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16. Abstract

This report presents the study plan for the evaluation of three high occupancy vehicle facilities currently being developed in Houston, Texas. Preliminary analyses of data from the first six months of the study are presented. These data include park-and-ride demands, travel times and vehicle and person demands for the three freeway corridors studied.

Operational data will continue to be collected within the study corridors both monthly and quarterly throughout the evaluation period (five years).

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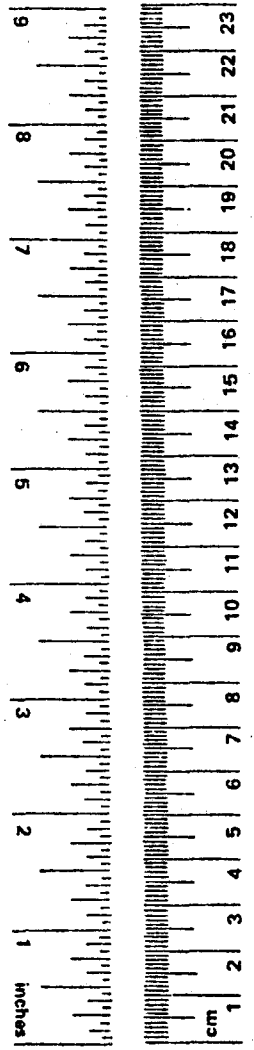
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
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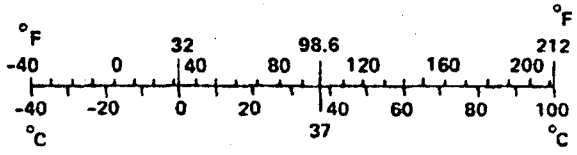

Evaluation of High-Occupancy Vehicle Priority Treatment Projects (Study Plan and Initial 6-Month Preliminary Analysis)

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Research Report 339-1

Improving Urban Mobility Through Application
of High-Occupancy Vehicle Priority Treatments
Research Study Number 2-10-84-339

Sponsored by

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The Texas A&M University System
College Station, Texas

March 1984

ABSTRACT

This report presents the study plan for the evaluation of three high occupancy vehicle facilities currently being developed in Houston, Texas. Preliminary analyses of data from the first six months of the study are presented. These data include park-and-ride demands, travel times and vehicle and person demands for the three freeway corridors studied.

Operational data will continue to be collected within the study corridors both monthly and quarterly throughout the evaluation period (five years).

SUMMARY

The State Department of Highways and Public Transportation has strongly endorsed provision for high-occupancy vehicle (HOV) priority treatment. The first effort in this regard, the Houston Contraflow Lane (CFL), has proven highly successful from both an operational and a public acceptance standpoint. Subsequent projects, directed to exclusive, physically separated HOV facilities, have reached implementation stage, and additional projects are in the planning stage. However, many of the effects of priority treatment are relatively unknown. There have been few successful priority treatment projects implemented nationwide; none of this type have previously been implemented in Texas. Therefore, it is very important to document and analyze information from the development of these initial HOV priority treatment projects such as those on the Katy (I-10W), North (I-45N) and Gulf (I-45S) Freeways in Houston, Texas.

In June 1983, two of the three study corridors already had transitway construction work underway, and the third had preconstruction work underway. The Gulf Freeway transitway construction began as early as September 1982.

The Katy Freeway had its construction ground breaking ceremonies in May 1983. The North Freeway preconstruction preparatory work began in April 1983, but actual construction did not begin until January 1984.

Consequently no comparative before and after analyses may be made at the time of this report. Preliminary findings from the first six months of data collection and analysis are presented along with projections of the operational effects of the implementation of a transitway. Use by high occupancy vehicles (HOVs) and corresponding passenger throughput in HOVs is expected to increase to 400 vehicles and 6,500 passengers. Likewise, the percentage of total peak period passenger demand served by HOVs will increase from about 5% to 35%. It is not known whether the extent of modal shift to the transitway from the freeway mainlanes will be significant enough to dramatically enhance freeway operations, as this may possibly be negated by population growth, latent demand, and diversion of traffic. However, this effect, if present, will be noted.

Operational data will continue to be collected within the study corridors monthly and quarterly throughout the five year evaluation period. Updates for each freeway will be available as required.

IMPLEMENTATION STATEMENT

This project was established to provide continued support to the Texas State Department of Highways and Public Transportation for the implementation of priority treatment techniques for high-occupancy vehicles. Several highway-transit projects have been designed and are under construction, while numerous others are in the conceptual and planning stages. This report documents the first six months of a "before and after" evaluation of those projects currently under implementation. The results of the subsequent analysis will be summarized as guidelines for future projects.

DISCLAIMER

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INTRODUCTION

Scope

The tremendous growth experienced in urban areas of Texas in the last decade has caused concern by state and local transportation officials over degradation of mobility. Future growth and economic vitality in the Texas metropolitan regions are in serious jeopardy unless major improvements are implemented in the existing urban transportation system. It is clear that it would be neither economically nor physically possible to provide enough additional highway capacity (by expanding freeway cross-sections or by expanding transit services) to equal anticipated demand. Therefore, new and innovative means of freeway system management have been looked to as possible remedies.

One approach taken to increase capacity which is strongly endorsed by both the State Department of Highways and Public Transportation and the Metropolitan Transit Authority in Houston is to provide for high-occupancy vehicle (HOV) priority treatment. The first effort, the Houston Contraflow Lane (CFL), has proven operationally successful and has received public acceptance. Several subsequent projects, exclusive, physically separated authorized HOV facilities, have reached the implementation stage and numerous additional projects are in the planning stage. However, many of the effects of priority treatment are relatively unknown. There have been few successful projects implemented nationwide; none of this type has previously been implemented in Texas. Therefore, it is important to document and analyze information from the implementation of these initial HOV priority treatment projects.

Implementation of three projects on the Katy (I-10W), North (I-45N), and Gulf (I-45S) freeways in Houston, Texas will begin in 1984 and will continue

through 1987. It is the purpose of this report to present the evaluation plan of these three projects and the preliminary findings from the the six months of data collection and analysis.

Objectives

The objectives of this study report are as follows:

1) Formulate a detailed study design for data collection and analysis of HOV projects;

2) Collect continuous operational data before, during, and after project implementation;

3) Monitor all activities during implementation of HOV projects with particular emphasis on the transition of the contraflow lane to an exclusive, physically separated facility;

4) Perform a comprehensive evaluation of the implementation of each specified HOV project; and

5) Develop guidelines for application to future HOV projects.

PROJECTS UNDER IMPLEMENTATION

Houston, Texas is currently in the process of implementing exclusive, physically separated HOV priority facilities (transitways) along three major radial freeway corridors:

- Katy Freeway (I-10W)
- North Freeway (I-45N)
- Gulf Freeway (I-45S)

The Katy, North and Gulf Transitways have similar designs with a transitway cross section of approximately 20 feet. They are single reversible lanes; traffic will travel inbound toward downtown in the morning and outbound in the afternoon. They are constructed within the existing median of the freeway and protected from other traffic lanes by concrete barriers.

Adequate space is provided for emergencies and breakdowns within the transitway. Access points are limited and controlled. However, each transitway facility differs slightly from the others in design, construction, and operational features.

Geographical location and project limits are illustrated in Figure 1. Discussions of individual freeway corridors follow.

Katy Freeway Transitway

The Katy Freeway is a major interstate highway serving travel demands from western Harris County to various parts of Houston. Traffic volumes have increased at annual rates in excess of 4% throughout the 1970's. Currently, weekday traffic volumes approach 25,000 vehicles per lane; peak-direction flow exceeds 1,900 vehicles per hour per lane.(1)

The Katy Freeway Transitway will be built and operated in three phases (Figure 2). The first phase is being developed at this time and will stretch five miles from Post Oak (near I-610) to Gessner. The second phase will extend the transitway another five miles to SH 6 and the third phase will include an interchange at Addicks. When fully completed, the transitway will extend 11.5 miles from near the West Loop to Addicks and have intermediate access at Gessner. Construction on the first phase began in April 1983 and will be completed in October 1984.

At the eastern end near I-610, a bridge over the freeway will connect the transitway to Katy Road at the Post Oak intersection. From this intersection, transitway traffic can turn north or south to reach major employment centers along the West Loop, or continue eastward on I-10 to downtown. At Gessner, a ramp will provide direct access to and from the freeway mainlanes, and additional ramps will eventually be located at the western end at Addicks.

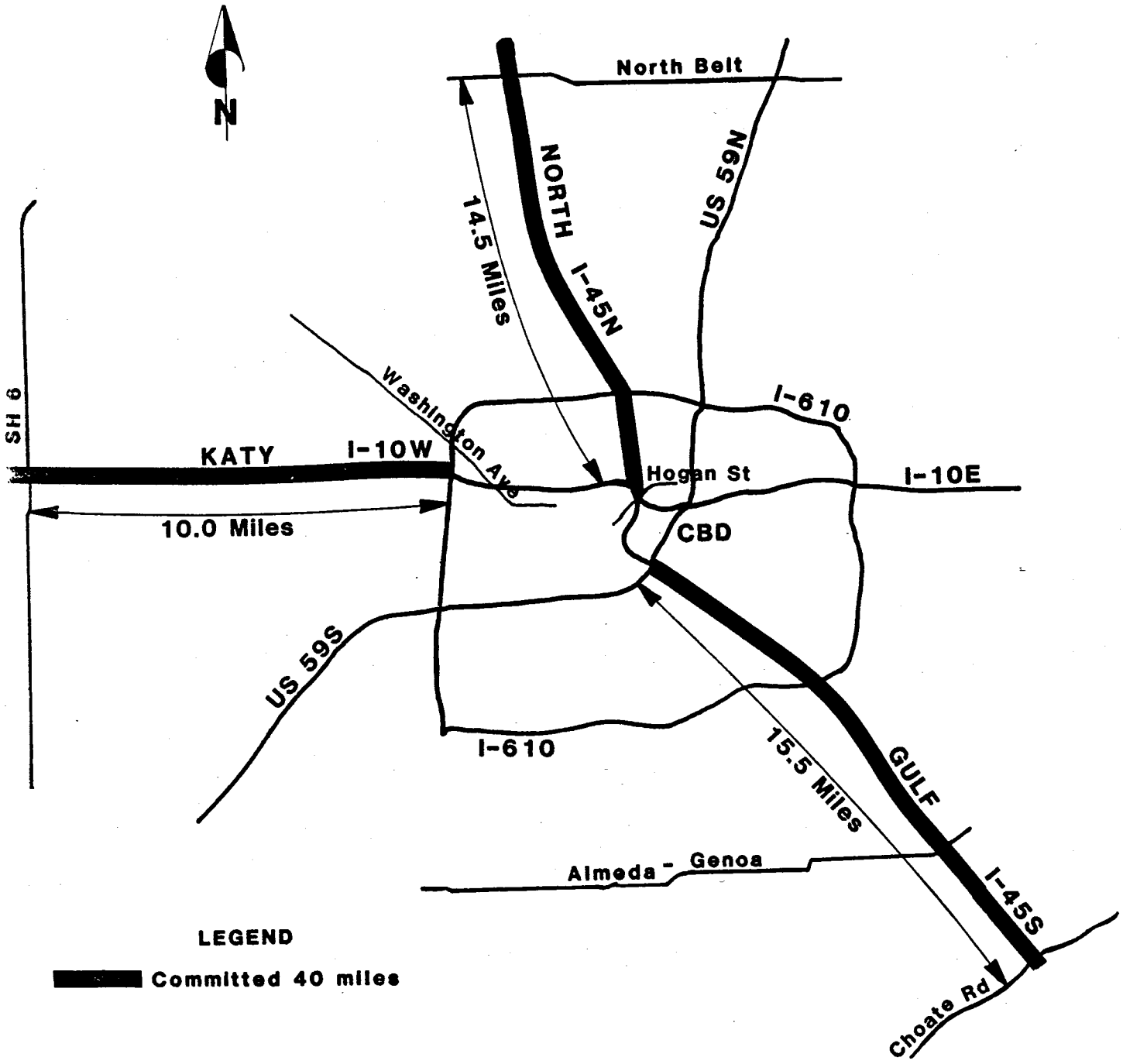
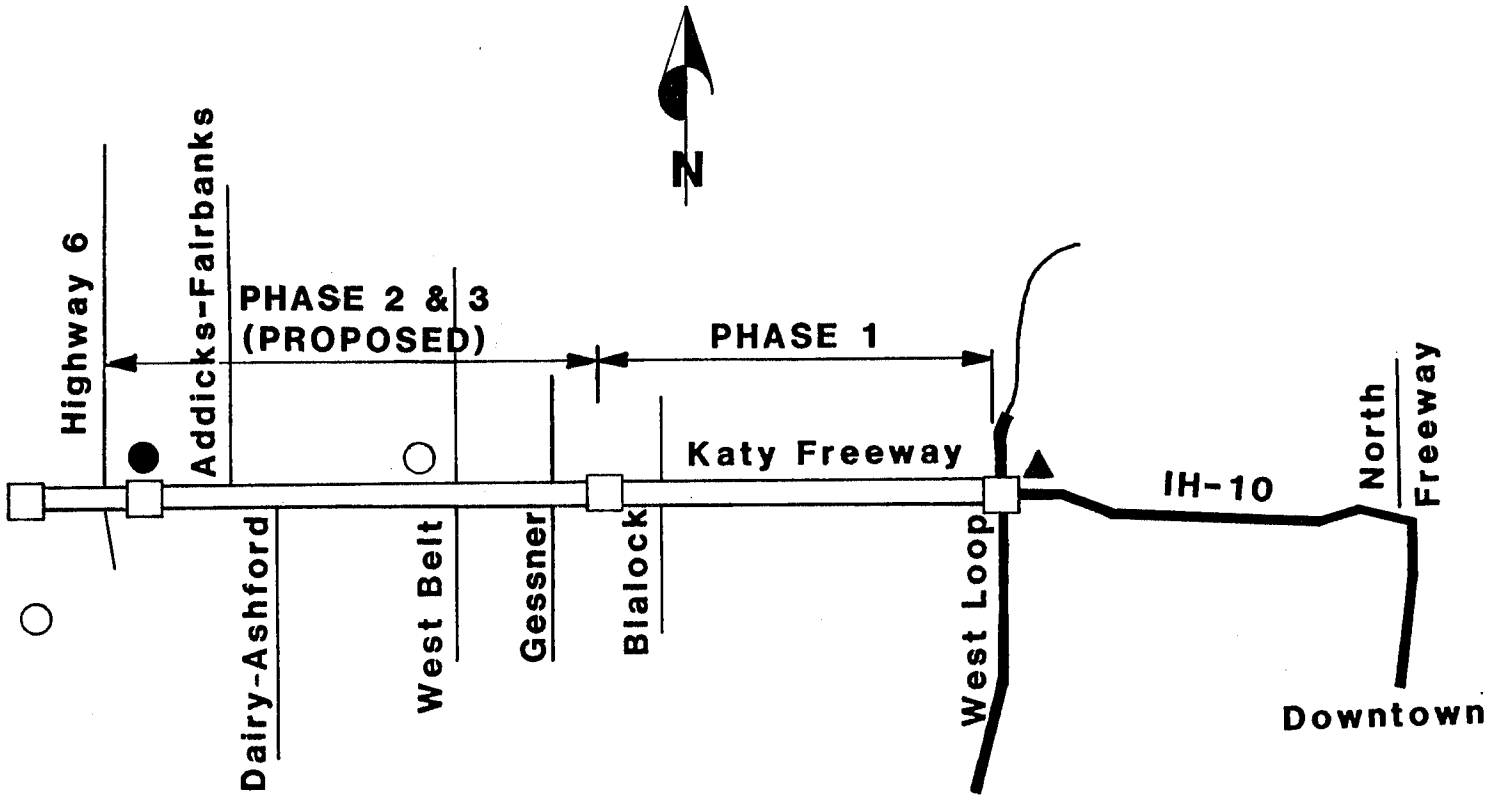


Figure 1: Scope of Transitway Projects Under Implementation



LEGEND

- ☐ Access Points
- ● Existing P & R Lots
- ○ Proposed P & R Lots
- ▲ Transit Center

Figure 2: Katy Freeway Transitway, Phase Construction

By 1987 in the peak hour alone, the Katy Freeway Transitway should accommodate approximately 60 buses and 190 vanpools, or 3,900 persons. Daily ridership could exceed 15,000 commuters. Peak hour travel time from the Addicks Park-and-Ride lot to downtown, via the lane, will be reduced from the current 45 minutes down to 25 minutes.(2)

North Freeway Transitway

The North Freeway currently carries more than 150,000 vehicles each weekday. Population in the freeway corridor is expected to grow 38% by 1995, and traffic volumes will increase accordingly.(1)

The transitway will be built and operated in four phases (Figure 3). Phases I and II include both transitway and mainlane construction, a total of 9.6 miles from downtown to North Shepherd. Construction will begin in April 1983 and be completed in 1985. Phase III will extend the lane 4.9 miles from North Shepherd to North Belt. And Phase IV will continue an additional 3.1 miles to Airtex. Phase III construction is scheduled to begin in January 1985 with a completion date in June 1986. Phase IV construction will begin in May 1985 and end in June 1986.

The North Freeway Transitway will be constructed in the median of the freeway and separated from general traffic lanes by concrete barriers. Since the construction of the transitway is part of the SDHPT work to upgrade and expand the North Freeway to eight lanes, disruption for building the lane will be minimal. The North Freeway Transitway will significantly reduce peak hour travel time. When completed, the travel time for transitway users during peak periods will be half that for current mainlane users. The transitway will also significantly increase the carrying capacity of the freeway. During its first full year of operation, the North Freeway Transitway is expected to benefit 26,000 commuters daily in vanpools and buses.(3)

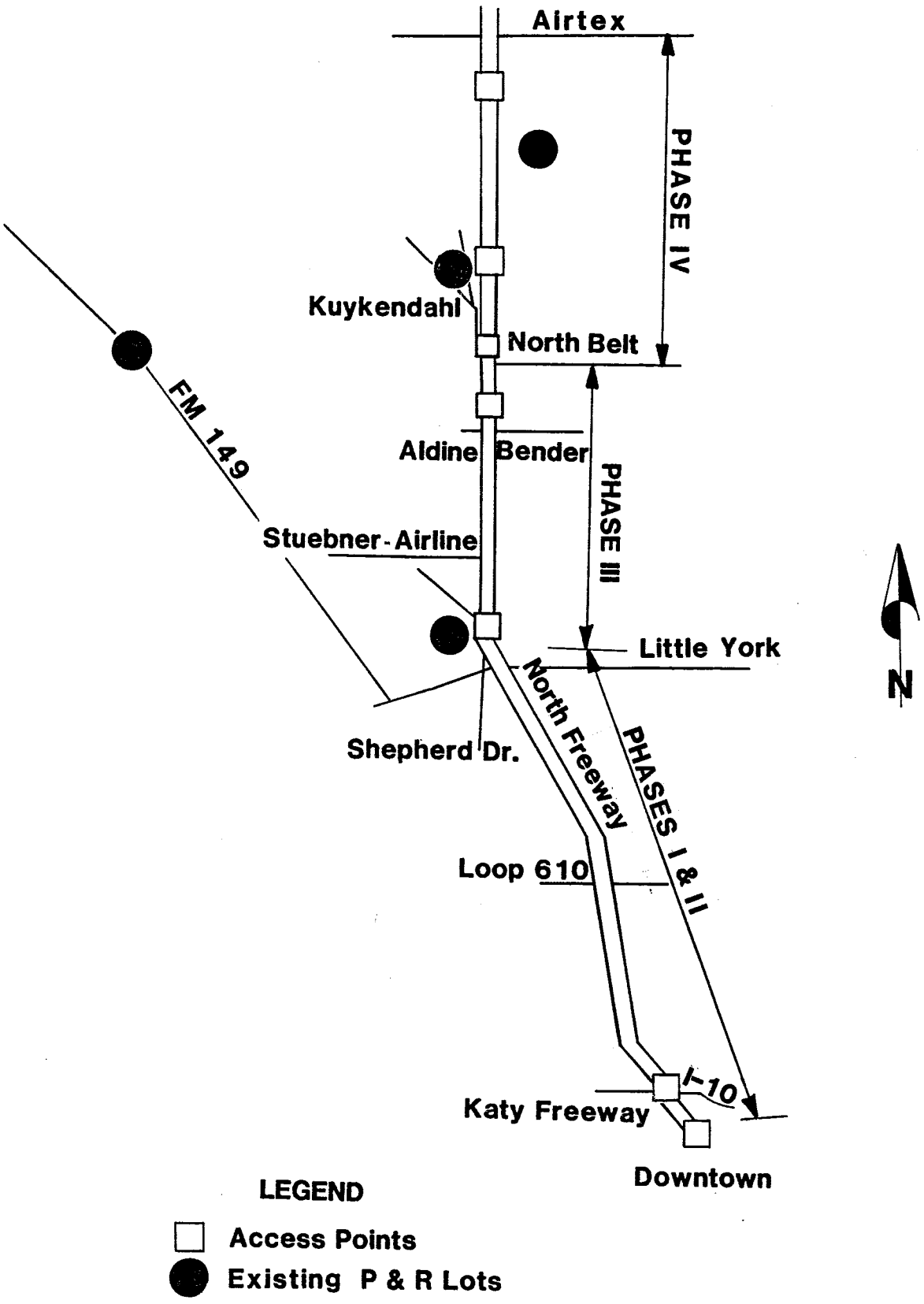


Figure 3: North Freeway Transitway, Phase Construction

Gulf Freeway Transitway

Currently, on the Gulf Freeway 150,000 vehicles travel the freeway each weekday. Traffic in peak periods exceeds 1,900 vehicles per hour per lane.(1)

The transitway will be built and operated in three phases as part of the freeway reconstruction (Figure 4). The first phase stretches five miles from Lockwood Drive to Airport Boulevard. Construction began in 1982 and is scheduled to be completed in mid-1985. The second phase will extend the lane 2.5 miles from Lockwood to downtown; this section should open as an interim facility in 1986. The eight-mile third phase will extend the lane from Airport Boulevard south to Choate Road near Ellington Air Force Base. This phase may be built in segments as traffic demands dictate. The total transitway will be 15.5 miles long when completed.

Four intermediate grade separated interchanges will allow direct access to the transitway and connections to other transit facilities. Interchanges at Lockwood, Hobby and Fuqua employ elevated ramps and bridges over the freeway for entry and exit. Construction will include improvements to general traffic freeway ramps and to intersections at several major cross streets.

The Gulf Freeway Transitway will significantly reduce peak hour travel time for users of the transitway. On the five-mile Phase I section, travel time will be reduced 5 to 10 minutes. When all 15.5 miles are completed, a bus trip on the transitway to downtown should be about 13 minutes, half the current time. The transitway will also significantly increase the carrying capacity of the freeway. About 15,000 daily commuters are expected to travel the lane in vanpools and buses during its first full year of operation. The completed transitway should be able to move 30,000 commuters per hour in buses and vans.(4)

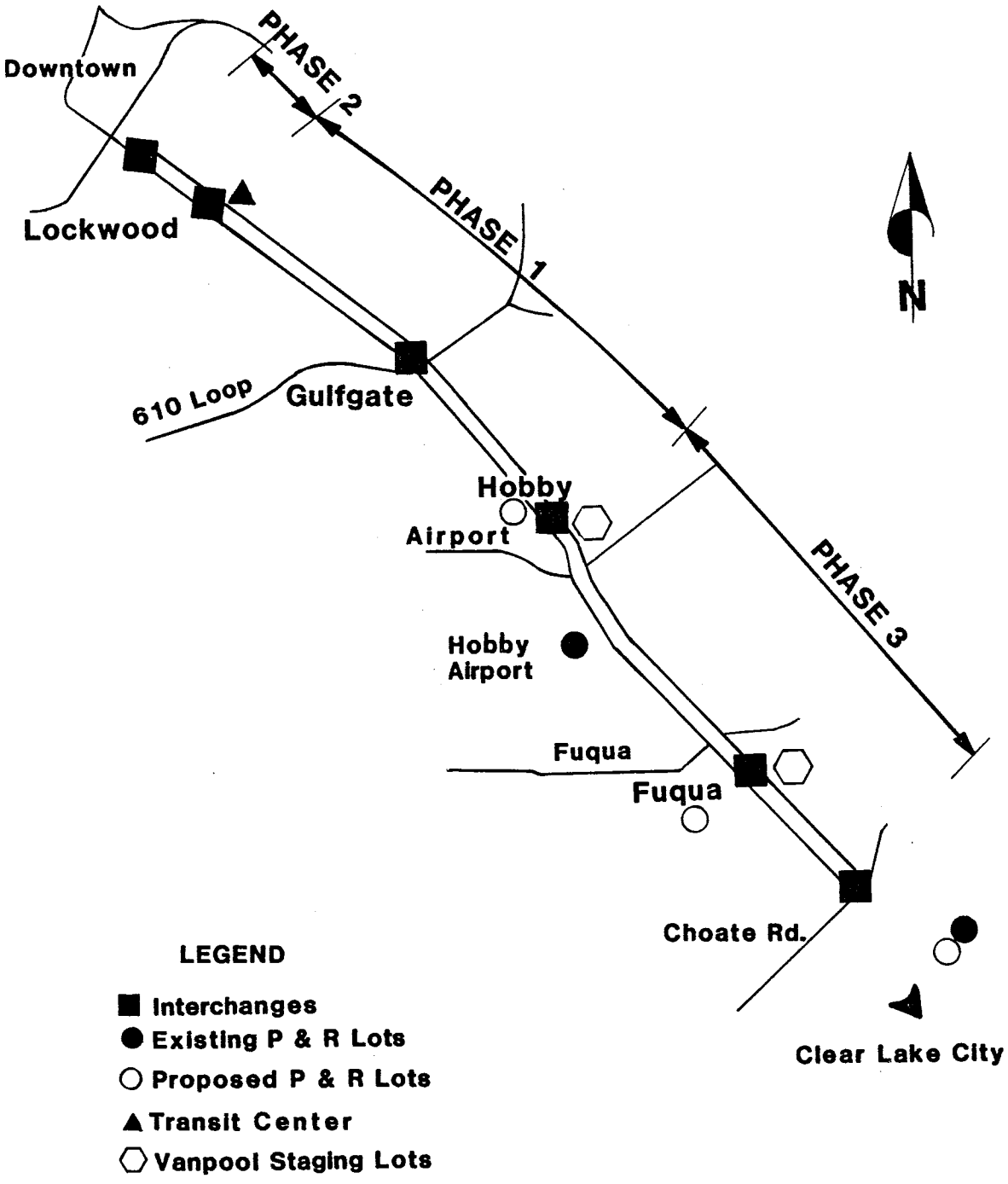


Figure 4: Gulf Freeway Transitway, Phase Construction

STUDY DESIGN

Data Base

The following three general groups of data are being collected along the Gulf, Katy and North Freeway corridors: (1) Park-and-Ride Demands, (2) Peak and Off-Peak Direction Freeway Travel Times, and (3) Peak Direction Freeway and Frontage Road Vehicle Volumes and Occupancies. The Park-and-Ride data includes the number of vehicles parked in each of the surveyed lots, and the time and date the lot was counted. The travel time surveys include the collection of cumulative travel times at various check points along the study corridors, the weather, light, and pavement conditions at the time of the runs, and the severity of any incidents during the runs. Queueing and stopped vehicle data have also been collected during these travel time runs. Finally, in the vehicle volume and occupancy survey, mainlane occupancies and volumes by vehicle types have been recorded. The frontage road volume is also recorded without being categorized by vehicle type or by occupancy.

Collection Methodology

Beginning in June 1983, Park-and-Ride demand levels were sampled monthly at two lots on the Gulf, two lots on the Katy, and four lots on the North Freeway. These lots are shown in Figure 5. The samples were collected between the morning and the evening peak periods (i.e. after 10:00 a.m. and before 4:00 p.m.). In this study, the park-and-ride demand levels are being represented by the number of vehicles found parked inside the park-and-ride lots. The study is not sampling the demand for park-and-ride service, rather, the demand for park-and-ride lot space. However, for lots not at capacity, this provides a rough measure of demand.

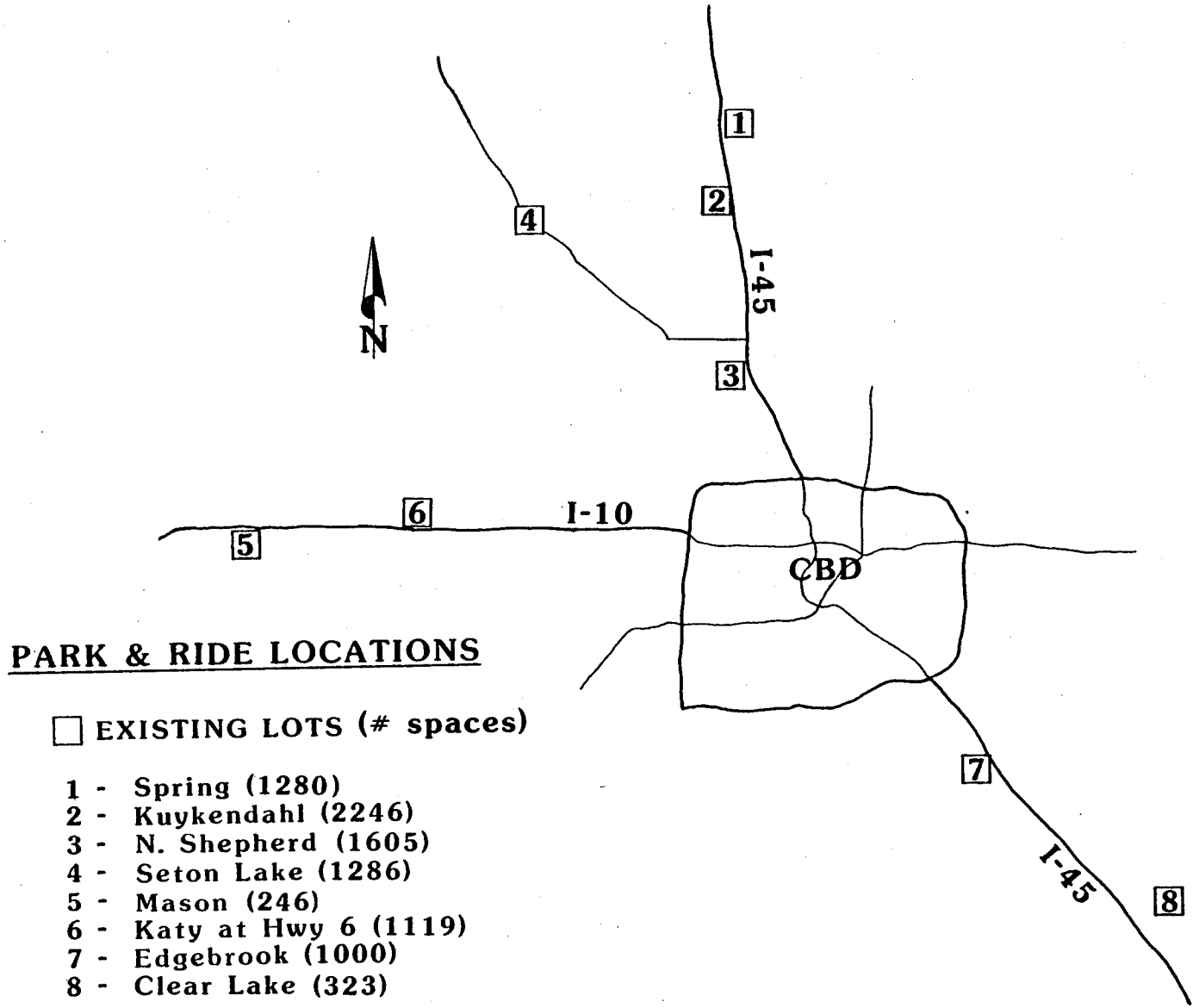


Figure 5: Park-and-Ride Lot Locations

Freeway travel times are also being sampled on a monthly basis. All the travel times are sampled near the middle of each month (i.e 2nd or 3rd complete week of each month) with a specific day of the week assigned to each freeway. The Katy Freeway travel times are always sampled on a Tuesday, the North Freeway on a Wednesday, and the Gulf Freeway on a Thursday. This sampling schedule screens out the daily and the weekly variations in travel times that may be present and allows one to see the monthly changes.

On the Gulf Freeway, the travel times from Choate Road to the Hogan Street Overpass are being recorded. On the Katy Freeway, the travel times are being recorded from State Highway 6 to Washington Avenue. On the North Freeway, the travel times are being recorded from the North Belt to the Hogan Street Overpass. Beginning at 6:00 a.m., travel time runs are begun at 30 minute intervals ending by 11:00 a.m. In the afternoon, also at 30 minute intervals, travel time runs are made between 4:00 p.m. and 8:00 p.m. Cumulative travel times are recorded at sequential checkpoints in both the inbound and outbound directions in the morning and in the afternoon. Terminal checkpoints are shown in Figure 1, and all checkpoints with their associated mile points are listed in Table 1. Each vehicle is manned by two people, so that one person may record while the other is free to concentrate on driving in rush hour traffic.

Freeway vehicle volumes and occupancies are being sampled on a quarterly schedule at the following locations: (1) Gulf Freeway at Monroe, (2) Katy Freeway at Bunker Hill, and (3) North Freeway at Little York. An initial plan to sample on a monthly schedule was found to be infeasible because of monetary and manpower restrictions. Further, it has proven difficult to amass the manpower necessary to sample on a bi-monthly basis. Consequently,

TABLE 1. TRAVEL TIME CHECK POINTS

Inbound					
Gulf		Katy		North	
Milepoint	Cross Street	Milepoint	Cross Street	Milepoint	Cross Street
0.00	Choate Road	0.00	SH 6	0.00	North Belt
2.00	South Belt	1.63	Eldridge	1.70	West Road
4.05	Almeda-Genoa	2.30	Dairy Ashford	2.90	West Mr. Houston
5.35	Edgebrook	3.28	Kirkwood	4.45	North Shepherd
6.25	Airport	4.18	Wilcrest	4.95	Little York
8.15	Howard/Bellfort	4.93	West Belt	5.75	Parker
9.05	Park Place	6.08	Gessner	6.85	Tidwell
10.15	South Loop	6.81	Bunker Hill	7.75	Airline Drive
10.45	Reveille	7.44	Blalock	8.20	Crosstimbers
11.35	Griggs	8.80	Bingle	9.30	North Loop (I-610)
12.10	Wayside	9.62	Wirt	11.00	North Main
13.75	Calhoun	10.19	Antoine	12.20	Hogan St. Overpass
14.50	Scott	10.64	Silber		
15.30	Dowling	11.56	West Loop		
16.85	Dallas	12.81	Washington		
18.20	Hogan St. Overpass				

Outbound					
Gulf		Katy		North	
Milepoint	Cross Street	Milepoint	Cross Street	Milepoint	Cross Street
0.00	Hogan St. Overpass	0.00	Washington	0.00	Hogan St. Overpass
1.35	Dallas	1.25	West Loop	1.20	North Main
2.90	Dowling	2.17	Silber	2.90	North Loop (I-610)
3.70	Scott	2.62	Antoine	4.00	Crosstimbers
4.45	Calhoun	3.19	Wirt	4.45	Airline Drive
6.10	Wayside	4.01	Bingle	5.35	Tidwell
6.85	Griggs	5.37	Blalock	6.45	Parker
7.75	Reveille	6.00	Bunker Hill	7.25	Little York
8.05	South Loop	6.73	Gessner	7.75	North Shepherd
9.15	Park Place	7.83	West Belt	9.30	West Mt. Houston
10.05	Howard/Bellfort	8.63	Wilcrest	10.50	West Road
11.95	Airport	9.53	Kirkwood	12.20	North Belt
12.85	Edgebrook	10.51	Dairy Ashford		
14.15	Almeda-Genoa	11.18	Eldridge		
16.20	South Belt	12.81	SH 6		
18.20	Choate Road				

a three month schedule was selected. Volumes are counted for 15 minute intervals on a lane-by-lane basis between 6:00-10:00 a.m. and between 4:00-7:00 p.m. These counts, like the park-and-ride and the travel time surveys, have also been conducted in the 2nd and 3rd week of each month, with the same specific day of the week being assigned to each freeway corridor. Due to inadequate lighting conditions volumes could be recorded only from 6:30 to 9:30 a.m. and from 4:00 to 6:00 p.m. in the winter quarter. However, all other quarters were sampled for a minimum of three full hours for each peak period. To allow the afternoon winter data to reflect a full three hour peak period, the last hour of data was extrapolated from the data taken in previous quarters and from the preceding two hours of winter quarter data.

Surveyors are stationed in the peak directions in the outer separation between the freeway and the frontage road, or at sites on the other side of the frontage road. Locations have been chosen just before or after the point where the freeway crosses the survey street to maximize visibility of the surveyed vehicles and the safety of the surveyors while minimizing the disruption of normal traffic flow. A surveyor is assigned to each peak direction lane on the freeway, and one surveyor is assigned to the frontage road. The surveyor counting the frontage road is also responsible for the contraflow volumes on the day that the North Freeway is counted. Surveyors must record both the total number of vehicles of each type and the occupancies of each vehicle type. These vehicle and occupancy classifications are listed in Table 2.

TABLE 2. VEHICLE OCCUPANCY CATEGORIES

Vehicle Categories	Occupancy Categories
Pickups/Passenger Cars	1 2 3 4+
Vans	1-3 4-6 7+
Buses	Empty 1/4 full 1/2 full 3/4 full Full

Analysis Techniques

Regression techniques will be applied to all three general groups of data. The resulting regression models will allow the investigation of the statistical relationships between the variables of interest. They will be used to determine the magnitude and significance of changes in travel times, park-and-ride lot demands, and person volumes that may be attributed to the operation of transitway projects. Additionally, the Tukey Multiple Comparison procedure will be used to compare the relative degrees of success of the various different combinations of design features.(2)

Park-and-ride demand levels will be regressed on three factors: (1) time, (2) CFL operation, and (3) transitway operation. Time will be discretized by month. CFL and transitway operation will be indicator variables with a value of one if the CFL or the transitway is in use and zero otherwise. The two indicator variables permit the investigation of the unusually steep gains in demand anticipated when priority vehicle lanes are opened to authorized vehicles. The time variable simply estimates the general trend of

the surveyed park-and-ride demands. The regression relationships will be used to project demand levels forward in time.

Overall speeds will be regressed on: (1) the extent of construction work, (2) the number of lanes taken for construction, (3) the weather conditions, (4) the lighting conditions, (5) the pavement conditions, (6) the severity of accidents or incidents, (7) the reduction of lane widths, (8) the operation of the transitway in the corridor, and (9) the time of day. Since speed is a function of both distance and travel time, regression will be applied only to speed. The results will then be converted to travel time. The first six variables take integer values from zero upwards as the conditions worsen. Lane width reduction and transitway operation are class variables that will be converted into indicator variables to facilitate regression analysis. They will take the value of one if lane widths have been narrowed or if the transitway is operational and zero otherwise. Finally, time of day simply will be the times when the travel time runs were started. These travel time variables and their values are listed in Table 3.

Vehicle volumes and occupancies will undergo a similar regression analysis once an adequate data base is established. Four variables will be examined: (1) the total vehicle volume, (2) the total person volume, (3) the overall average occupancy rate, and (4) the HOV contribution to each of the preceding three variables. The independent variables will be: (1) the extent/severity of construction (i.e. number and/or width of lanes reduced, etc.), (2) the weather conditions, (3) the existence/severity of accidents or other such disruptive incidents, (4) the operation of a CFL, and (5) the operation of a transitway. The regression procedure is continued for this group of data because of interest in both the presence and the magnitude of any significant increases or decreases in volumes and occupancies of the

TABLE 3. TRAVEL TIME VARIABLES AND VALUES

Weather (W):	Extent of Construction Work:
0 = Clear 1 = Overcast 2 = Light Rain or Drizzle 3 = Heavy Rain	0 = 0% of corridor length 1 = 25% of corridor length 2 = 50% of corridor length 3 = 75% of corridor length 4 = 100% of corridor length
Light Conditions (L):	Lane Width Reduction:
0 = Normal Daylight 1 = Dark or Twilight 2 = Sunglare 3 = Fog	0 = No lane width narrowing 1 = Lanes narrowed
Pavement Conditions (P):	Number of Lanes Removed:
0 = Dry 1 = Wet 2 = Ice, Snow or other extreme slickness	0 = No lanes removed in any section 1 = 1 lane removed in any section 2 = 2 lanes removed in any section 3 = 3 lanes removed in any section
Incidents (I):	
0 = None 1 = Minor (off-road) (No appreciable impact on speed) 2 = Major (lane blockage, etc.) (Significant impact on speed)	

implementation of transitways on the Katy and Gulf Freeways, and after the upgrading from CFL to transitway on the North Freeway. Finally, the Tukey Multiple Comparison procedure is employed to identify any statistically significant as well as any practically significant differences between the volume changes resulting from the three different transitway treatments.

Tables and plots illustrating relevent statistics will also be available to supplement the statistical tests. For the park-and-ride demand data, tables will be produced to display the monthly demand levels for each of the

lots as well as for the entire corridor. The plots will graphically illustrate the general trends in the corridor's park-and-ride parking demands as compared to its capacity. Finally, the total parking demands for all three corridors will be superimposed on the same graph to provide a rough visual means of comparing the demand levels on the three corridors.

The travel time tables will summarize the average peak period and peak hour travel times and speeds (on a section by section basis), total travel times, and average travel speeds in both the peak and the off-peak directions. Two of the graphs will illustrate the changes that the average speeds and the total times have experienced each month. The third graph will plot the section speeds by the milepoints. Each month's data will be represented by a curve connecting the various monthly section speeds. The extent of the transitway construction/road surface renovation will then be indicated on these monthly curves. This last graph would illustrate the impact (if any) that transitway construction has on freeway travel time for non-transitway users.

Tables for the volume study will summarize peak period and peak hour vehicle volumes, person volumes, HOV percent of vehicle volume, HOV percent of person volume, and overall vehicle occupancy rates in the peak directions. The accompanying graphs fall into three basic categories, those depicting (1) vehicle and person volumes, (2) HOV percent of vehicle and person volumes, and (3) overall occupancy rates by vehicle type. A separate set of graphs will be pictured for each freeway, for each peak period and for each peak hour.

PRELIMINARY RESULTS

Overview

At the beginning of this study in June 1983, two of the three study corridors already had transitway construction work underway, and the third had begun preconstruction work. The Gulf Freeway transitway construction started as early as September 1982. The Katy Freeway had its construction ground breaking ceremonies in May 1983. The North Freeway preconstruction preparatory work began in April 1983, but actual construction did not begin until January 1984.

All three study corridors are heavily involved in actual transitway construction now. However, only the Katy Freeway has experienced lane narrowing, restriping and traffic reassignment along extensive sections of its length. While the Gulf Freeway has undergone spotty construction work mostly around the Lockwood Interchange, the Katy Freeway has seen construction extending from West Belt all the way in to Post Oak/West Loop during the first six months of this study. Until January 1984, work on the North Freeway consisted of the relocation of signing, lighting and guard railing from its median. Although the North Freeway did not experience any extensive construction through the first six months of this study, it has had an operational HOV contraflow lane for more than five years. All three corridors are different, whether in operational characteristics or in functional circumstances. All three are experiencing high degrees of traffic congestion and the resulting unacceptable levels of service; installation of median transitways should improve mobility on all three corridors.

Park-and-Ride Parking Demand

Figure 6 illustrates the variations in Park-and-Ride Demand for each corridor on a monthly basis. All three corridors exhibit very small rates of change per month. The Gulf Corridor has decreased slightly at a rate of 18 vehicles per month. The Katy Corridor has increased slightly at a rate of 10 vehicles per month, and the North Corridor has increased at a rate of 24 vehicles per month. These slope estimates are very preliminary since they are based upon only 6 months of data. Any conclusions drawn at this time lack reliability. Further inspection of the demand plots reveals that very little notable variation can be seen from month to month. However, once the transitways become operational, large monthly, if not weekly, increases in park-and-ride demand are anticipated on the Katy and the Gulf Freeways.

Travel Times/Speeds

Figures 7 through 17 illustrate monthly changes in total travel times, overall speeds, and sectional speeds that the Gulf and North Freeways have experienced since June 1983, and the Katy Freeway since January 1982.

Gulf Freeway

In Figure 7, the morning outbound and afternoon inbound total travel times have shown no pronounced changes since June 1983. For the study length of 18.20 miles, the estimated total time for a vehicle traveling at 55 mph would be 19.9 minutes. The off-peak direction travel times have fallen below this mark in almost every month, although both rose above this mark in July 1983. The 6 month averages for the two off-peak direction travel times are 19.6 minutes in the morning and 20.3 minutes in the afternoon. Both averages

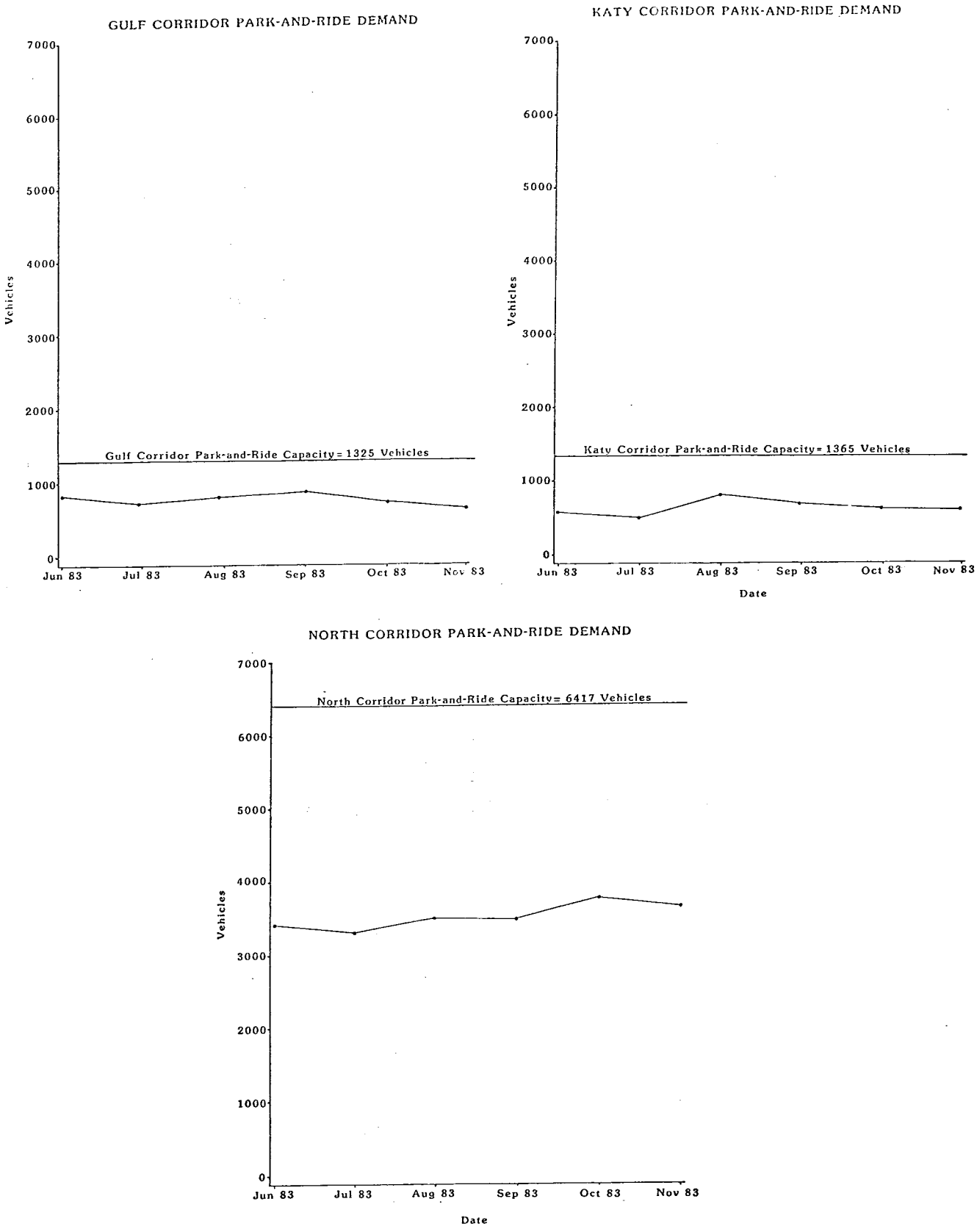
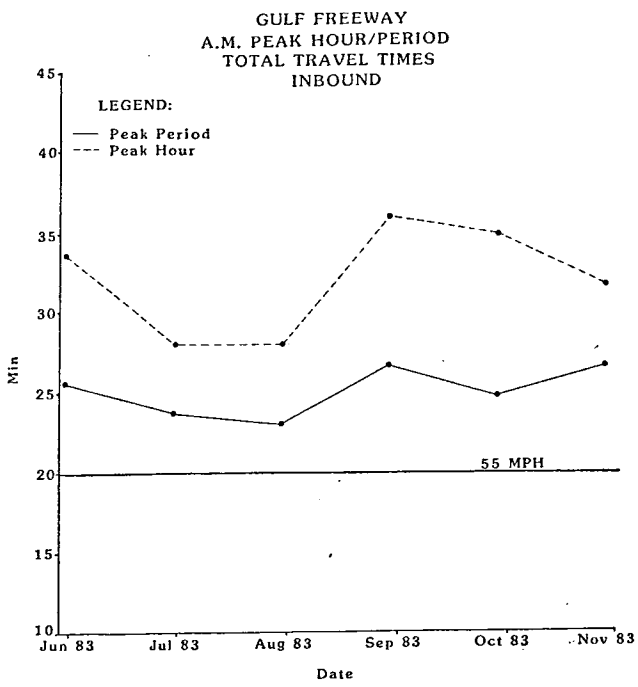
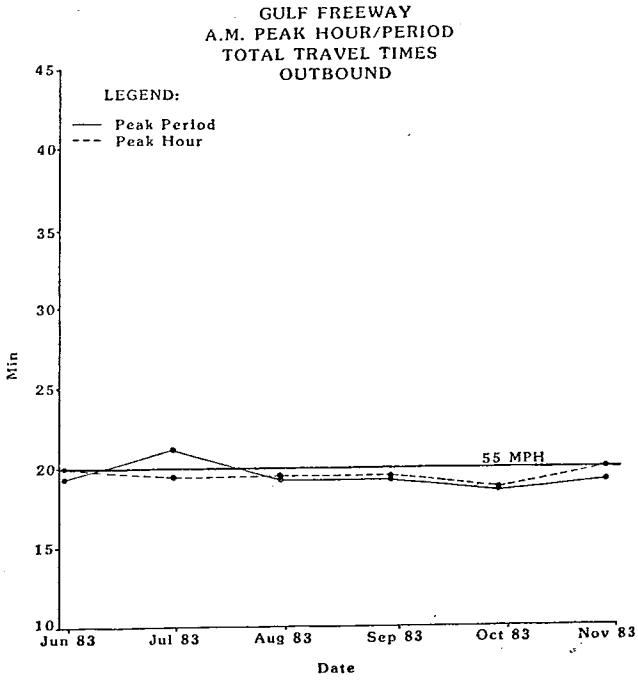
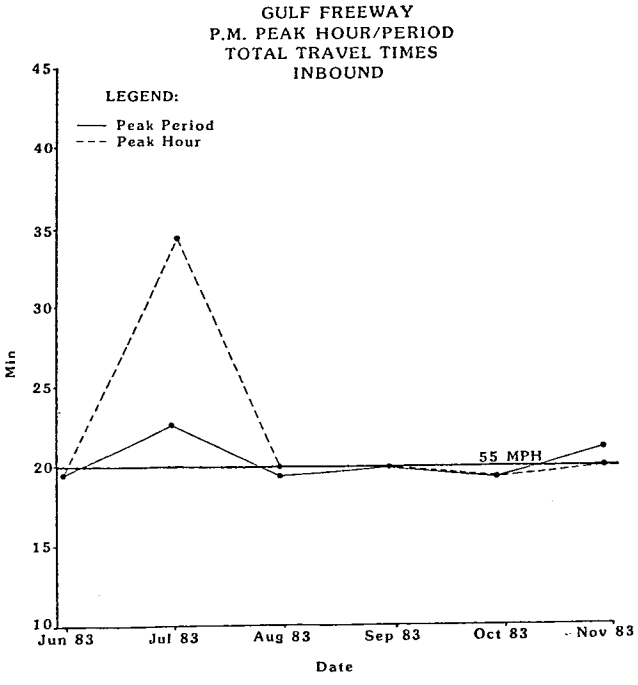


Figure 6: Park-and-Ride Demands in Study Corridors







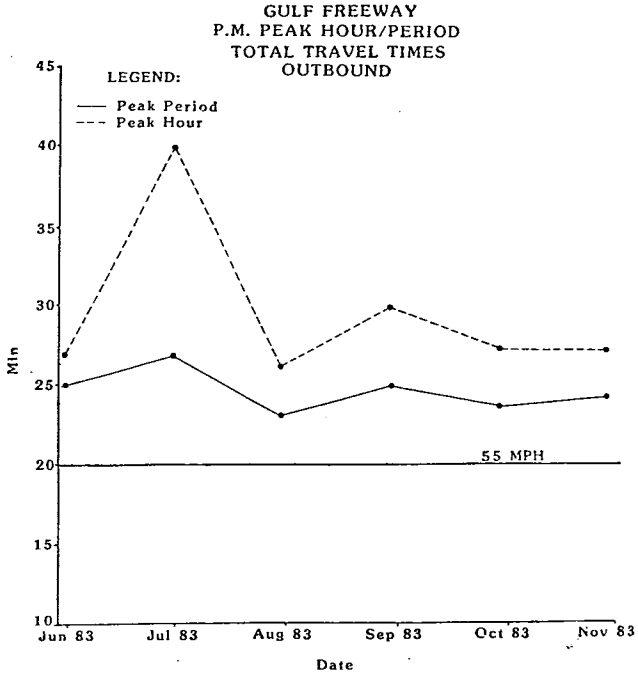


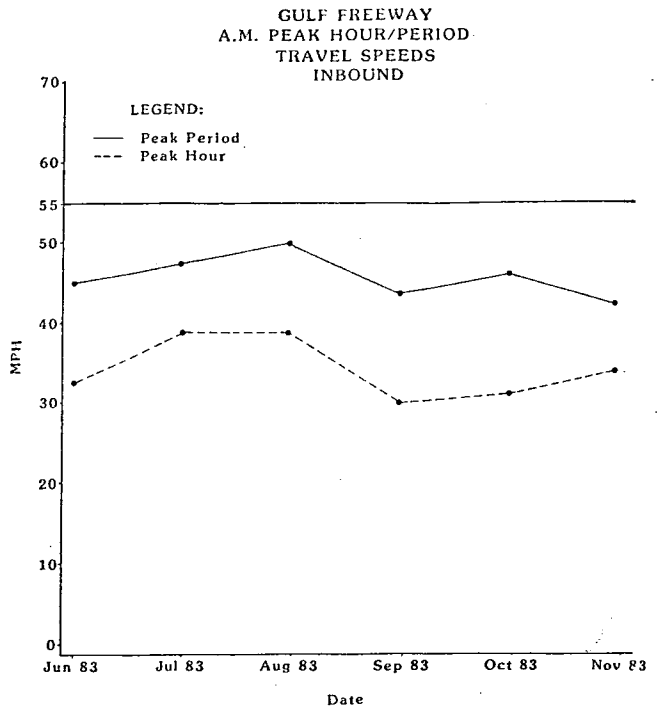
Figure 7: Gulf Freeway Total Travel Times

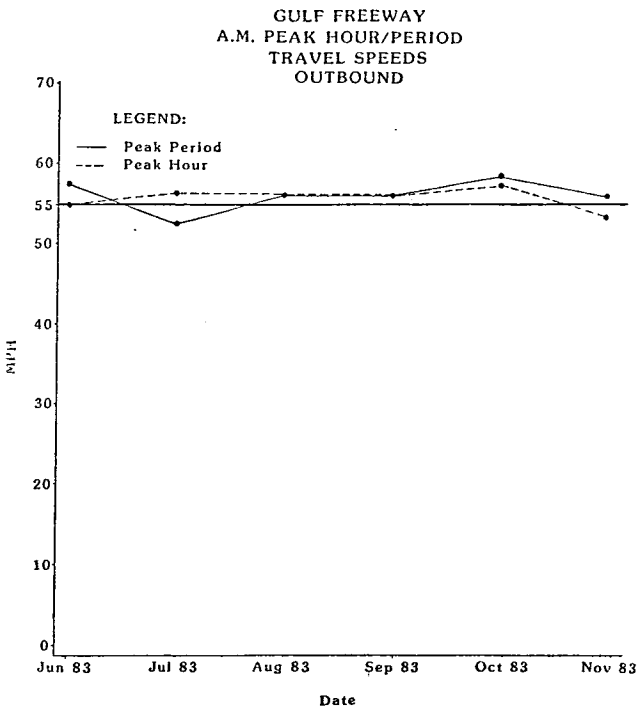
are close to the desired free flow travel time of 19.9 minutes, based upon a 55 MPH speed limit.

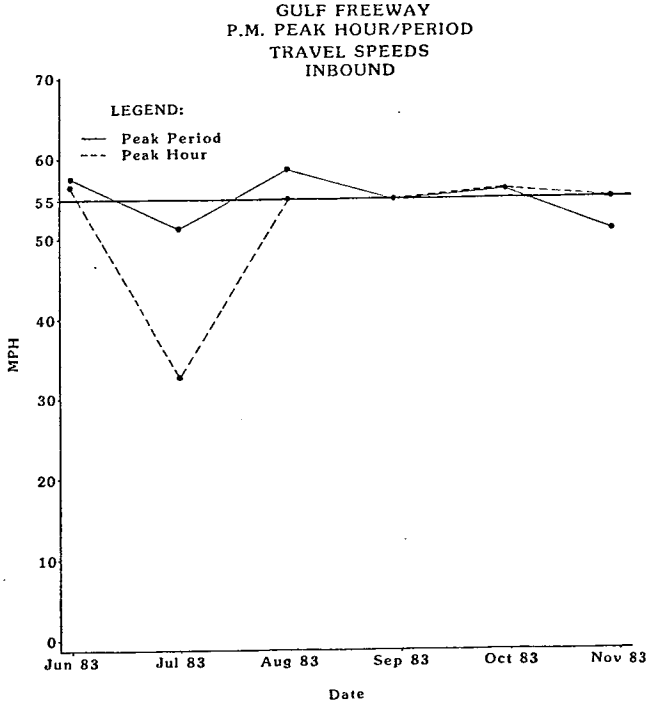
The peak direction travel times (morning inbound and afternoon outbound) have not been as stable as the off-peak direction travel times. Both morning and afternoon peak travel times have been increasing since June 1983. The six month average for the morning peak direction is 25.2 minutes; for the afternoon peak, it is 24.6 minutes. Both exceed the free flow time by roughly 25%.

Study of the average corridor speed graphs in Figure 8 indicates that the increases in travel time discussed in the proceeding paragraphs are not substantial when compared to the study length of the corridor. The average Gulf corridor speeds are 46 MPH in the morning inbound direction, 47 MPH in the afternoon outbound direction, 56 MPH in the morning outbound direction, and 55 MPH in the afternoon inbound direction. The peak directions are running close to 10 MPH less than the legal speed limit of 55 MPH, but the off-peak directions appear to be operating very close to 55 MPH.

The plots of average peak period sectional travel speeds versus sectional cross street limitations in Figure 9 point out the problem areas along the corridor. In the morning peak directions, the travel speeds consistently drop to their minimums at Airport and at Scott. In the afternoon peak direction, the worst slow-downs occur near Calhoun and at Howard/Bellfort, just before Airport. The off-peak directions do not appear to have any sections with substantial congestion at the present time. The peak hour sectional travel speeds plotted in Figure 10 show queueing at Edgebrook and Calhoun in the morning inbound, and at Park Place and Howard/Bellfort in the afternoon outbound. The off-peak traffic flow shows no problems during the peak hour.







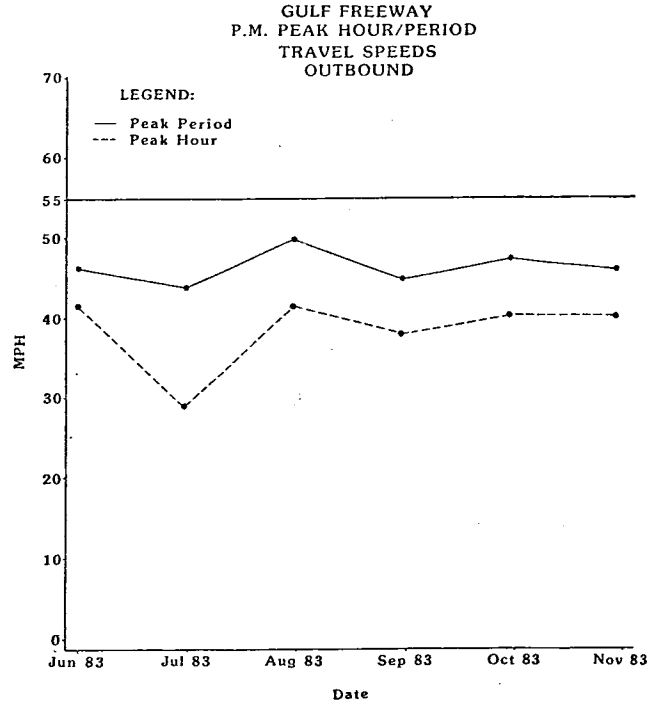
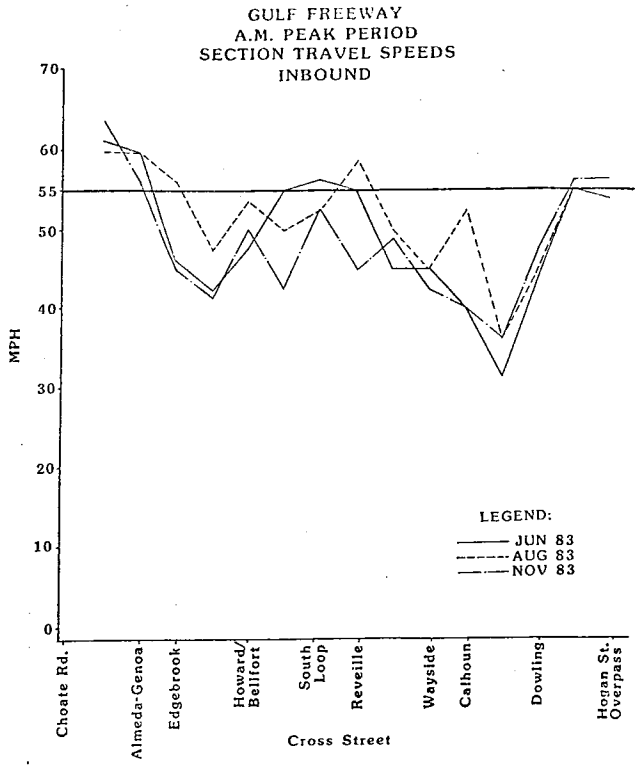
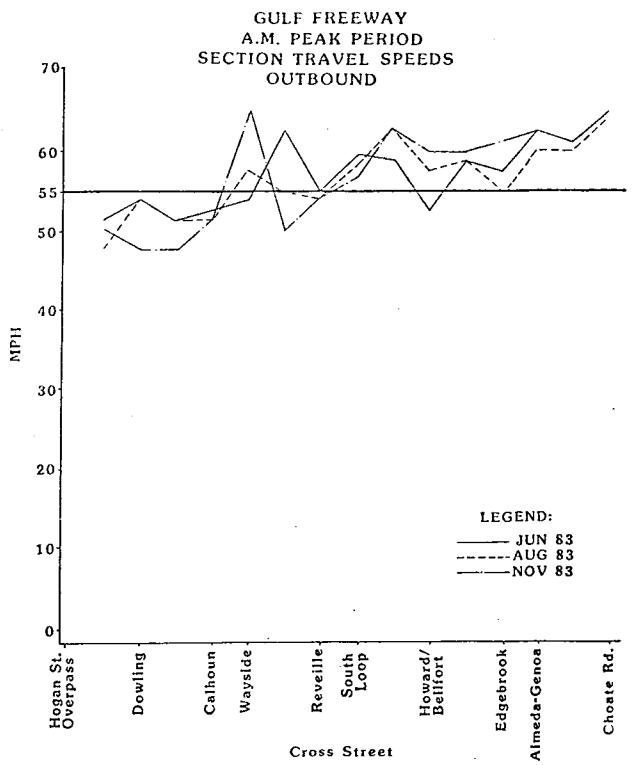
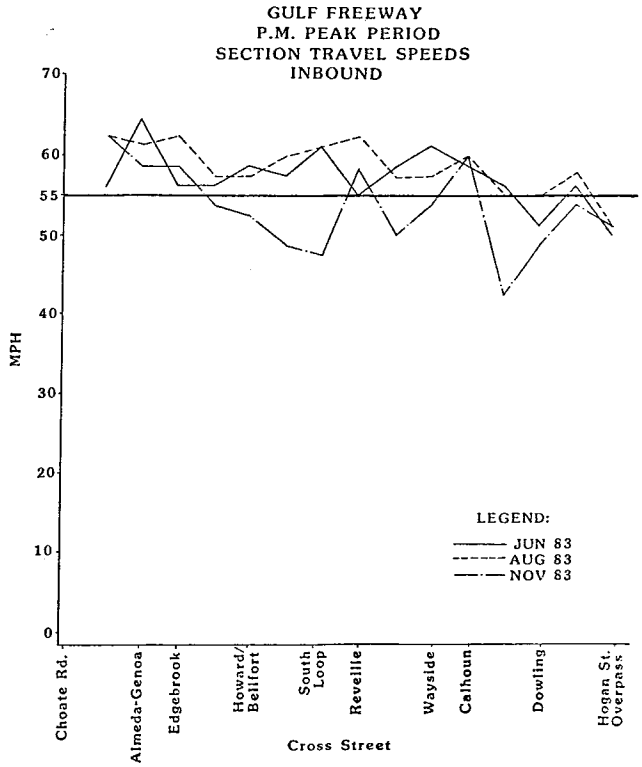


Figure 8: Gulf Freeway Overall Travel Speeds







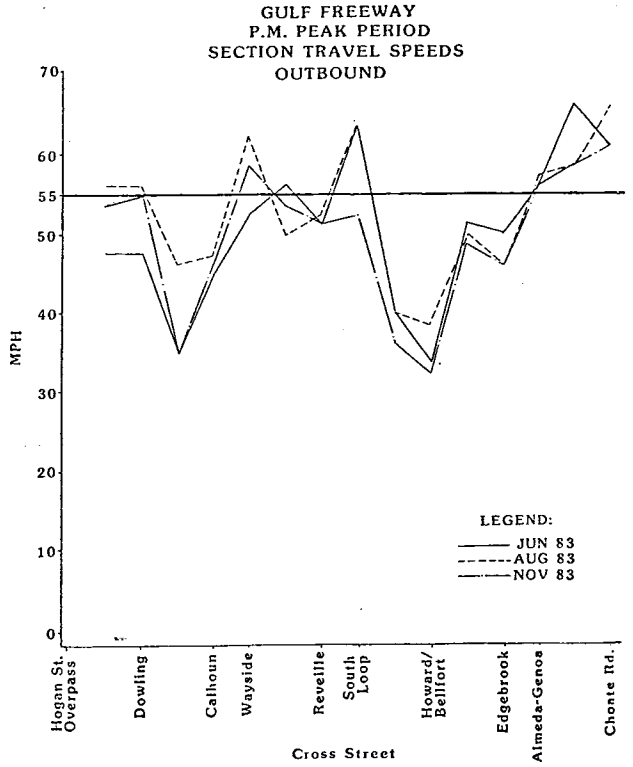


Figure 9: Gulf Freeway Peak Period Section Travel Speeds

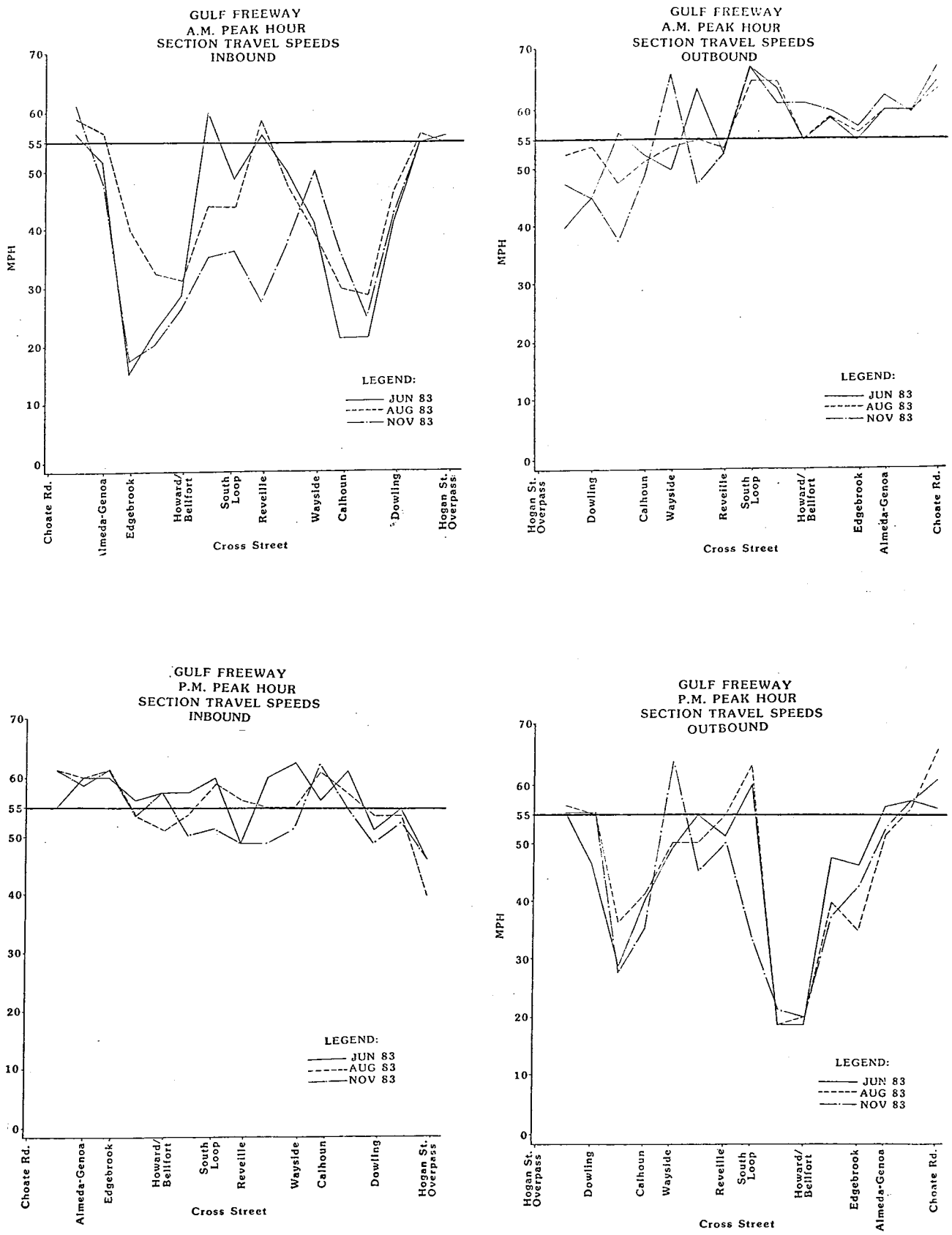


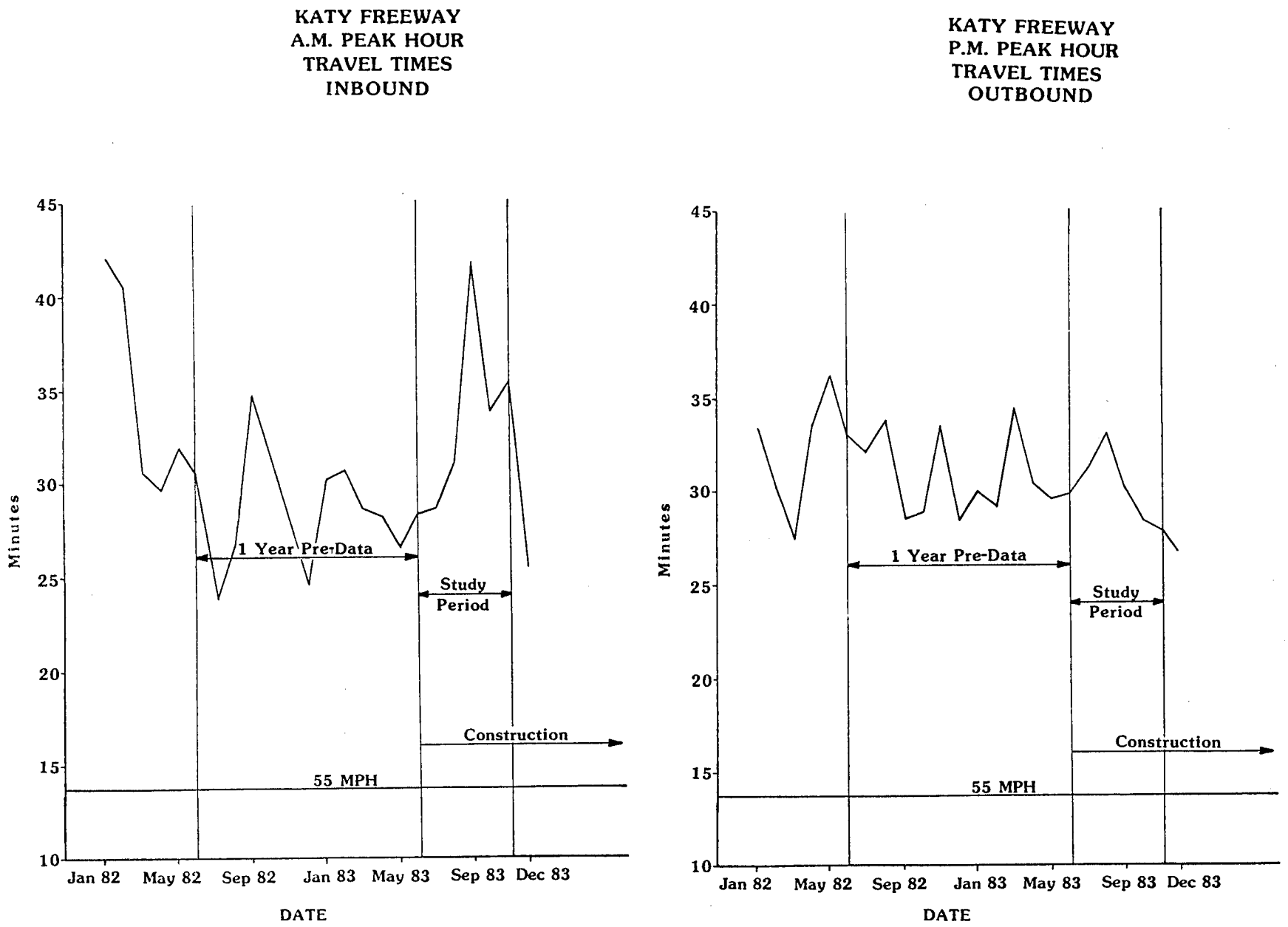
Figure 10: Gulf Freeway Peak Hour Section Travel Speeds

Katy Freeway

In addition to the Texas Transportation Institute (TTI) data collected since June 1983, it has also been possible to obtain peak hour peak direction travel time and speed data from the SDHPT. These times and speeds are plotted in Figures 11 and 12. That data goes back as far as January 1982 and extends to the end of 1983. The picture presented by these two years of data is ambiguous. No distinct trends are apparent. The 1982 data shows the Katy Freeway operating no better and no worse than in 1983. The average 1982 travel times were only about one minute more than the 1983 travel times; and the 1982 travel speeds were only about one MPH faster in the morning and 1 MPH slower in the afternoon than the 1983 travel speeds. Despite the transitway construction, the overall 1983 traffic conditions in terms of travel time have not deteriorated substantially.

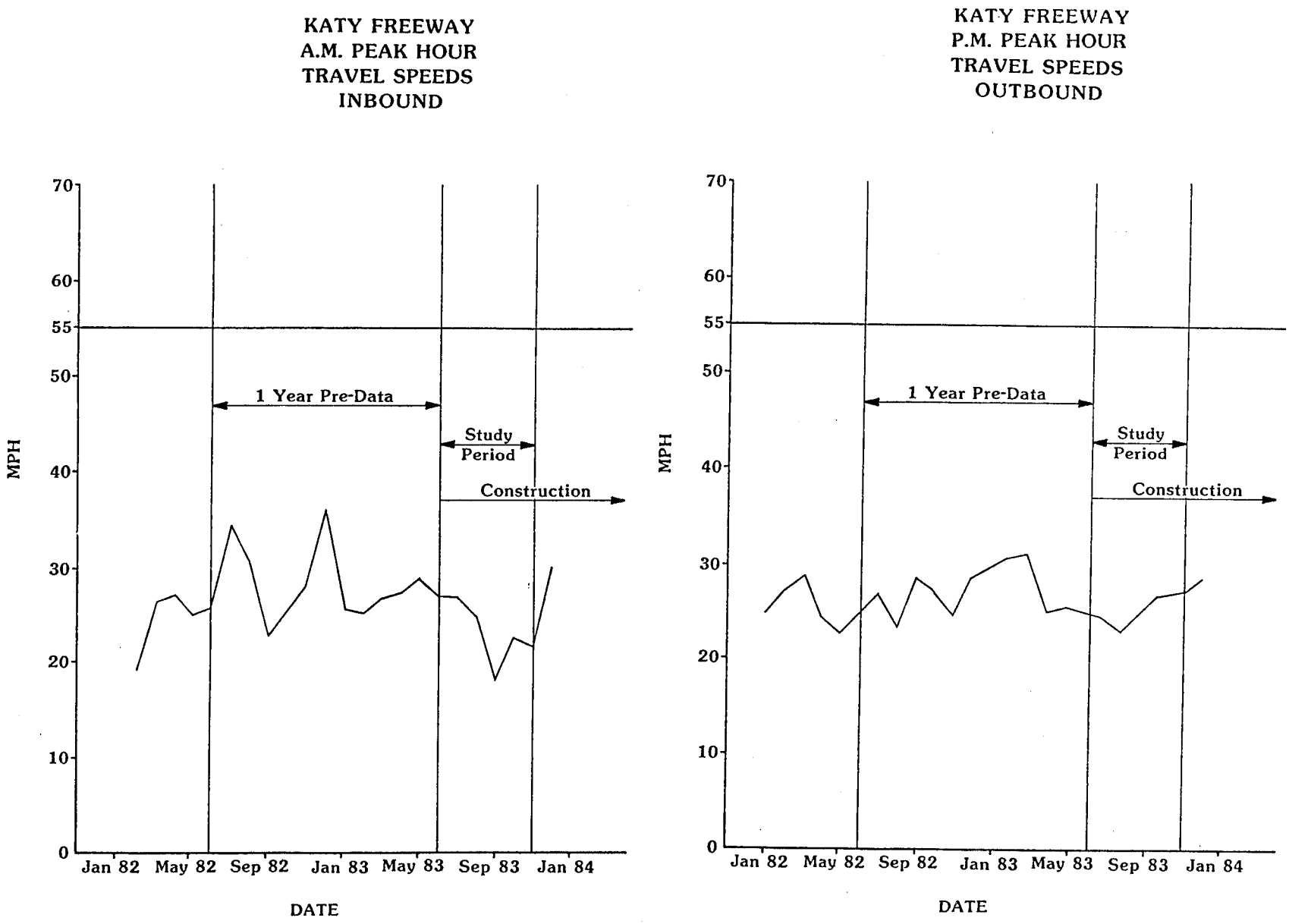
The Katy Freeway study length is 12.81 miles. A car traveling at 55 MPH over this distance would have a travel time of 14.0 minutes. In Figure 13, the off-peak direction travel times are near 14.0 minutes, but both peak direction travel times exceed this mark considerably. The morning off-peak direction travel times have been holding steady near the free flow time, but the afternoon inbound direction travel times appear to be increasing. The 6 month average for the morning outbound direction is 14.2 minutes and 14.6 minutes for the afternoon off-peak direction. Both averages lie above the free flow time but not by a substantial amount.

Peak hour, peak direction travel times from January 1982 to December 1983 are plotted in Figure 11, and peak period/hour times from June 1983 to November 1983 are plotted in Figure 13. The morning and afternoon peak direction data are very dissimilar. Whereas the afternoon peak direction times appears to be decreasing throughout the two year period, the morning peak direction times seem to have two different slopes. In Figure 11, the



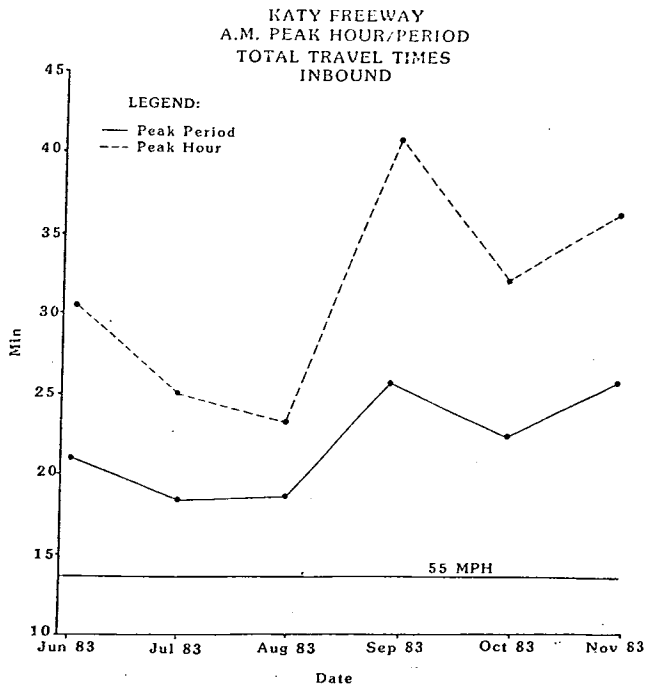
Source: SDHPT

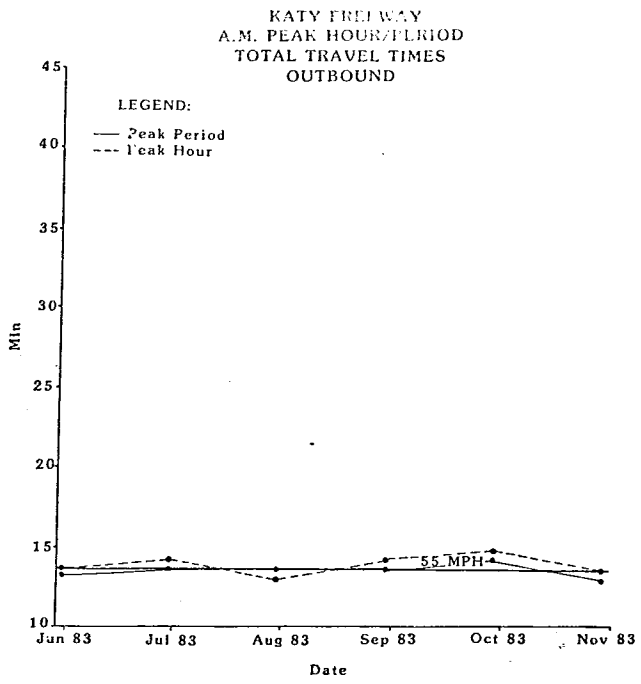
Figure 11: Katy Freeway 1982-1983 Peak Hour Total Travel Times

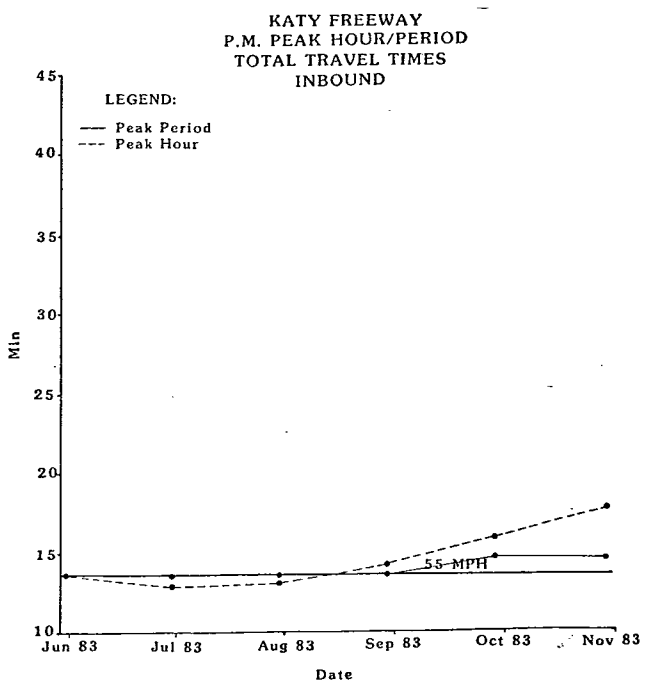


Source: SDHPT

Figure 12: Katy Freeway 1982-1983 Peak Hour Overall Travel Speeds







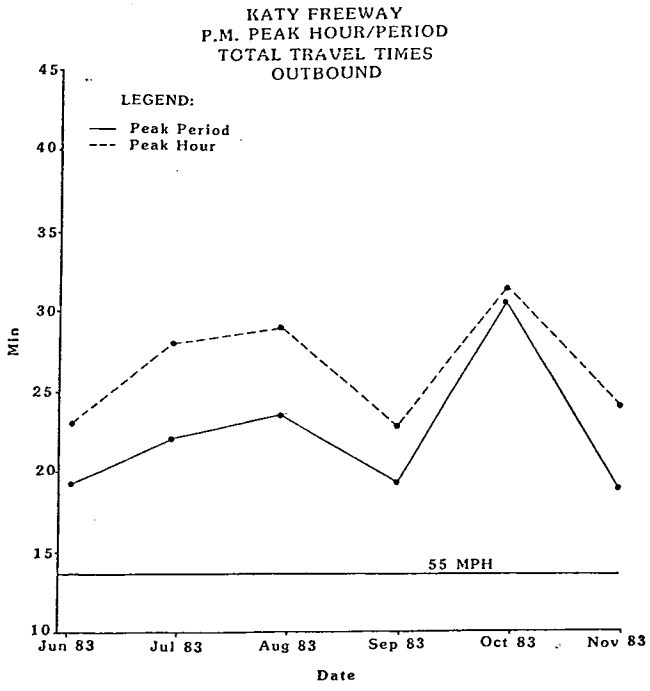
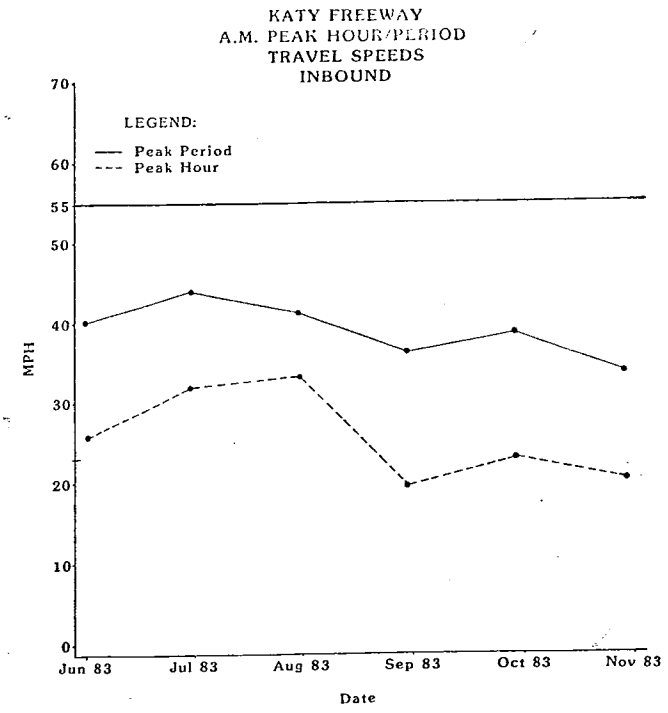


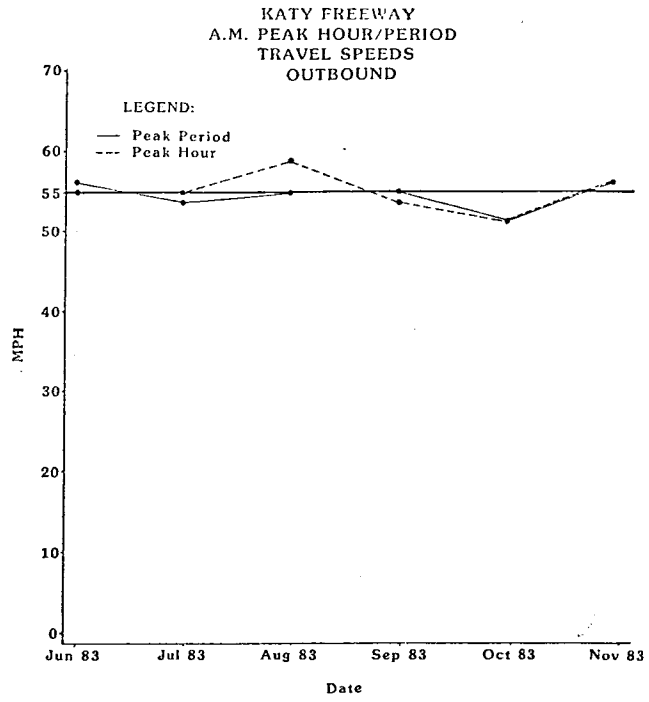
Figure 13: Katy Freeway Total Travel Times

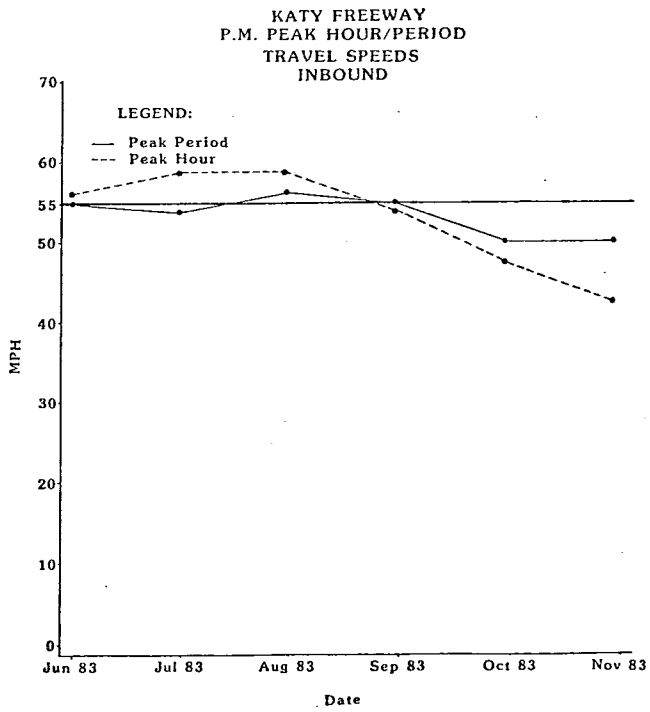
1982 times appear to be declining while the 1983 times appear to be increasing. There is also a great deal more variation in the morning times than in the afternoon times. Although the afternoon times varied only between 27 and 37 minutes, the morning times ranged from 24 to 42 minutes. The 1982 average peak direction travel time was 31.1 minutes in the morning and 31.7 minutes in the afternoon. The 1983 peak travel times averaged 30.7 minutes in the morning and 30.2 minutes in the afternoon. One characteristic that both peaks have in common is that they both climbed sharply for two to three months after extensive transitway construction began. After these few months, times dropped back to their previous levels. Drivers appear to have adjusted to the unfavorable driving conditions (e.g. reduced lane widths) within these few months.

As in the case with the Gulf Freeway, the speed plots in Figures 12 ('82-'83 peak hour) and 14 ('83 peak period/hour) reduce the magnitude of the monthly travel time changes. The off-peak direction travel speeds both hover around the 55 MPH mark although the last two months (October and November '83) have dropped to 50 MPH in the afternoon inbound direction. The morning peak direction speeds averaged 27 MPH in 1982 and 25 MPH in 1983. The afternoon peak direction speeds averaged 26 MPH in 1982 and 27 MPH in 1983. These speeds are less than half the legal speed limit.

The average peak period, peak direction speed versus cross street plots in Figure 15 indicate speeds below 30 MPH occurring between Kirkwood and Antoine in the morning and from West Loop to Wilcrest in the afternoon. This suggests that the Katy Freeway is operating in or close to a queue state for almost 60% of its length in both peak directions. The off-peak direction plots do not indicate any major problems. The peak hour sectional travel speeds plotted in Figure 16 show queueing from Antoine to Wilcrest in the







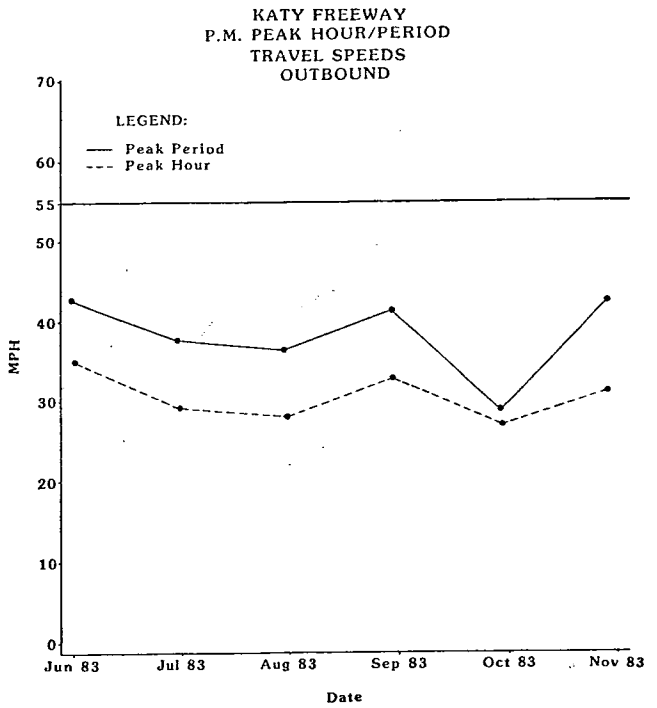
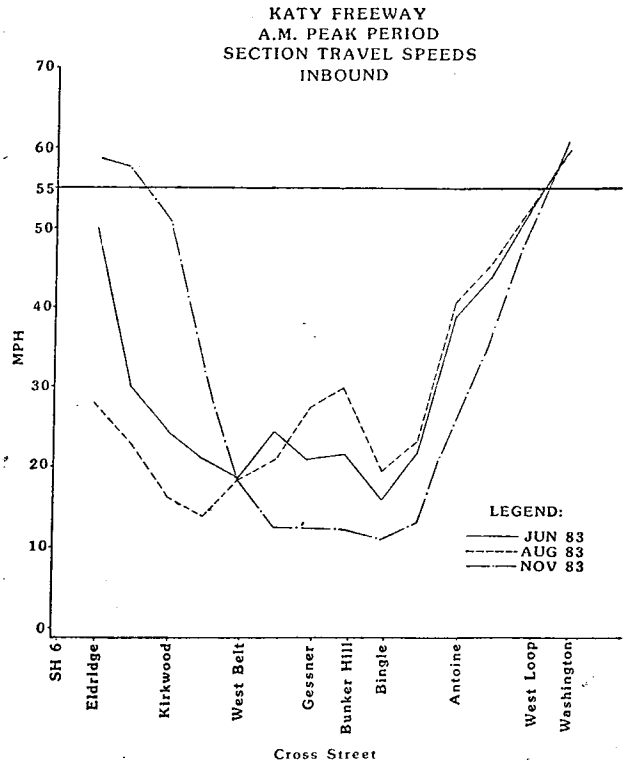
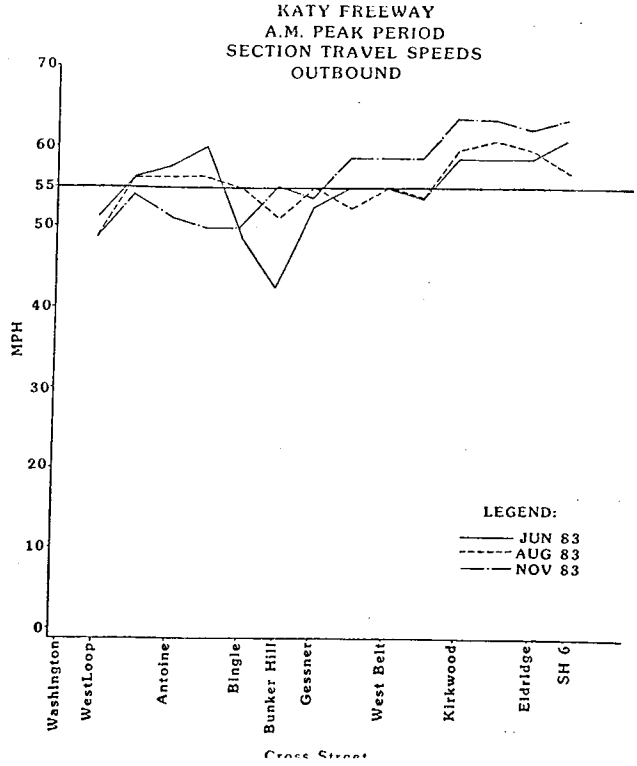
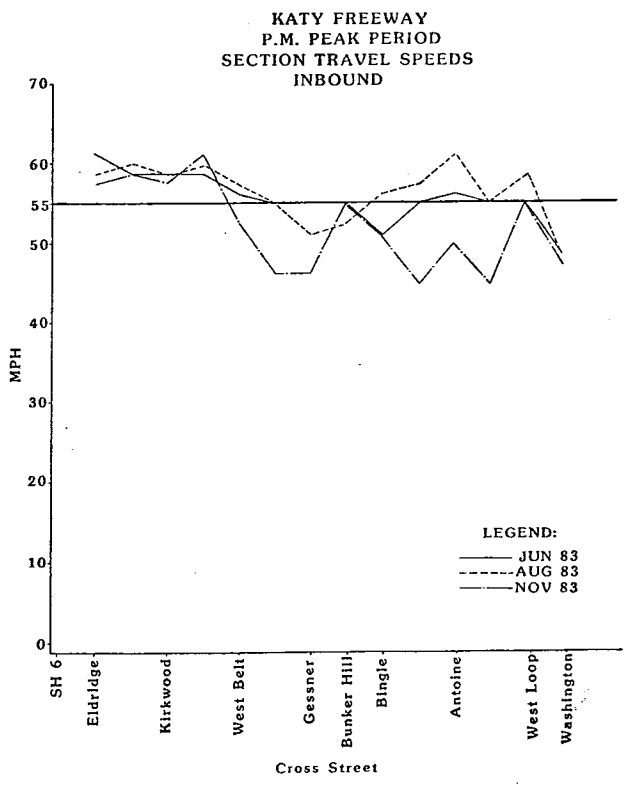


Figure 14: Katy Freeway Overall Travel Speeds







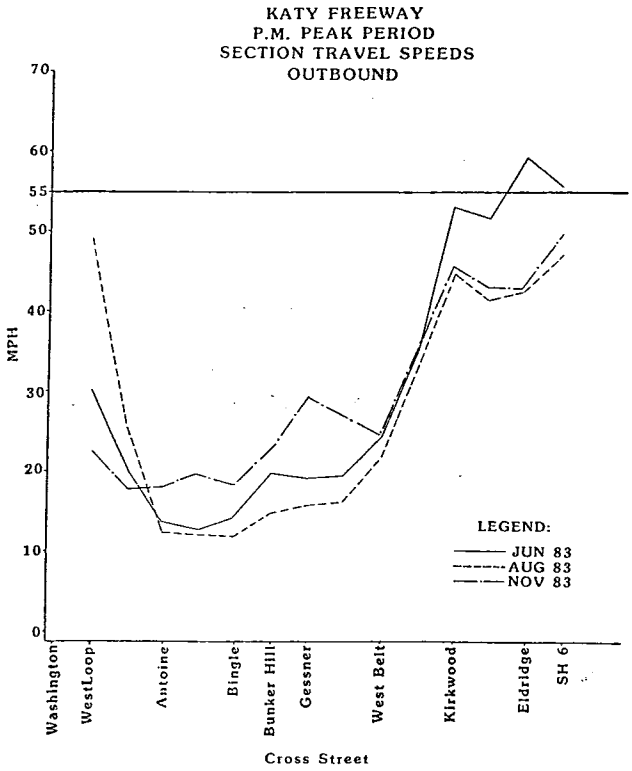
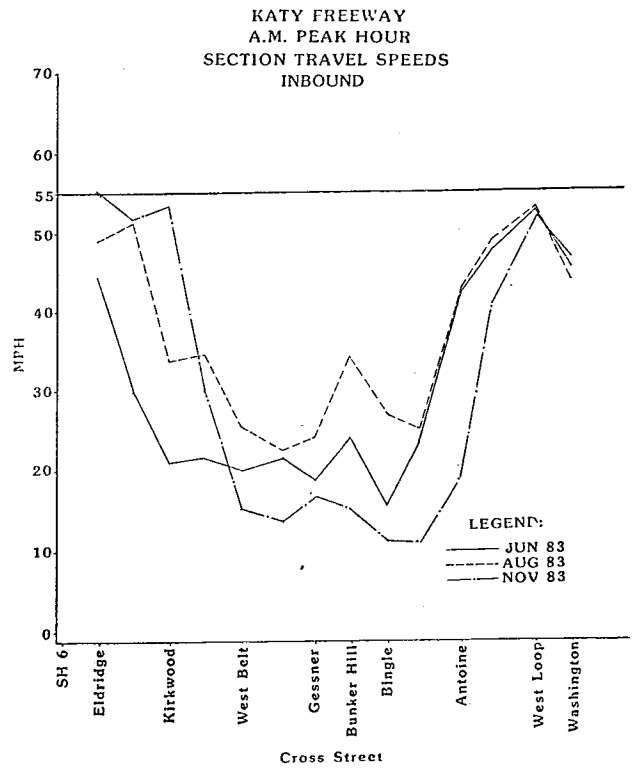
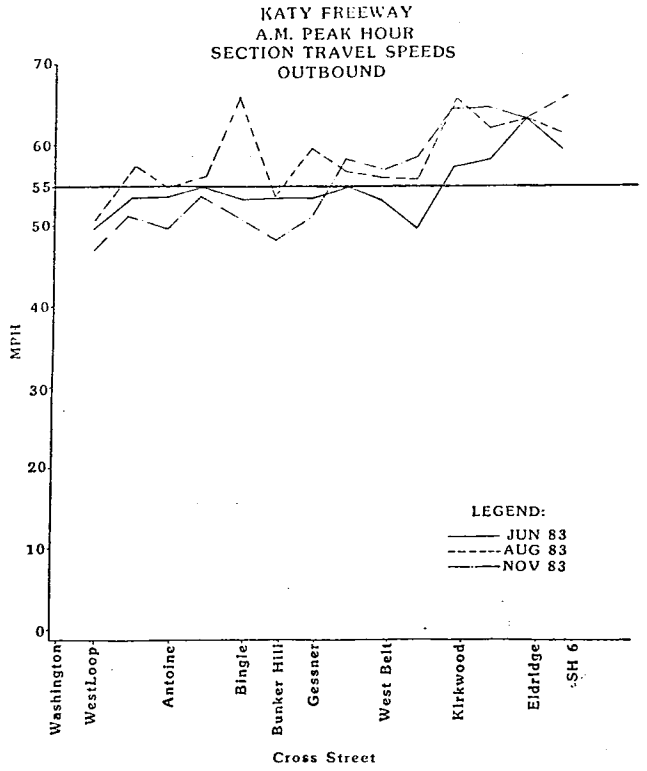
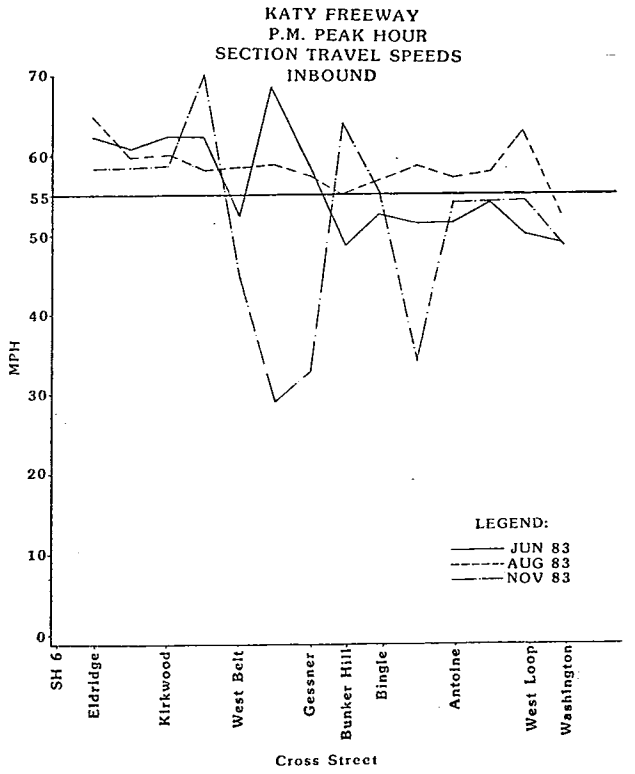


Figure 15: Katy Freeway Peak Period Section Travel Speeds







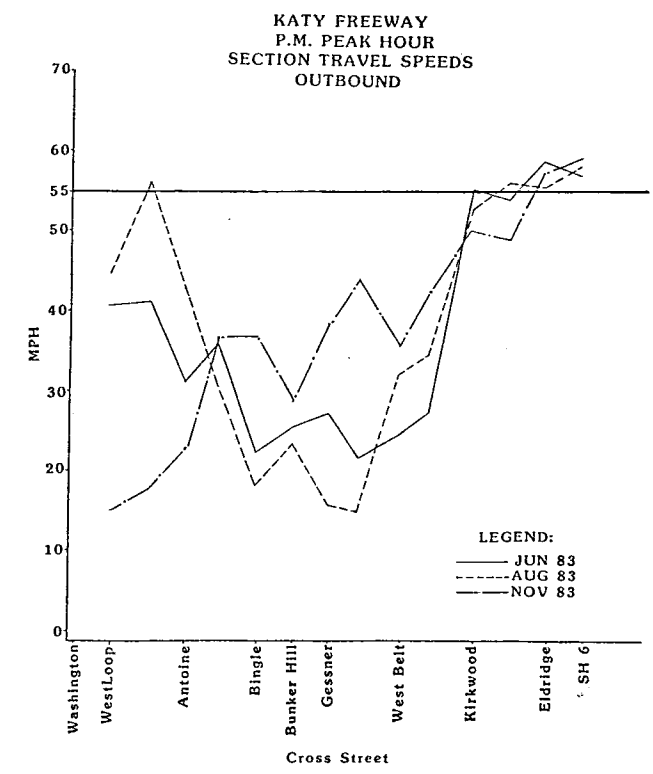


Figure 16: Katy Freeway Peak Hour Section Travel Speeds

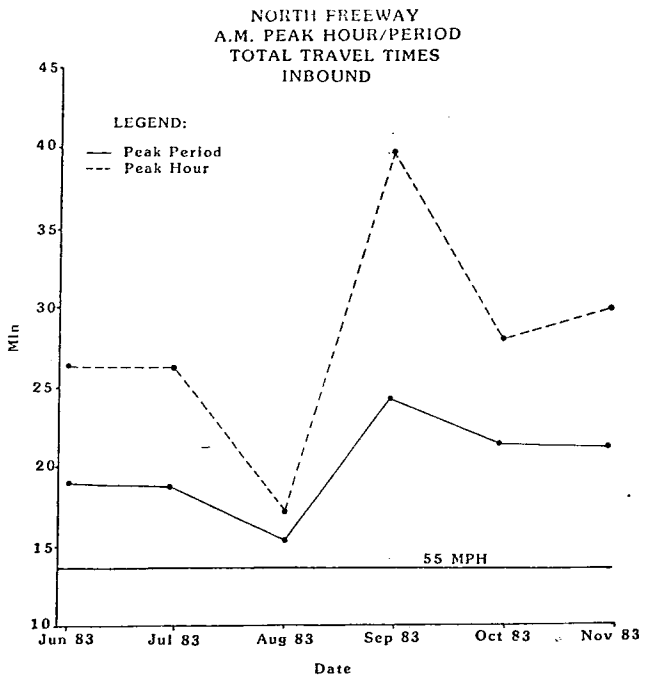
morning inbound direction and from Kirkwood to Antoine in the afternoon outbound direction. The peak hour, off-peak directions have been fairly stable except in November when the afternoon inbound developed some problems at Gessner and Wirt and showed a general degradation of speeds throughout the transitway construction areas.

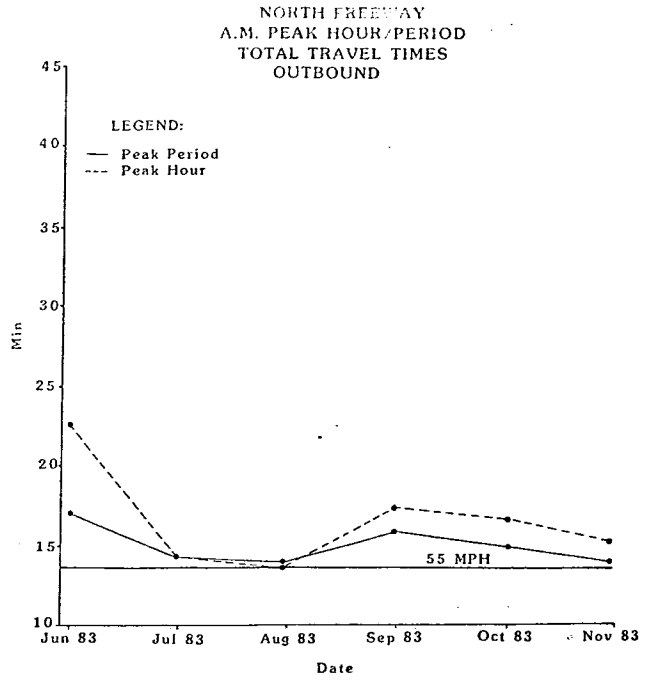
North Freeway

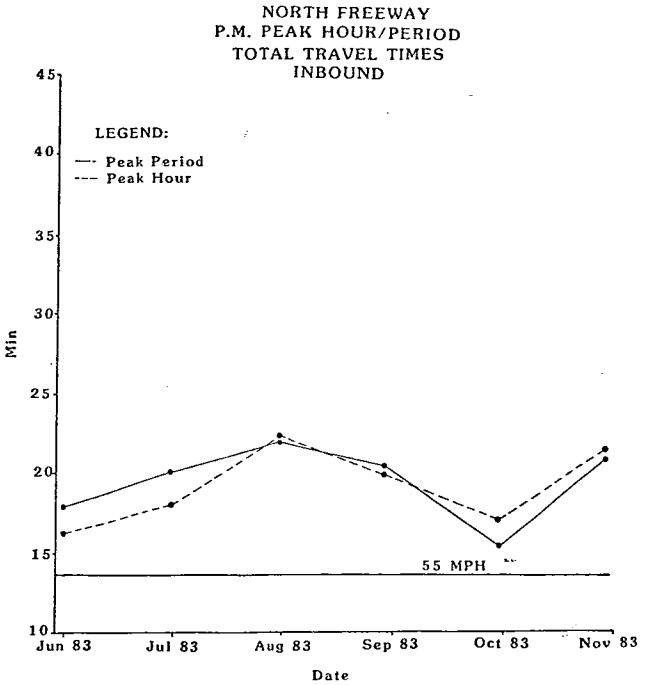
The North Freeway study length is 12.20 miles with a free flow 55 MPH travel time of 13.3 minutes. The six months of travel time data plotted in Figure 17 exhibits a scatter from 15 to 25 minutes with an average of 20.1 minutes in the morning inbound direction. This average time translates to almost 7 minutes of delay incurred by the average peak direction morning non-contraflow driver. The morning inbound direction travel times are increasing at a rate of 0.5 minutes per month. The afternoon outbound direction main lane travel times with an average of 19.5 minutes have also shown a scatter of data points similar to the morning peak data. A rough trend estimate would indicate that times could be increasing at a rate of close to 1.0 minute per month. However, this estimate, like the peak morning estimate, is not reliable given the small data base.

In Figure 18, the 6 month average speed for the morning inbound traffic is 42 MPH. The afternoon 6 month average outbound corridor speed is 33 MPH, 22 MPH less than the legal speed limit. There could be decreasing trends in both the morning and the afternoon speeds, but as with the time data, these tendencies are not clear.

The average peak period speed versus cross street plots in Figure 19 for the North Freeway show the slowest speeds occurring from West Road to North Shepherd in the morning inbound direction, and from Airline to West Road in the afternoon outbound direction. The peak hour sectional travel speed plots







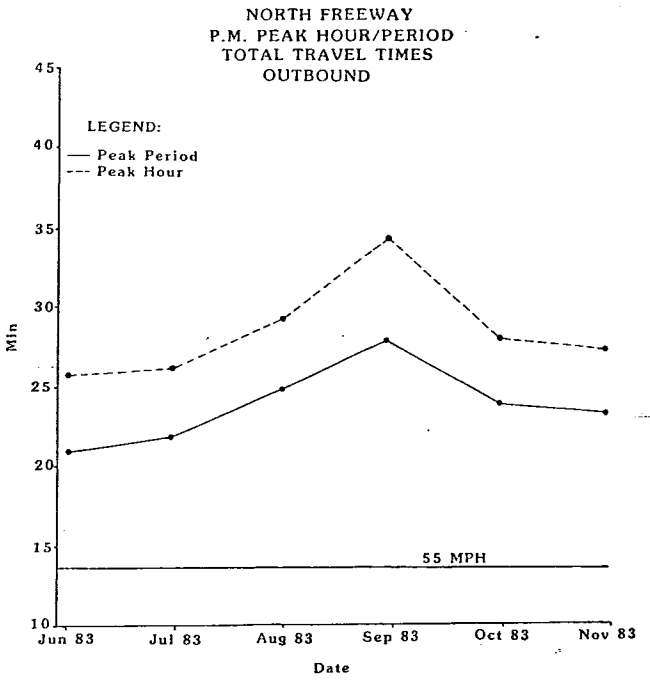
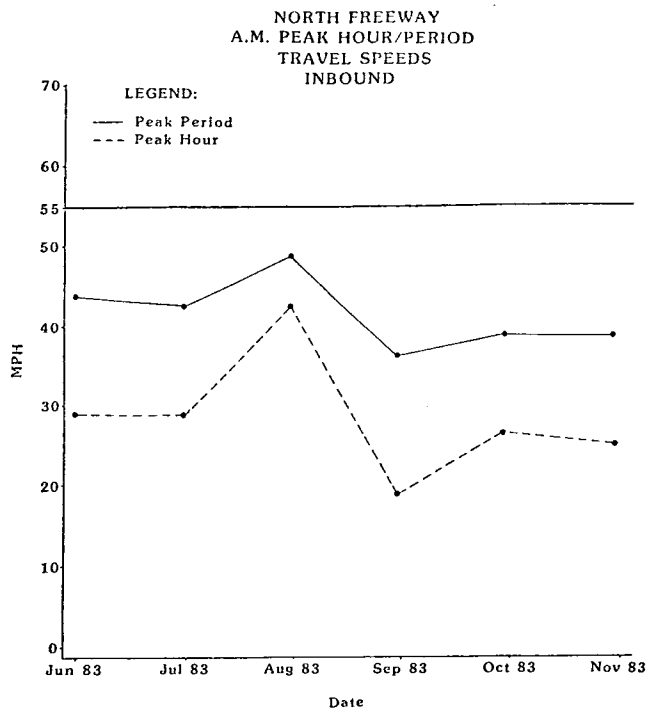
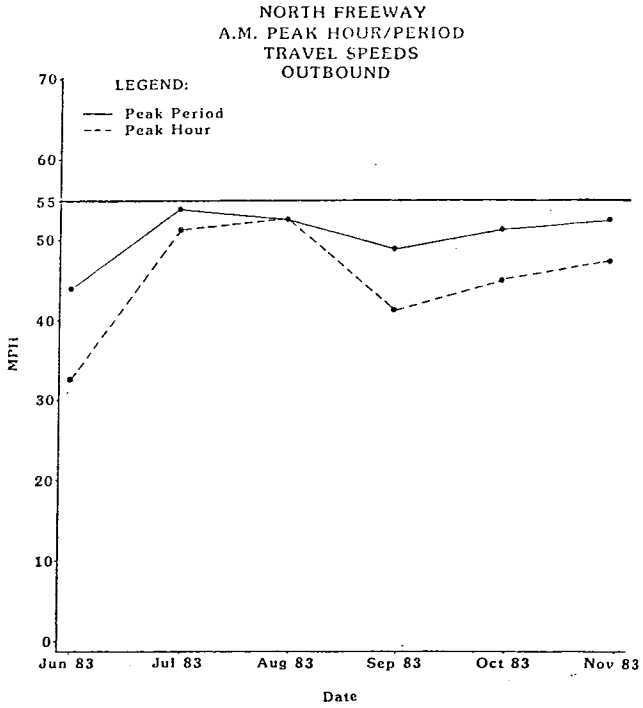
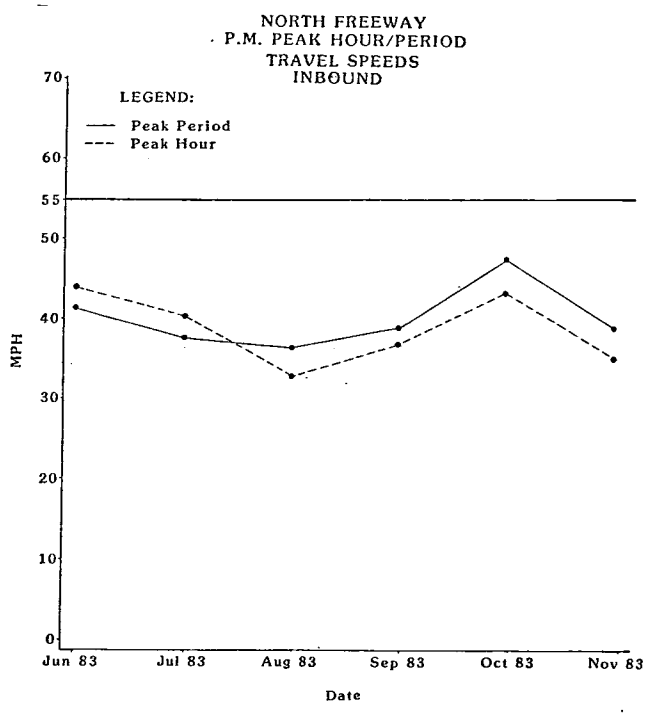


Figure 17: North Freeway Total Travel Times







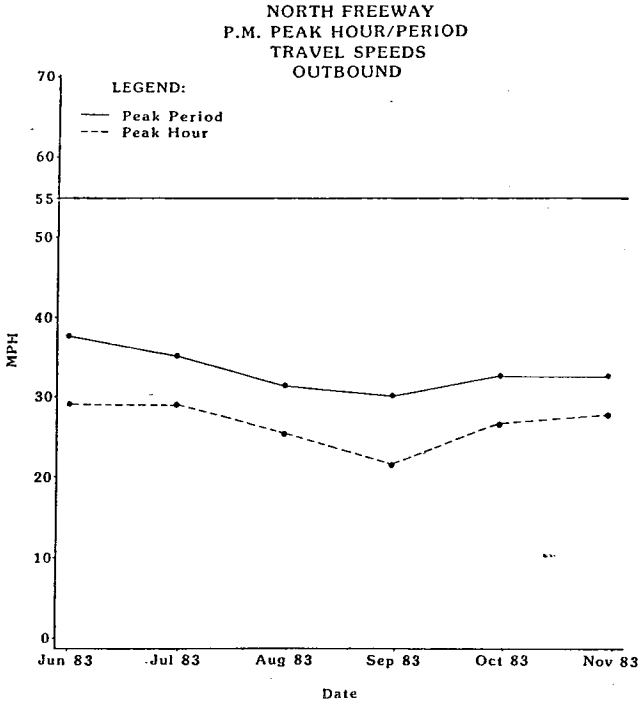


Figure 18: North Freeway Overall Travel Speeds

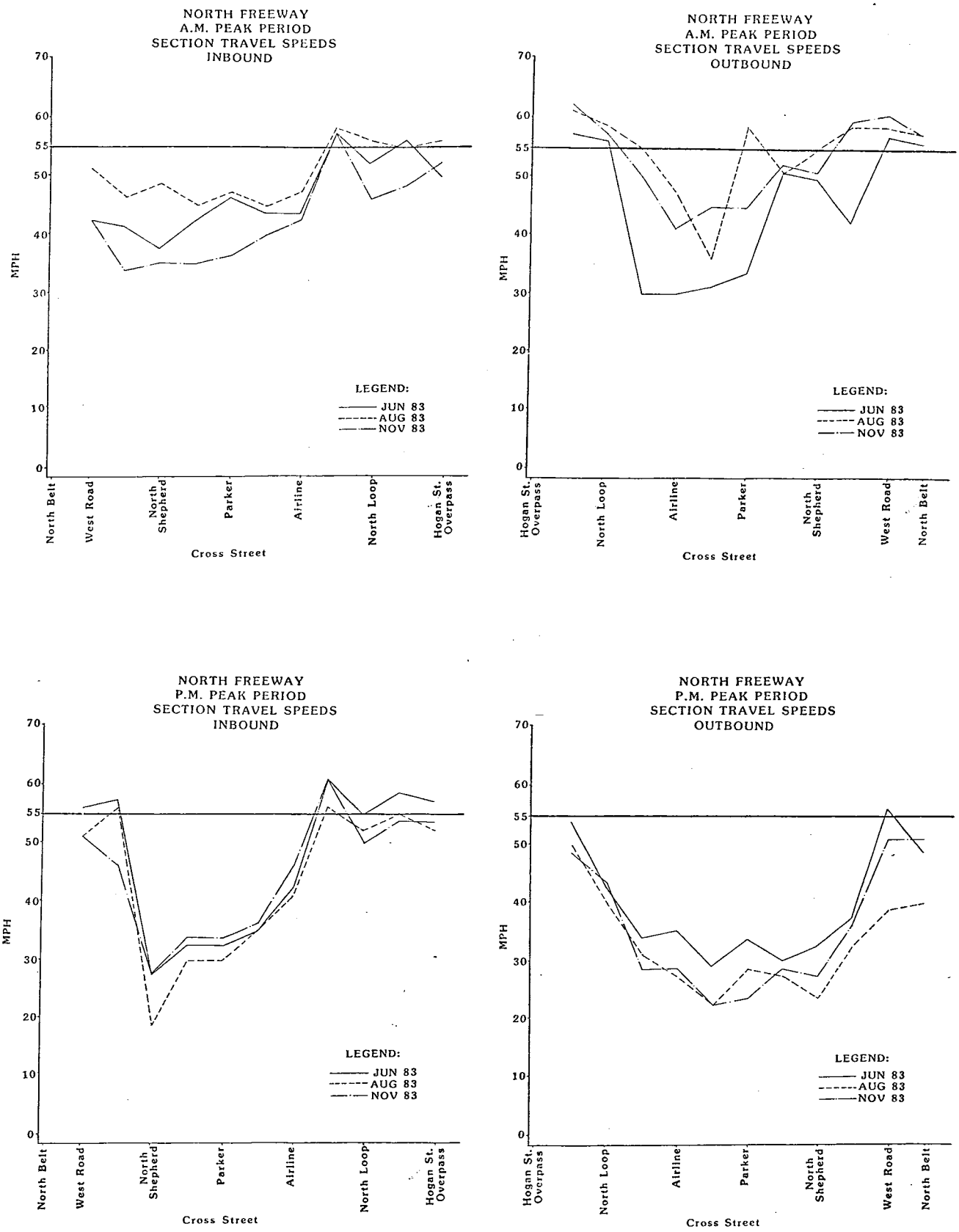


Figure 19: North Freeway Peak Period Section Travel Speeds

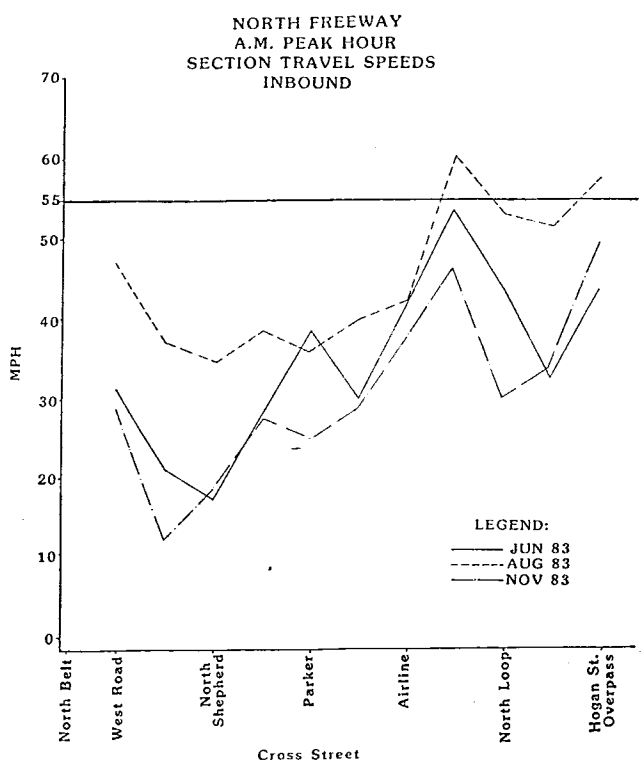
in Figure 20 show substantial slowdowns extending from West Road to Airline in the morning inbound direction and from the North Loop to West Road in the afternoon outbound direction.

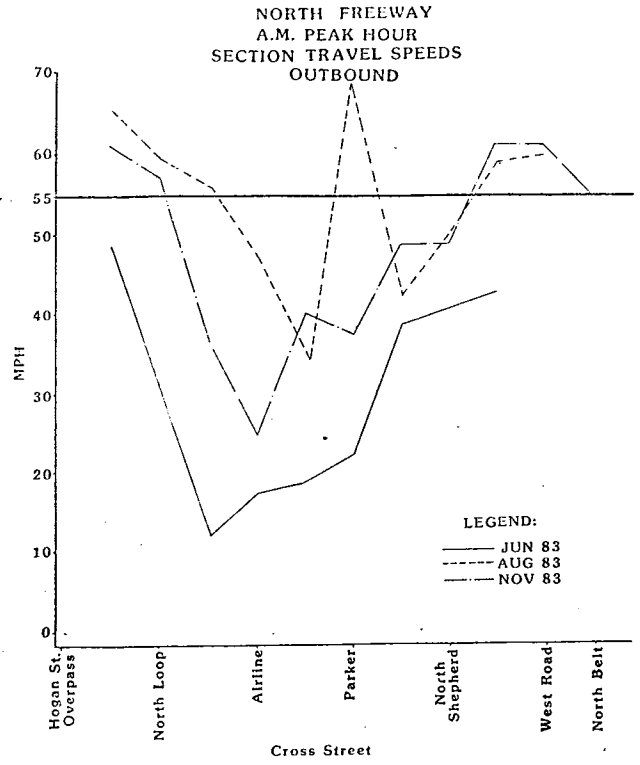
Contraflow Lane Transition

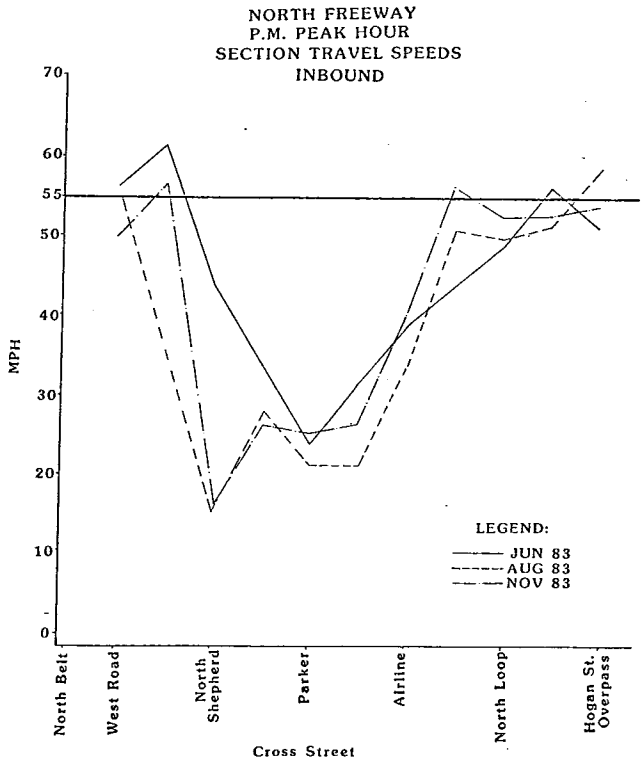
The upgrading of the North Freeway contraflow lane (CFL) to a transitway is being monitored for its impact on the off-peak direction travel times and speeds. The off-peak direction traffic on the North Freeway has had to cope with one less lane than was originally allocated to it. Since August 1979, the North Freeway has had a CFL operating during both the morning and afternoon peak periods. Resulting from this reduction in roadway capacity and the continued growth of travel demand in the off-peak directions, the morning and afternoon off-peak direction travel times and speeds for the North Freeway in Figures 17 and 18 have exhibited strong signs of deteriorating service levels.

The morning outbound travel times have risen above the free flow mark in every survey month. The average time from June to November 1983 was 14.8 minutes, almost two minutes more than the free flow time of 13.3 minutes. Aside from the average delay of 2 minutes, the morning outbound data does not yet suggest any appreciable deterioration in level of service. The 6 month average for the afternoon inbound is 19.5 minutes (a delay of more than 6 minutes) with a trend towards increased travel times. Such a trend confirms that the contraflow operation cannot continue to take a lane from the off-peak direction traffic indefinitely without continued degradation of service.

The morning outbound lanes are operating relatively smoothly with an average speed of 51 MPH. The afternoon inbound lanes have not coped with the loss of capacity as well as the morning outbound lanes. With conditions worse than the morning inbound lanes, the afternoon inbound lanes have a 6







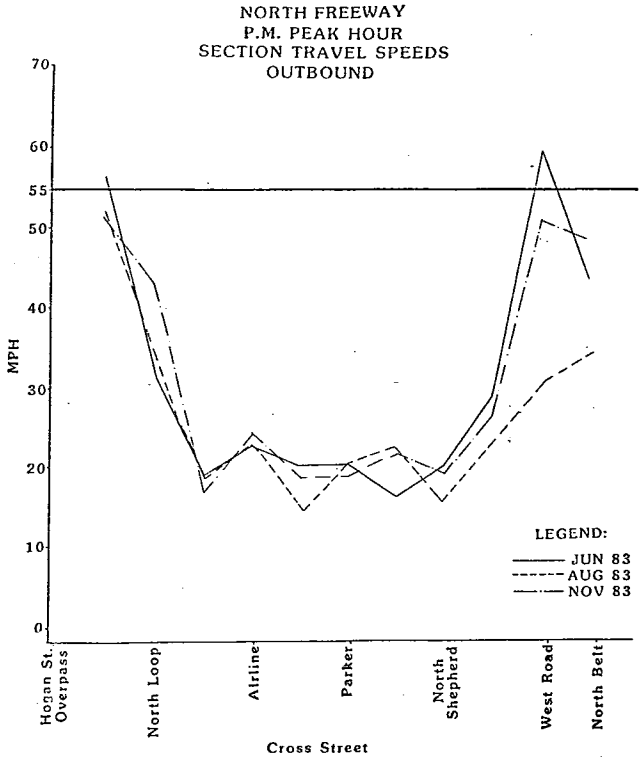


Figure 20: North Freeway Peak Hour Section Travel Speeds

month average speed of 40 MPH. This is more than 15 MPH less than the speed limit, and this gap is still increasing. In particular, as indicated in Figure 19, average speeds close to and below 30 MPH are occurring from the North Loop to Parker in the morning outbound lanes and from North Shepherd to Parker in the afternoon inbound lanes. The peak hour off-peak direction plots in Figure 20 show substantial speed reductions occurring between the North Loop and Parker in the morning outbound direction and between West Road and Airline in the afternoon inbound direction. Even a cursory examination of the off-peak direction travel times and speeds strongly indicates that upgrading the North Freeway CFL to a transitway is highly desirable.

Vehicle and Person Volumes

Unlike the Park-and-Ride and the Travel Time Surveys, the Volume Survey is being conducted on a quarterly basis. The preliminary look at the volumes occurred in June 1983. Since then, quarterly sampling, beginning in August 1983, has been initiated. The following analysis consists of three parts for each freeway and each peak period: (1) an analysis of the vehicle and person volumes, (2) án analysis of HOV contributions to overall vehicle and person volumes, and (3) an analysis of the resulting occupancy levels. Since only 3 months of data have been collected to date, plots of the volume data will be of either value, and therfore, are not presented in this report.

Gulf Freeway

Peak period vehicle volume has oscillated noticeably in the 3 months of data collected on the Gulf Freeway. In the morning peak period (6:30-9:30 a.m.), vehicle volume dipped as low as 11,400 and climbed as high as 12,800

vehicles. The person volume has not varied as erratically. It has increased steadily from 14,700 persons in June to 16,400 persons in November. These increases are traceable to monthly increases in HOV traffic. The HOV contribution to vehicle volume reached its highest level of 0.9% in November while contributing to 7.9% of the person volume in the same month. Not unexpectedly, within the HOV category, vanpools contributed more to vehicle volume and buses contributed more to person volume. Throughout this study, the overall occupancy rate in the morning peak period has hovered about 1.3 persons per vehicle. No strong trends can be discerned at this early stage of the study.

The afternoon peak period (4:00-7:00 p.m.) traffic characteristics are similar to the morning characteristics. Vehicle volume displays an even more pronounced pattern of change than the morning data exhibited. Vehicle volume has dropped as low as 9,500 vehicle in August and has jumped as high as 16,000 vehicles in November. Afternoon peak period person volume closely mimics the behavior of the vehicle volume. It varied from 13,300 to 21,400 persons, a difference of close to 1,000 persons per hour per lane. These variations in volume were also evidenced in the HOV data, though perhaps not as strongly. HOVs contributed as much as 0.9% to vehicle volumes in November. At the same time, they contributed to more than 8% of the person volume on the Gulf Freeway. Overall occupancies, have remained close to 1.4 persons per vehicle in the afternoon peak period. Statistics for the morning and afternoon peak hour (beginning around 6:30-7:00 in the morning and 4:30-5:00 in the afternoon) approximate the peak period statistics with slightly higher HOV statistics.

Katy Freeway

Morning peak period vehicle volume has declined on the Katy Freeway since June, 1983. Between June and August, morning peak period vehicle volume dropped from 11,600 to 10,900 vehicles. In November the decline continued although at a much slower rate. This decline could be related to the lengthy transitway construction occurring on the Katy Freeway which has required measures such as reducing lane widths and utilizing emergency shoulders for through traffic along various portions of the freeway. Despite the decreases in vehicle volume, person volume has essentially remained constant at about 13,800 persons. This relative lack of change in person volume despite a decline in vehicle volume may be attributed to the steady gains in HOV traffic and HOV average occupancy levels. The HOV contribution to vehicle volume has varied from 0.5% to 0.6%. However, the HOV contribution to person volume has steadily climbed from 5.4% in June, to 5.9% in August, and to 7.8% in November. In June, the overall occupancy level was close to 1.2 persons per vehicle, but in August and November the morning peak period occupancy rate rose to 1.3 persons per vehicle.

The morning peak hour shifted progressively later in the morning from 6:30 to 7:00 to 8:30. Within these peak hours the overall occupancy rates have been around 1.3 persons per vehicle, but the HOV contribution to vehicle and person volume has dropped sharply. The differences in peak hour and peak period HOV statistics suggest that HOV traffic possesses different characteristics from the overall traffic. In particular, the HOV traffic appears to be peaking earlier than the general traffic stream.

In the afternoon peak period, vehicle volume dropped sharply in August (from 12,400 to 11,400 vehicles) and then rose even more sharply in November

to 14,700 vehicles. Passenger volume followed the same pattern and dropped from 16,500 persons to 15,900, only to rise again to 19,400 persons. The HOV contribution to vehicle volume has risen steadily from 0.5% in June to 0.8% in November. The HOV contribution to person volume has also increased between June and November (from 5.8% to 7.3%), but in August it reached its highest of 8.8%. The high HOV contribution to person volume in August was primarily the result of an unusually high bus occupancy rate in that month. The overall occupancy rate has varied from 1.3 to 1.4 persons per vehicle in the three study months.

North Freeway

The data obtained on the North Freeway includes the buses and vanpools in the contraflow lane (CFL) which operates between 6:00-8:30 a.m. and 4:00-6:30 p.m. on the North Freeway. Most of the HOV volume on the North Freeway is found in the CFL. In fact, less than 10% of all the HOV volume may be found in the unrestricted lanes on the North Freeway.

Morning peak period vehicle volume started at 11,300 vehicles in June, dropped to 11,000 vehicles in August, and climbed to 13,500 vehicles in November. At the same time, person volume began at 17,500 in June, dropped to 10,600, and then rose again to 18,300 in November. Because the total vehicle volume has increased while the HOV volumes and occupancies remained more or less constant, the HOV contribution to both vehicle and person volume has dropped from 2.6% to 2.0% of vehicle volume and from 24.0% to 15.9% of person volume. The overall vehicle occupancy rate declined from 1.6 to 1.4 persons per vehicle with the HOV occupancy rate staying close to 15 persons per vehicle in the morning peak period.

Afternoon peak period vehicle volume exhibited the same pattern of fluctuations found in the Gulf and Katy vehicle volumes. Starting at 13,100 vehicles in June, it dropped to 10,700 vehicles in August and then rose again to 13,900 vehicles in November. The person volume followed the same pattern with a valley of 18,200 persons and a peak of 21,700 persons. Contributing to only 3% of the vehicle volume, HOV's comprized 14% and 21% of the person volume on the North Freeway. Overall occupancy levels have varied from 1.5 to 1.7 persons per vehicle in the afternoon peak period with the HOV average occupancy hovering around 10 persons per vehicle in the afternoon peak period. Discrepancies between morning and evening occupancy rates may be attributed to the subjective nature of the surveying techniques with regards to vehicle occupancy rates.

Contraflow Volumes

The Houston contraflow lane (CFL) operates from 6:00 to 8:30 in the morning and from 4:00 to 6:30 in the afternoon. Since these time periods do not exactly coincide with the Texas Transportation Institute (TTI) count times, it has been necessary to obtain CFL volumes and occupancy levels from the Houston Metropolitan Transit Authority (6). The vehicle volumes and classifications (i.e. van or bus) were obtained by matching up output from mechanical vehicle count devices and actual bus schedules. The occupancy levels were derived from actual head counts by the bus operators and by quarterly spot checks of vanpool occupancies. In the instances where Metro has had only daily figures, these volumes were halved based upon the assumption that morning and afternoon HOV volumes tend to be very similar. People going downtown by bus or vanpool in the morning usually return by the same mode in the afternoon.

CFL total vehicle volumes have remained fairly constant through June, August and November. Never exceeding 500 vehicles in the peak period, the CFL carried between 7600 and 8100 persons per peak period. These volumes are based upon CFL operating periods (6:00-8:30 a.m. and 4:00-6:30 p.m.). Despite the decline in vehicle volumes in August, the person movement has continued to grow in all three months. Overall occupancy levels have stayed close to 16 and 17 persons per vehicle. Bus occupancies appear to be dropping slightly from 37 to 34 persons per bus while vanpool occupancy has increased from 8.7 to 9.0 persons per vanpool. Although growth in CFL volumes have been stable for some time, continued increase is anticipated with further economic recovery.

SUMMARY

Projection of Findings

The project, to date, as presented in this preliminary report, encompasses the establishment of a study design and data collection methodology. Primarily, only "before" operational data has been actually obtained in the Gulf and North Freeway Corridors, and "during construction" information collected in the Katy Freeway Corridor. No comparative analyses may be made at this time. However, estimated projections of the operational effects of the implementation of a transitway within one of the study corridors is possible.

Use by High Occupancy Vehicles (HOVs) and corresponding passenger throughput in HOV vehicles is expected to increase to 400 vehicles and 6,500 passengers. Likewise, percentage of total freeway passenger demand served by HOVs will increase from about 5% to 35%. It is not known whether the extent of modal shift to the transitway from the freeway main lanes will be significant enough to dramatically enhance freeway operations since this may be negated by growth, latent demand, and diversion of traffic. However, this effect, if present will be noted.

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