. 61 BYPASS AT HERSHEY AVE.
AT-GRADE INTERSECTION
RIGHT IN / RIGHT OUT ONLY

5. Bridge over U.S. 61 – This alternative would construct a bridge over U.S. 61 north of the intersection. The existing intersection would be restricted to only right turns to and from U.S. 61. This alternative provides the majority of the benefits of an interchange, but at a reduced cost. The conflicting movements are eliminated from the intersection and there is only a minimal increase in circuitry of travel.

   The new alignment for Hershey Avenue would be set based on which form of interchange would be envisioned for the final build. Three alternatives are possible; diamond interchange, partial cloverleaf north of Hershey and partial cloverleaf south of Hershey. See Figure 22 for the bridge only alternative with the assumption of the partial cloverleaf south of Hershey. Of the three alternatives, the partial cloverleaf south of the intersection would require the least earthwork, but would place Herhsey Avenue and its bridge on a curve.

   The diamond alternative and the partial cloverleaf to the north would place Hershey Avenue and its bridge on a tangent alignment. The partial cloverleaf north of Hershey would require more excavation into the hill, but would minimize impacts on farmland and provide ramps with grades that would enhance their operation.

   The following improvements would be needed for the bridge only alternative:

   - A bridge over U.S. 61 with width for 1 through lane in each direction and space for a future left turn lane (44 ft. driving surface). The bridge would initially be striped for two lanes plus shoulders. The estimated bridge length would be 250 ft. - $1,000,000
   - A new Hershey Avenue to connect the two sides of existing Hershey Avenue to the new bridge - $800,000
   - "T" intersections at the junctions of the old and new Hershey Avenues - $120,000
   - Right turn lanes on U.S. 61 - $60,000
   - Acceleration lane for right turns onto U.S. 61 - $230,000
   - Median modifications to restrict movements - $40,000
   - Median islands on the Hershey Avenue approaches to help enforce the restrictions - $40,000
   - Total Cost - $2,290,000

6. Hershey Avenue underpass – This alternative would construct a new Hershey Avenue alignment to pass under U.S. 61 between Hershey Avenue and the old railroad alignment to the south of the existing intersection. A bridge would be constructed to carry the main line of U.S. 61 over new Hershey Avenue. The existing intersection would be restricted to only right turns to and from U.S. 61. As with the bridge over alternatives, there would be three full build alternatives that could be developed from this initial stage. These alternatives would consist of a diamond interchange, a partial cloverleaf to the north and a partial cloverleaf to the south.

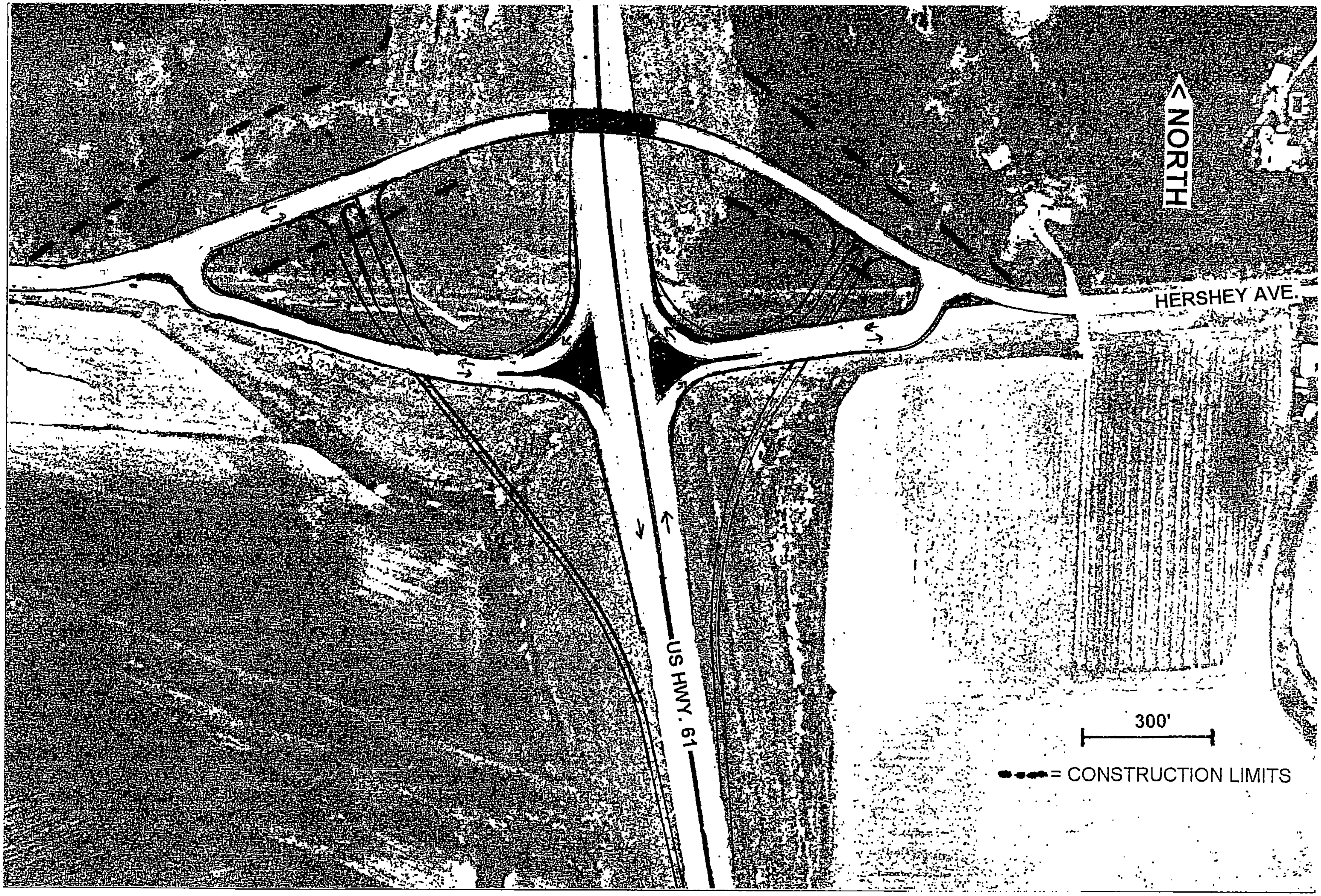


FIGURE 22

U.S. 61 BYPASS AT HERSHEY AVE.- BRIDGE OVER U.S. 61

The principal problem for each of the alternatives where U.S. 61 is bridged over Hershey Avenue is the accommodation of traffic during construction. The existing U.S. 61 roadbed is narrow and would need to be cut completely through in order to build any underpass for Hershey. This action would therefore require that a temporary roadway be built around the bridge construction site. Those alternatives with a Hershey bridge over U.S. 61 would be easier to construct while carrying through traffic. See Figure 23.

The following improvements would be needed for this alternative:

- A bridge to carry U.S. 61 over Hershey Avenue with width for 2 through lanes and shoulders and ramp tapers on each bridge. The width would be 200 ft. and the length would be 150 feet. - $1,950,000
- A new Hershey Avenue to connect existing Hershey Avenue to the new bridge – $800,000
- "T" intersections at the junctions of the old and new Hershey Avenues - $120,000
- Right turn lanes on U.S. 61 - $60,000
- Acceleration lanes for right turns onto U.S. 61 - $230,000
- Median modifications to restrict movements - $40,000
- Median islands on the Hershey Avenue approaches to help enforce the restrictions - $40,000
- Temporary roadways and traffic control for carrying U.S. 61 during the bridge construction – $1,000,000
- Total Cost - $4,240,000

7. <u>Diamond Interchange with Hershey over U.S. 61</u> – The "bridge over" alternative in item 5 is expanded to a standard diamond interchange with ramp lengths of about 1000 ft. A "hybrid" or staged alternative is also possible for which only the north side ramps are added initially to take advantage of the favorable topography and grades. The south ramp movements would be made via the existing intersection. See Figure 24. The following improvements would be needed for the full diamond alternative:

   - The two north side ramps - $800,000
   - The two south side ramps - $1,000,000
   - Removal of the existing Hershey Avenue roadway - $50,000
   - Total Cost (with grade separation and Hershey roadway from Item 5) – $3,690,000

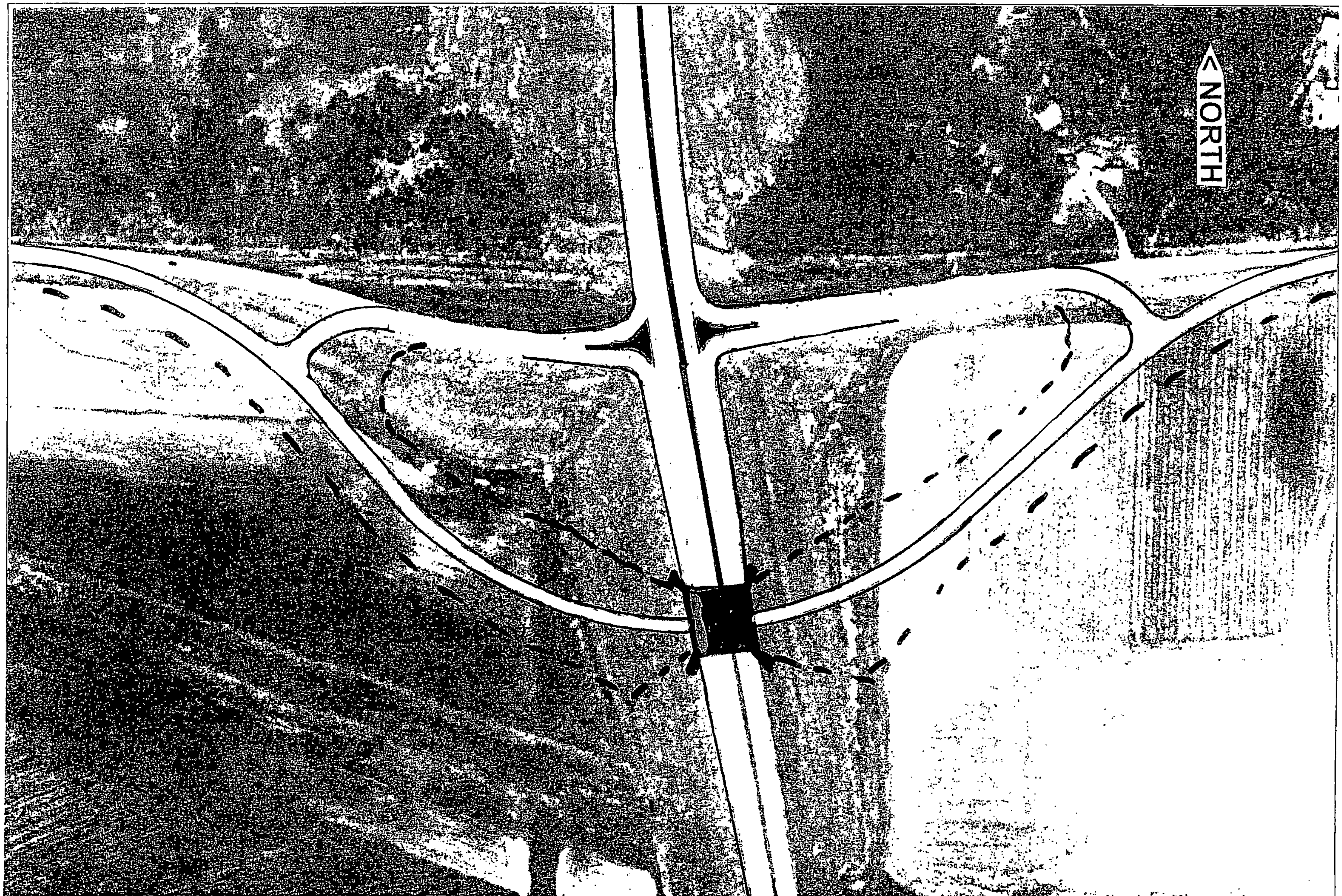


FIGURE 23
U.S. 61 BYPASS AT HERSHEY AVE.- HERSHEY AVENUE UNDERPASS

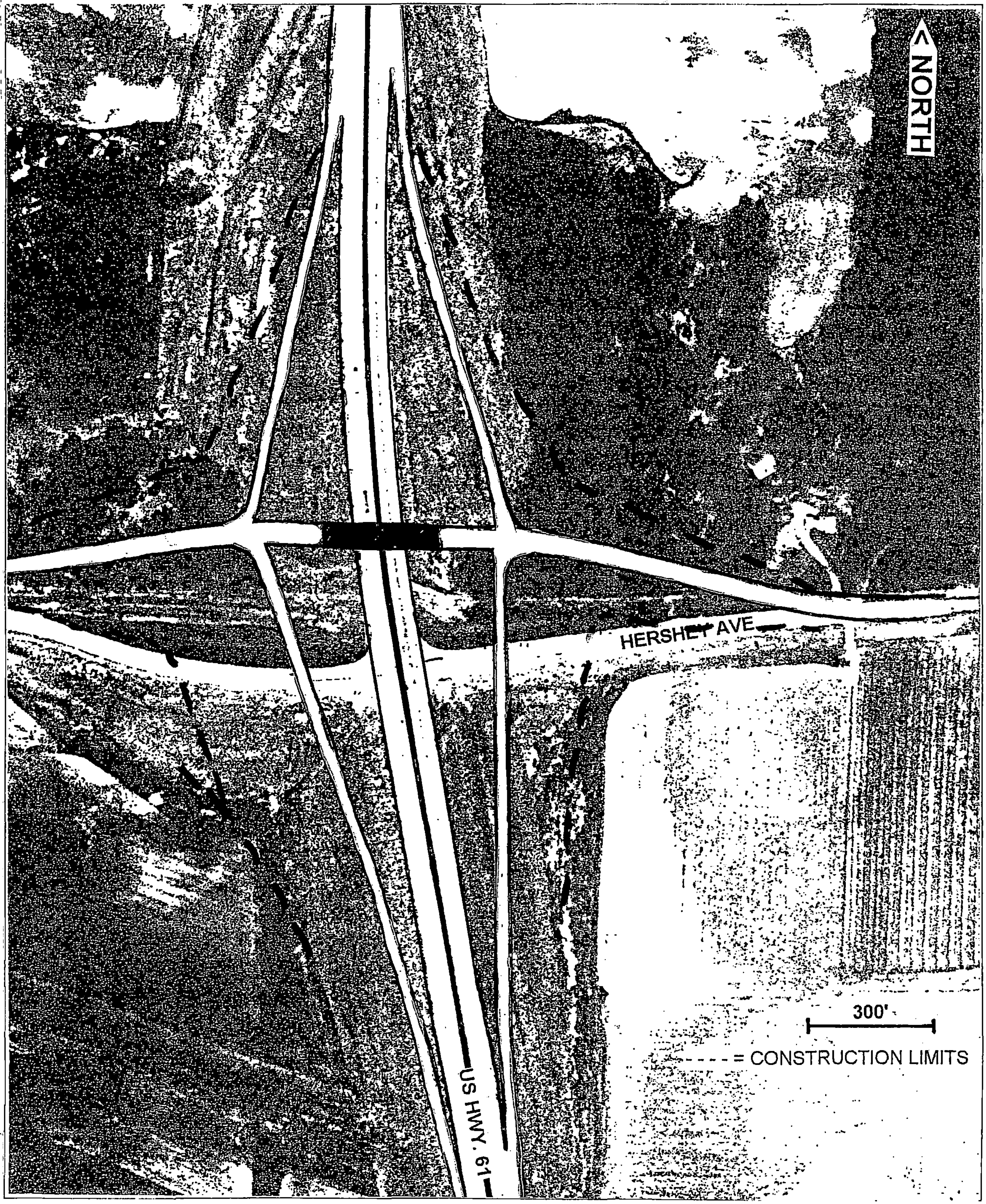


FIGURE 24
U.S. 61 BYPASS AT HERSHEY AVE.
DIAMOND INTERCHANGE WITH HERSHEY OVER U.S. 61

8. Partial cloverleaf north of bridge – The "bridge over" alternative in item 5 is expanded to a partial cloverleaf with two ramps and two loops north of the bridge. The ramps would have lengths of about 1000 ft. and loop radii would be 200 ft. This alternative would require extensive cutting into the hillside to accommodate the width needed for loops. However, loop and ramp grades would be relatively flat. See Figure 25. The following improvements would be needed for this alternative:

   - The two north side ramps - $800,000
   - The two north side loops - $900,000
   - Removal of the existing Hershey Avenue roadway - $50,000
   - Total Cost – (with grade separation and Hershey roadway from Item 5) – $3,590,000

9. Partial cloverleaf south of bridge – The "bridge over" alternative in item 5 is expanded to a partial cloverleaf with two ramps and two loops south of the bridge, with ramp lengths of about 1000 ft. and loop radii of 200 ft. This alternative would require placing fill to accommodate the ramps and loops as they extend into the valley. Ramp and loop grades would be steep. See Figure 26. The following improvements would be needed for this alternative:

   - The two south side ramps - $800,000
   - The two south side loops - $800,000
   - Removal of the existing Hershey Avenue roadway - $50,000
   - Total Cost – (with grade separation and Hershey roadway from Item 5) – $3,590,000

10. Diamond Interchange with Hershey under U.S. 61 – The underpass alternative in Item 6 is expanded to a standard diamond interchange with ramp lengths of about 1000 ft. A "hybrid" alternative is also possible for which only the south side ramps are added initially to take advantage of the favorable topography and grades. The north ramp movements would be made via the existing intersection. The north side ramp grades will be steep (No figure). The following improvements would be needed for the full diamond alternative:

    - The two north side ramps - $850,000
    - The two south side ramps - $850,000
    - Removal of the existing Hershey Avenue roadway - $50,000
    - Total Cost – (with grade separation, Hershey roadway and traffic provisions from Item 6) – $5,540,000

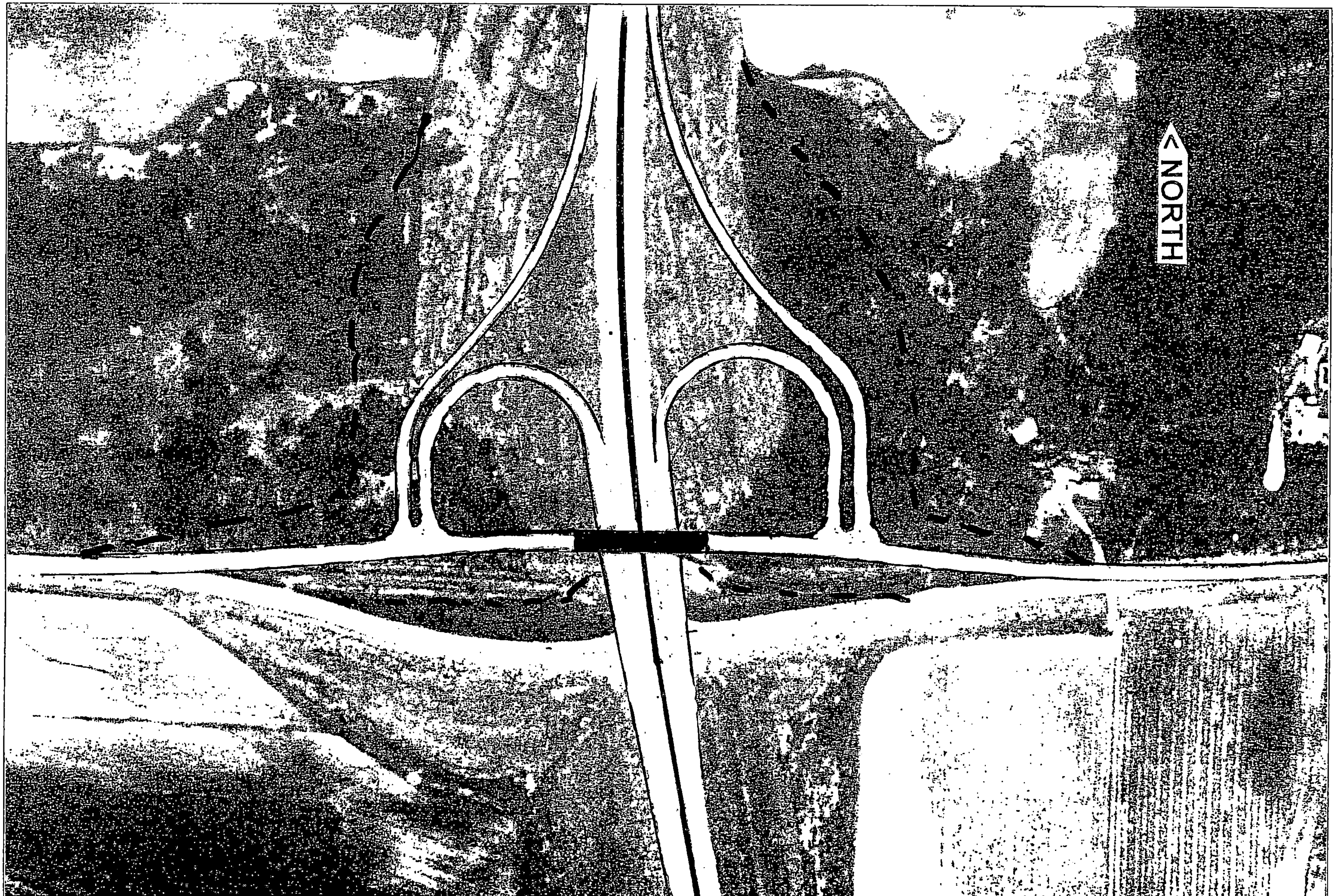


FIGURE 25

U.S. 61 BYPASS AT HERSHEY AVE.- PARTIAL CLOVERLEAF NORTH OF BRIDGE

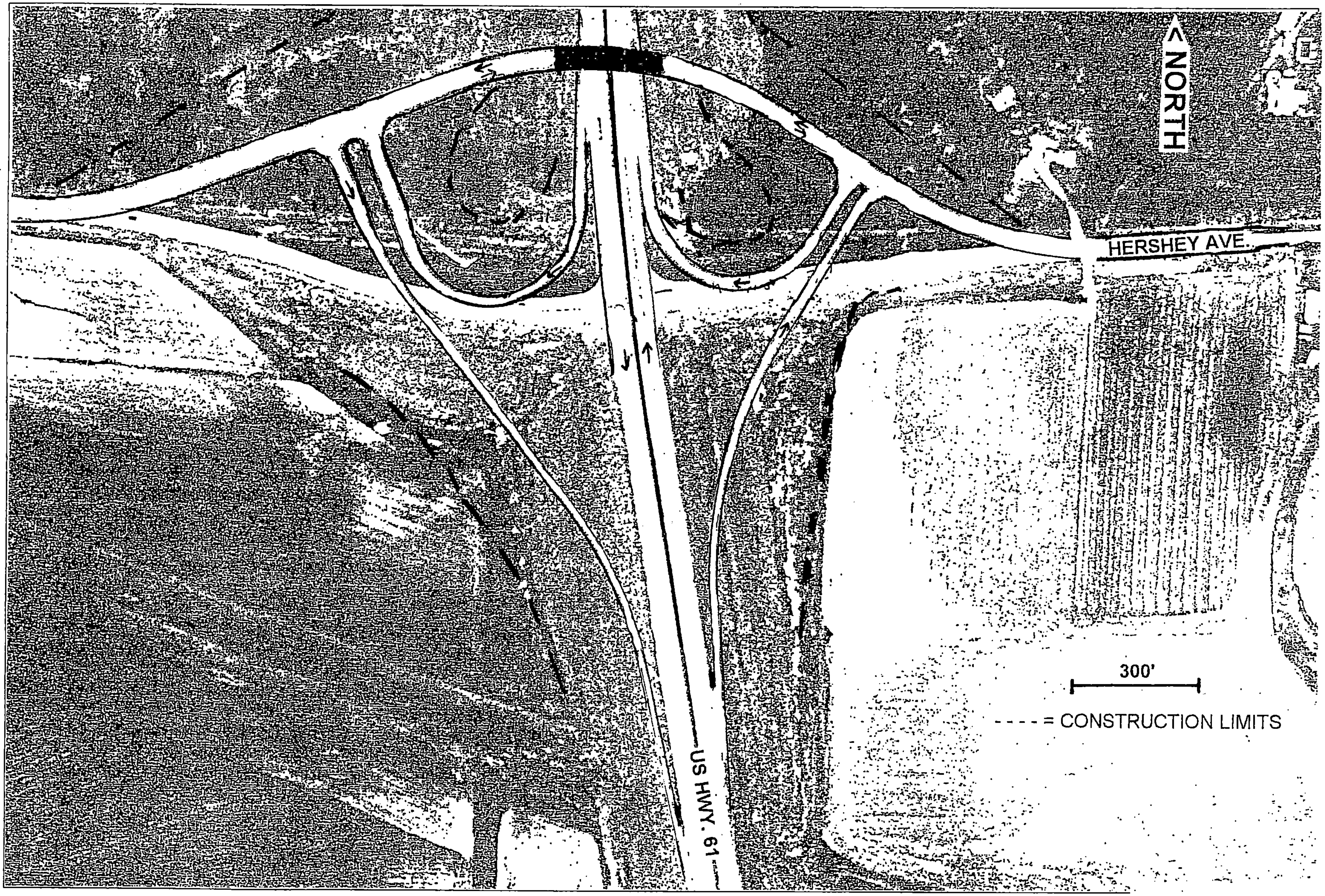


FIGURE 26

U.S. 61 BYPASS AT HERSHEY AVE.- PARTIAL CLOVERLEAF SOUTH OF BRIDGE

11. Partial cloverleaf north of underpass – The underpass alternative in item 6 is expanded to a partial cloverleaf with two ramps and two loops north of the underpasses, with ramp lengths of about 1000 ft. and loop radii of 200 ft. This alternative would require extensive cutting into the hillside and the removal of the exiting intersection during construction to accommodate the width needed for loops. The loop and ramp grades would be steep. See Figure 27. The following improvements would be needed for this alternative:

    - The two north side ramps - $900,000
    - The two north side loops - $800,000
    - Removal of the existing Hershey Avenue roadway - $50,00
    - Total Cost – (with grade separation, Hershey roadway and traffic provisions from Item 6) – $5,590,000

12. Partial cloverleaf south of underpass – The underpass alternative in item 6 is expanded to a partial cloverleaf with two ramps and two loops south of the underpasses, with ramp lengths of about 1000 ft. and loop radii of 200 ft. This alternative would require some minor filling to accommodate the ramps and loops as they meet the main line grade as it extends into the valley. Ramp and loop grades would not be steep. However, this alternative would require the largest amount of additional right-of-way and much of what would be acquired is farmland (No figure). The following improvements would be needed for this alternative:

    - The two south side ramps - $750,000
    - The two south side loops - $750,000
    - Removal of the existing Hershey Avenue roadway - $50,000
    - Total Cost – with grade separation, Hershey roadway and traffic provisions from Item 6) – $5,340,000

SUMMARY AND CONCLUSIONS

Provisions should be made for some form of future interchange at Hershey Avenue. However, the existing traffic conditions do not readily justify the immediate installation of an interchange on the basis of costs and benefits. The interchange would become justified if the traffic volumes were to increase to the point where traffic signal control would be needed to handle traffic volumes on Hershey Avenue. In the future, with higher volumes on both U.S. 61 and on Hershey Avenue, the costs associated with frequently stopping a high-speed, high-volume main line highway would offset the costs of an interchange.

There has been a history of accidents at Hershey Avenue, but fortunately in the more recent years, the accident experience has lessened. Should an accident problem again develop, it may become advisable to either restrict movements at the intersection or install traffic signals until a bridge or full movement interchange can be constructed.

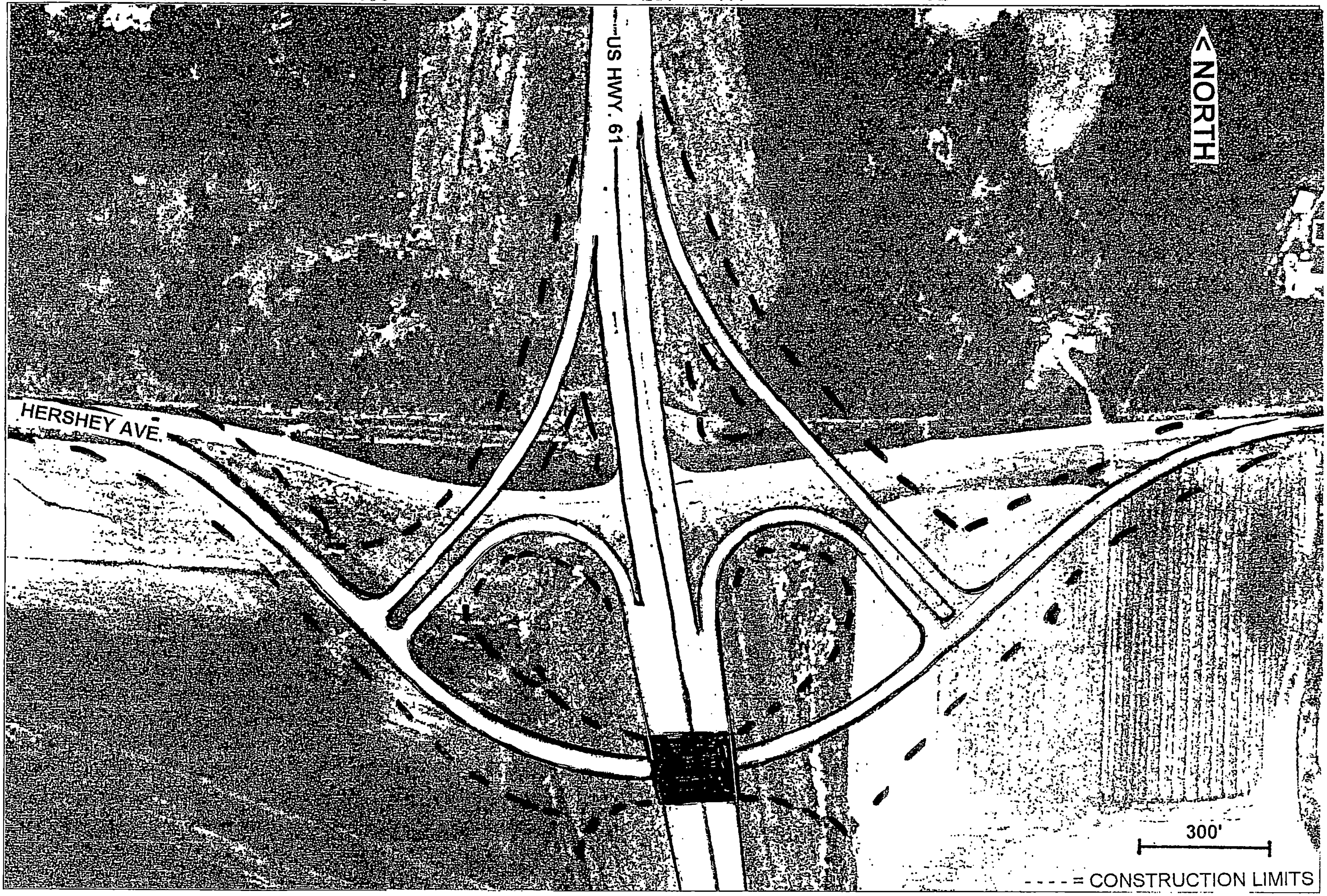
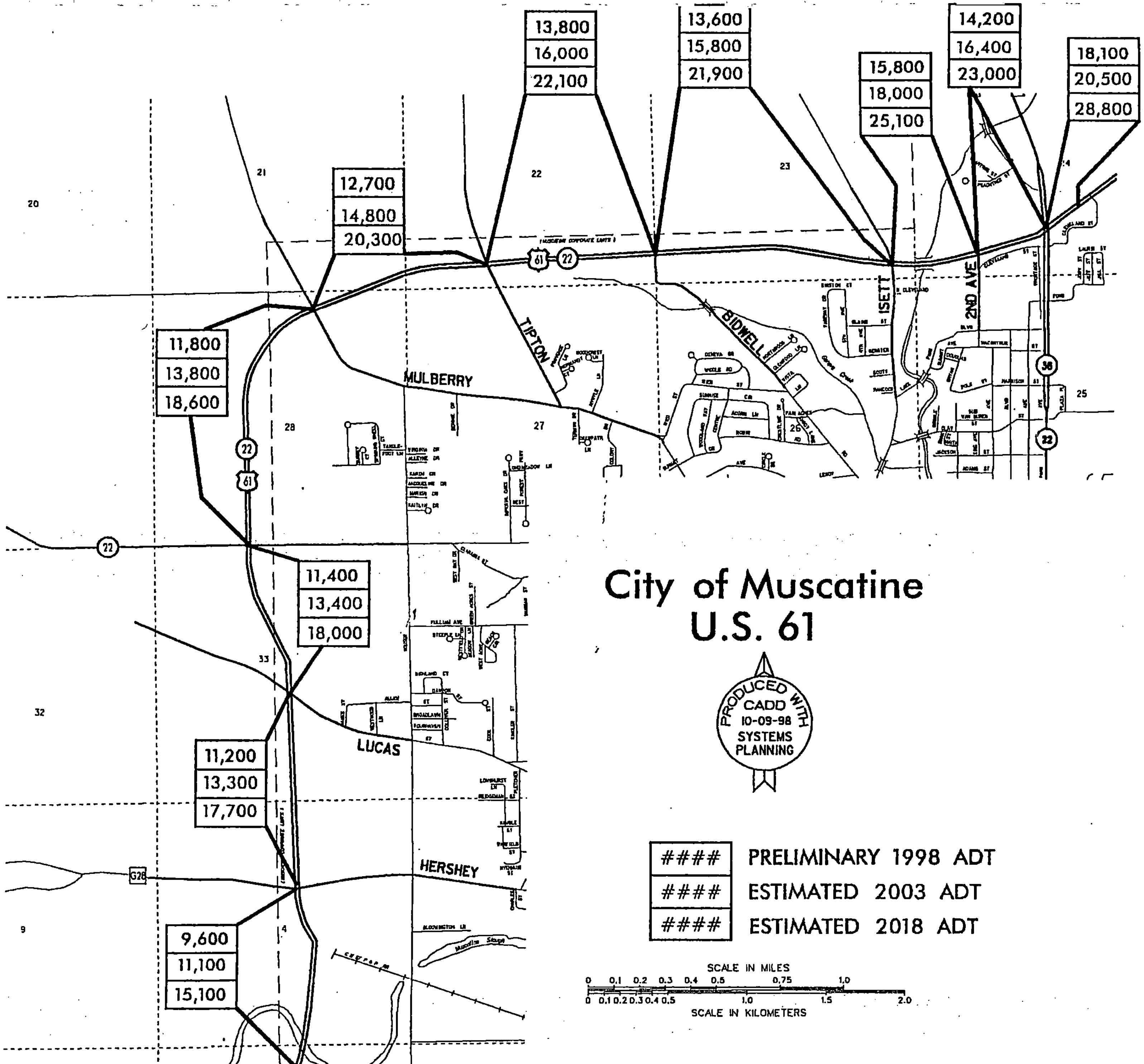


FIGURE 27
U.S. 61 BYPASS AT HERSHEY AVE.- PARTIAL CLOVERLEAF NORTH OF UNDERPASS

If an interchange or restricted intersection becomes the long-range solution, then consideration must be given to the disposition of the other full access intersections located on either side of Hershey Avenue at Sampson and at Lucas. With an interchange at Hershey, the intersections at Lucas and Sampson could be eventually restricted to only right turn movements. However, if only a limited movement intersection is provided at Hershey Avenue, then there is likely to be increased turning activity at Sampson and Lucas generated by those vehicles affected by the turn prohibitions at Hershey Avenue. For this long-range circulation pattern it will be likely that signals would be needed at both Sampson and Lucas. The sight distance at Lucas for cross street traffic to enter or cross U.S. 61 has been reported to be only minimally acceptable.

For the interchange alternatives for Hershey Avenue, those alternatives with a bridge to the north of the existing intersection that also have ramps to the north appear to be the most economical to be build while still being able to adequately accommodate the traffic movements.

APPENDIX


City of Muscatine
U.S. 61
13,800
16,000
22,100
13,600
15,800
21,900
15,800
18,000
25,100
14,200
16,400
23,000
18,100
20,500
28,800
12,700
14,800
20,300
11,800
13,800
18,600
11,400
13,400
18,000
11,200
13,300
17,700
9,600
11,100
15,100
MULBERRY
TIPTON
BIDWELL
ISETT
2ND AVE
LUCAS
HERSHEY
PRODUCED WITH CADD 10-09-98 SYSTEMS PLANNING
PRELIMINARY 1998 ADT
ESTIMATED 2003 ADT
ESTIMATED 2018 ADT
SCALE IN MILES
SCALE IN KILOMETERS
Crawford
graph235.dgn

TRAFFIC ANALYSIS

Project: US 61 Bypass Corridor Study — *Created By:* RGGriffith — *Date:* 01/18/99

Location: U.S. 61 at Mulberry Avenue — *Checked By:*

Traffic: 1998 Traffic Volumes

MOEs

Traf Vol	Alternative	E.Appr Delay Time sec/veh	E.Appr Stop Delay veh-min	E.Appr D/A Delay veh-min	W.Appr Delay Time sec/veh	W.Appr Stop Delay veh-min	W.Appr D/A Delay veh-min	N.Appr Delay Time sec/veh	N.Appr Stop Delay veh-min	N.Appr D/A Delay veh-min	S.Appr Delay Time sec/veh	S.Appr Stop Delay veh-min	S.Appr D/A Delay veh-min	Description
Peak Hour	ex1	10.6	29.1		13.7	32.1		24.2	11.7		18.5	9.2		existing no change
	pr1	11.6	36.3		13.6	29.6		18.3	9.5		15.1	8.3		proposed -- added mainline detection
	ex2	9.5	29.3		7.3	16.3		17.7	9.4		9.6	5.3		existing -- lowered min green for ph's 3,7,2,6 and veh ext for ph's 2,6
	pr2	8.3	25.7		9.0	20.5		18.5	9.6		15.1	8.6		proposed -- added mainline det, same changes as ex2
8th Highest Hour	ex1	9.0	12.3		7.3	8.5		10.7	2.5		8.6	2.1		existing no change
	pr1	11.7	18.1		9.9	13.2		16.1	4.3		13.1	3.5		proposed -- added mainline detection
	ex2	7.7	11.7		5.5	7.3		10.2	2.7		8.6	2.3		existing -- lowered min green for ph's 3,7,2,6 and veh ext for ph's 2,6
	pr2	7.7	11.5		5.8	7.6		11.4	3.0		8.8	2.4		proposed -- added mainline det, same changes as ex2
Future Peak Hour (1.5 x existing volumes)	ex1	16.2	68.5		13.1	46.9		20.1	14.4		17.0	12.5		existing no change
	pr1	14.7	68.1		13.6	54.8		23.2	18.6		16.2	13.2		proposed -- added mainline detection
	ex2	12.4	57.2		11.1	45.3		21.0	16.5		15.5	12.4		existing -- lowered min green for ph's 3,7,2,6 and veh ext for ph's 2,6
	pr2	11.4	52.8		8.8	36.1		23.3	18.2		17.3	14.1		proposed -- added mainline det, same changes as ex2

Warrant Analysis - U.S. 61 at University Drive

Projected ADT upon opening of intersection is 3,500.
From the IDOT 1998 traffic flow map, U.S. 61 ADT is 10,300.

Assume peak hour volume is 10% of ADT.
Assume 8th highest hour volume is one half of peak hour volume.
Assume 50-50 directional split in peak hour and 8th highest hour.

70% volume thresholds apply because of high speed.
Assume 2+ approach lanes on mainline, 1 approach lane on cross-street.

Based on the above assumptions, warrant volume thresholds are:

	Mainline		Cross-street
Warrant 1	420		105
Warrant 2	630		52
Warrant 8	336		84
		and	
	504		42

A) Analysis using projected volumes upon opening of intersection

Mainline ADT = 10,300
Peak Hour Volume = 1,030
8th Highest Hour Volume = 515

Cross-street ADT = 3,500
Peak Hour 2-way Volume = 350
Peak Hour Approach Volume = 175
8th Highest Hour Approach Volume = 87

Volumes for 8 hour volume warrant analyses are 515, 87
Volumes for peak hour volume warrant analysis are 1030, 175

Volume Requirements for Warrant 8 (Combination of Warrants) are met.
Warrant 11 (Peak Hour Volume) is met (see attached graph).

B) Analysis including HON trucking facility and proposed commercial development

Commercial development projects a typical weekday ADT of approx. 1800 vehicles.
Assume 60%, or 1080, travel thru U.S. 61/ University Drive intersection.
Peak hour volume = 108 (add 54 to mainline, 54 to cross-street)
8th highest hour volume = 54 (add 27 to mainline, 27 to cross-street)

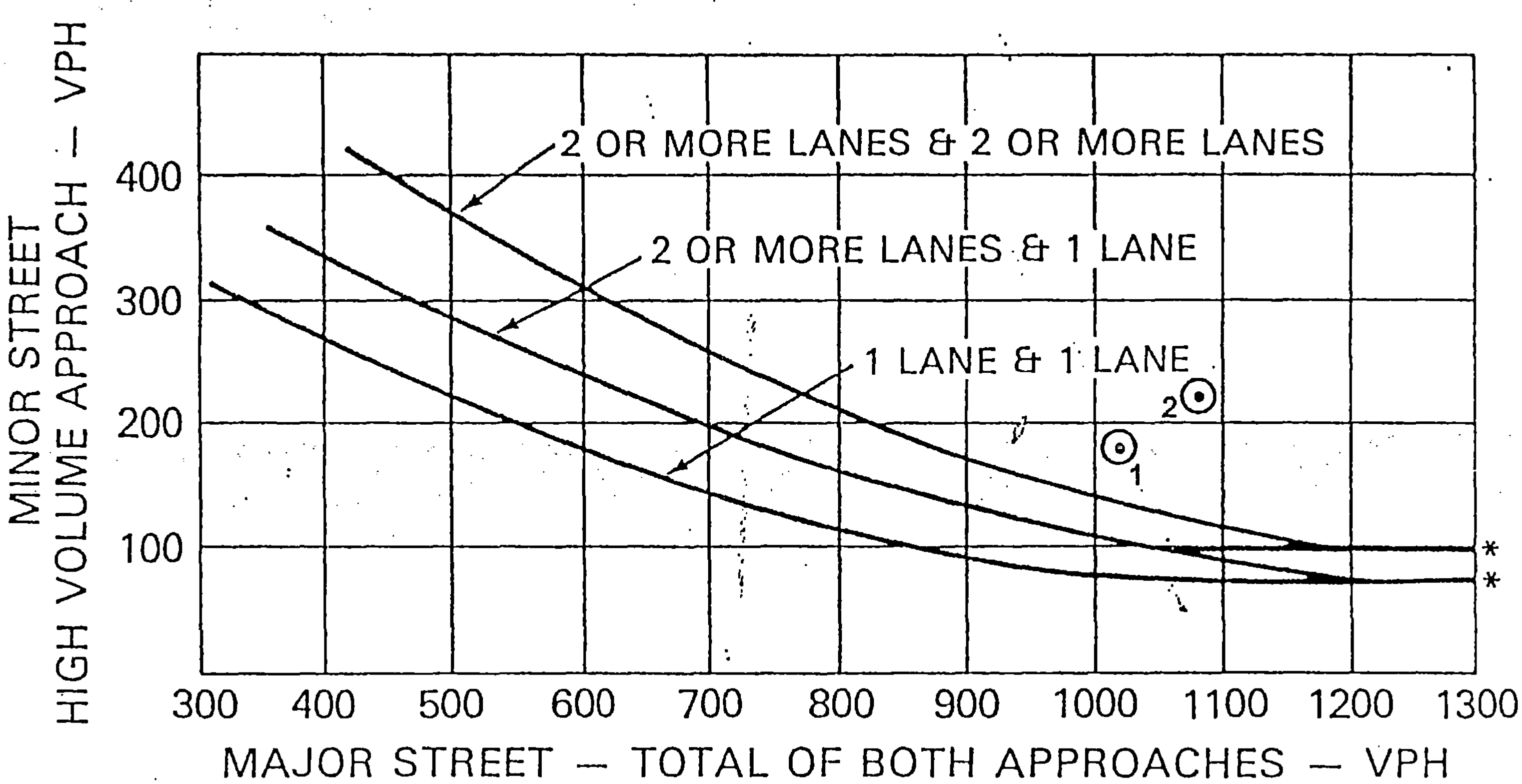
HON Co. projects approx. 120 trucks per day.
Assume distribution of volume is the same as roadway system.
Peak hour volume = 12 (add 6 to mainline, 6 to cross-street)
8th highest hour volume = 6 (add 3 to mainline, 3 to cross-street)

Adding these volumes to background volumes,
Volumes for 8 hour volume warrant analyses are 545, 117
Volumes for peak hour volume warrant analysis are 1090, 235

Warrant 1 (Minimum Vehicular Volume) is met.
Volume Requirements for Warrant 8 (Combination of Warrants) are met.
Warrant 11 (Peak Hour Volume) is met (see attached graph).

PEAK HOUR VOLUME WARRANT

(COMMUNITY LESS THAN 10,000 POPULATION OR ABOVE 40 MPH ON MAJOR STREET)



*NOTE: 100 VPH APPLIES AS THE LOWER THRESHOLD VOLUME FOR A MINOR STREET APPROACH WITH TWO OR MORE LANES AND 75 VPH APPLIES AS THE LOWER THRESHOLD VOLUME FOR A MINOR STREET APPROACHING WITH ONE LANE.

1 - (1030,175) - PEAK HOUR AFTER OPENING OF UNIV. DR.

2 - (1090,235) - PEAK HOUR AFTER OPENING OF HON FACILITY AND PROPOSED DEVELOPMENT

SRF CONSULTING GROUP, INC.

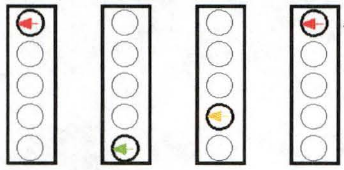
U.S. 61 AT UNIVERSITY DRIVE SIGNAL WARRANTS ANALYSIS

FIGURE

BI-MODAL LEFT TURN SIGNAL

(USING BI-MODAL LED RED INDICATION)

PROTECTED ONLY SEQUENCE



Bi-modal L.E.D. Signal Indication

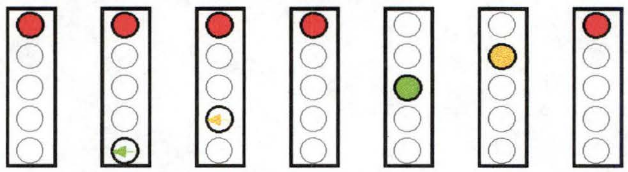
Fiber-optic changeable message sign - Legend "A"

For protected only sequence

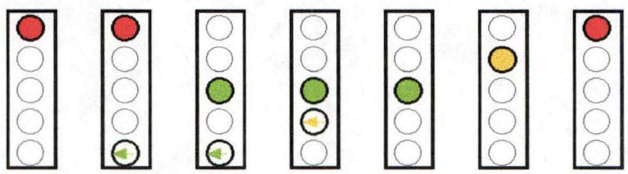
(SUGGESTED SIGN)

PROTECTED - PERMISSIVE SEQUENCES

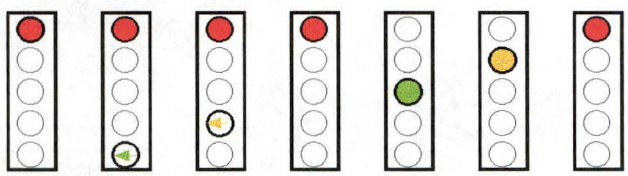
SEQUENCE "A" (ONCOMING LEFT TURN IS LONGER)



SEQUENCE "B" (THIS LEFT TURN IS LONGER THAN OPPOSING)



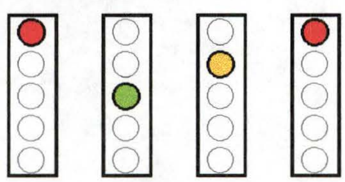
SEQUENCE "C" (BOTH LEFTS TIME OUT TOGETHER)



Fiber-optic changeable message sign - Legend "B"

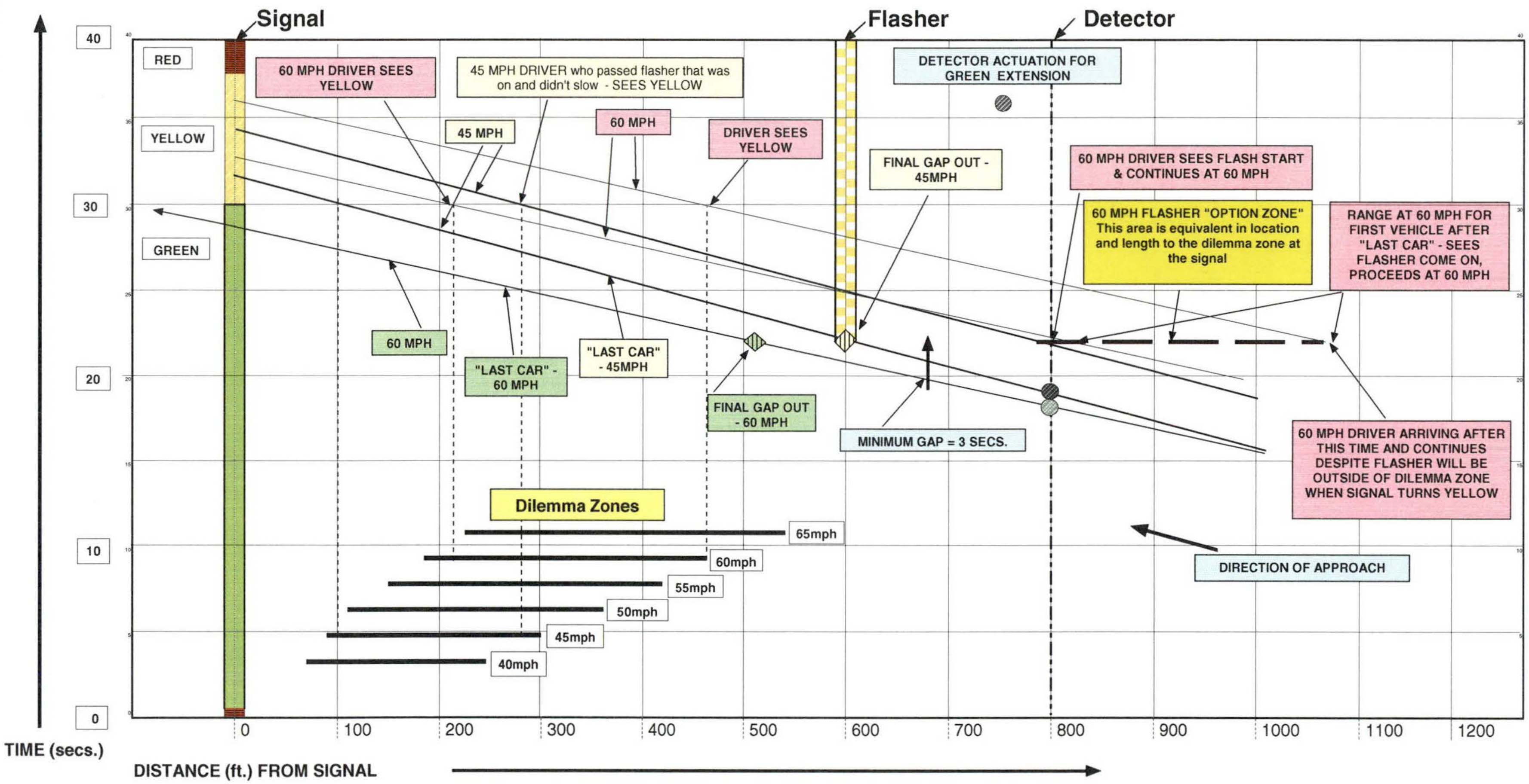
For protected - permissive and permissive only sequences

PERMISSIVE ONLY SEQUENCE

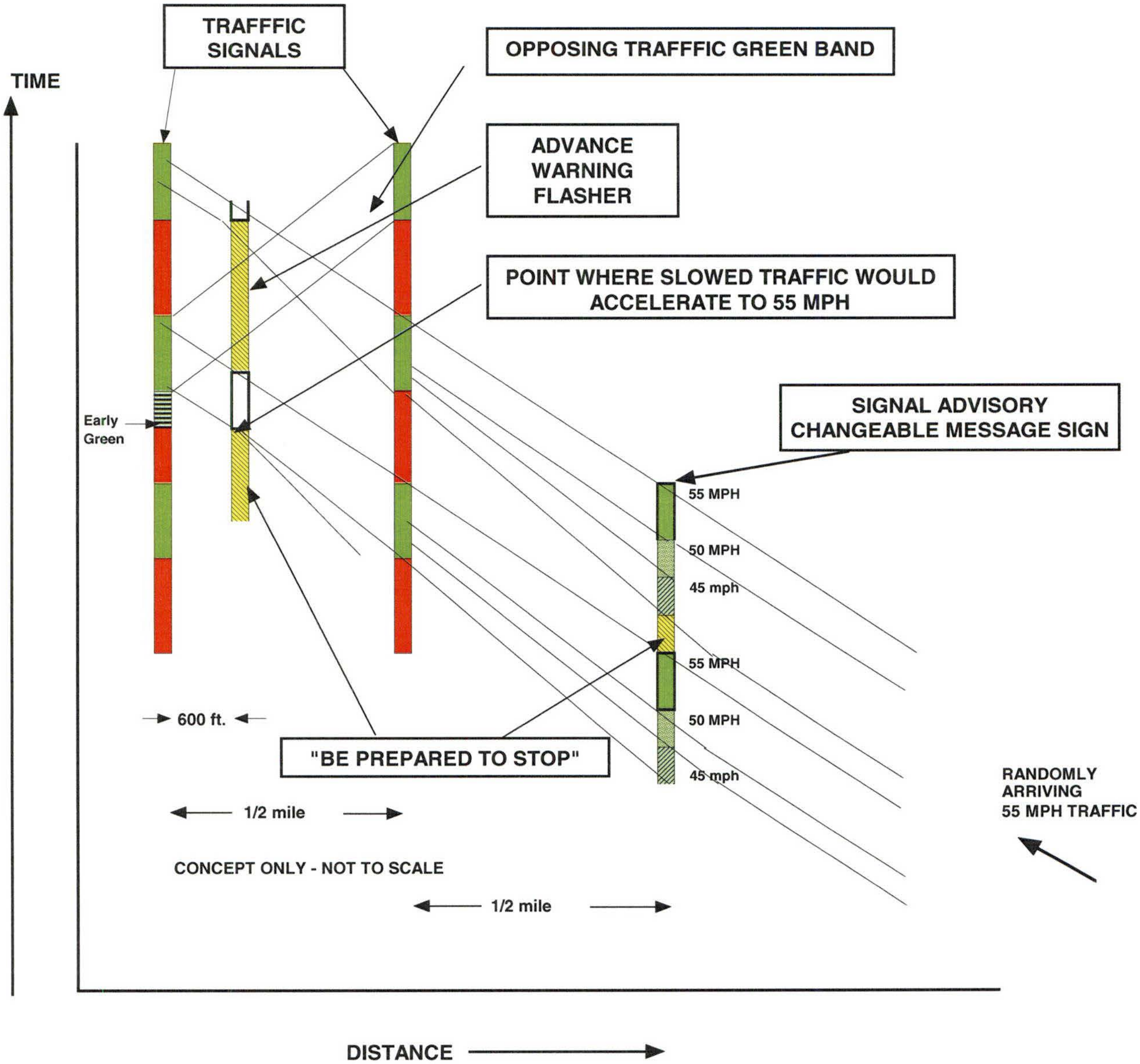


ADVANCE WARNING FLASHER OPERATION

TIME - SPACE DIAGRAM FOR VEHICLES APPROACHING SIGNAL AT END OF MAINLINE GREEN INTERVAL

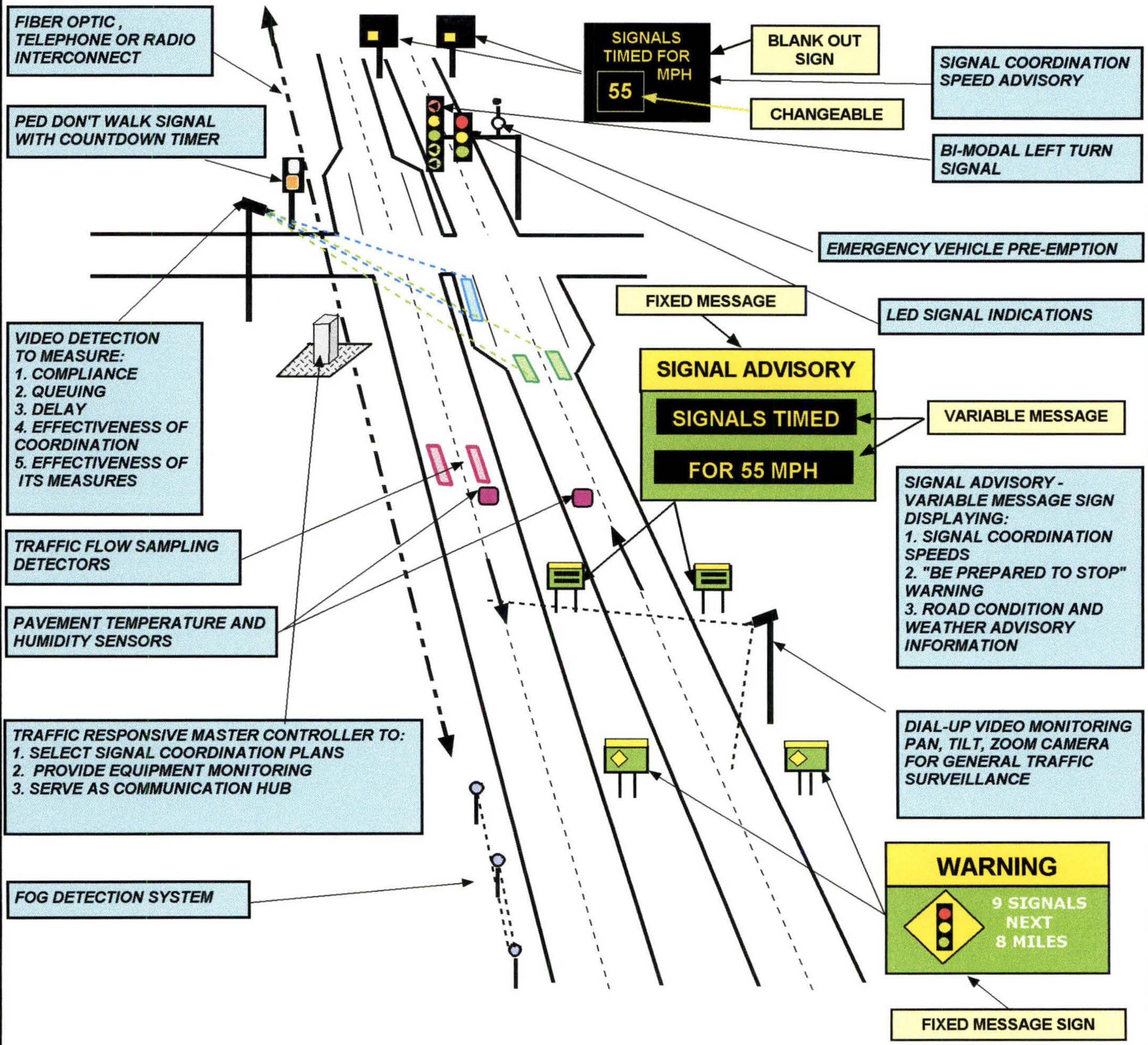


"SPEED FUNNEL" - ADVISORY SIGNING SYSTEM



NOTE: ONLY SIGNS FOR RIGHT TO LEFT TRAFFIC FLOWS ARE SHOWN

SPEED FUNNEL -- TIME-SPACE DIAGRAM



ITS APPLICATIONS AND ADVANCED SIGNAL CONTROL FEATURES

Glossary of Terms

Call: A demand for service registered in a controller assembly.

Calling Detector: A detector installed in a selected location to detect vehicles that may not otherwise be detected, and whose output may be modified by the controller unit.

Controller: A device that controls the sequence and duration of indications displayed by traffic signals.

Coordination: The establishment of a definite timing relationship between adjacent traffic signals.

Cycle: One complete sequence of signal indications.

Cycle Length: The time required for one complete sequence of signal indications.

Detector: A device for indicating the presence or passage of vehicles or pedestrians (NEMA). This general term is usually supplemented with a modifier indicating type (e.g., loop detector, magnetic detector, etc.), operation (e.g., point detector, presence detector, etc.), or function (e.g., calling detector, extension detector, etc.).

Dilemma Zone: The segment of roadway on the approach to a traffic signal bounded by the two points where, when the signal indications turn yellow:
1) 95 percent of drivers will continue through the intersection, and
2) 95 percent of drivers will stop.
For safety reasons, it is desirable to have as few vehicles in the dilemma zone at the start of the yellow interval as possible, particularly on high speed approaches.

Extend Detector: A detector arranged to register actuations at the controller only during the green interval for that approach so as to extend the green time of the actuating vehicles.

Interval: A period of time in a signal cycle during which all signal indications remain constant.

Laminar Flow: Traffic flow characterized by constant speeds and no interruptions of flow.

Level of Service: A qualitative measure describing operational conditions within a traffic stream: generally described in terms of such factors as speed and travel time, freedom to maneuver, traffic interruptions, comfort and convenience, and safety.

Master Controller: A device that controls the operation of an interconnected system of local signal controllers.

Measures of Effectiveness (MOEs): Indices of the effectiveness of the system in improving traffic flow. Common bases of comparison include congestion, density, lane occupancy, stops, delay, and queue length.

Offset: The time difference or interval in seconds between the start of the green indication at one intersection as related to the start of the green interval at another intersection or from a system time base.

Permissive Turns: Left or right turns at a signalized intersection which are made against an opposing or conflicting vehicular or pedestrian flow.

Phase: A part of the traffic signal time cycle allocated to any combination of traffic movements receiving right of way simultaneously during one or more intervals.

Platoon: A group of vehicles or pedestrians traveling together as a group, either voluntarily or involuntarily due to signal control, geometrics or other factors.

Protected Turns: Left or right turns at a signalized intersection made with no opposing or conflicting vehicular or pedestrian flow.

Protected/Permissive Turns: Turns at a signalized intersection that can be protected during one interval and permissive during another interval within a cycle.

Queue: A platoon or group of vehicles waiting in a single lane at an intersection.

Reaction Offset: The distance from the closest edge of the closest thru lane to the closest edge of a free right turn lane at the point where the two lanes are tangent to each other.

Split: A percentage of the cycle length allocated to each of the various phases in a signal sequence.

Turbulent Flow: Traffic flow characterized by changing speeds and disruptions to smooth flow.