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16. Abstract The operation of the Katy Freeway Transitway in the second year was evaluated. This second year of the transitway operation was characterized by a nine-month period when only authorized vehicles were allowed to use the transitway, followed by a 3-month period when the authorization was lifted, and vehicles with 2 or more persons were allowed on the transitway. The introduction of 2+ carpools resulted in the number of vehicles and persons using the transitway to increase to about 4,300 vehicles and nearly 14,000 persons per day, respectively. Despite the many-fold increase in the number of vehicles on the transitway after 2+ carpools were introduced, the time savings for the transitway traffic relative to the traffic on the parallel freeway mainlanes remained substantial. The benefit in terms of time savings accrued to the transitway users during the second year of transitway operation was estimated to be 670 person-hours of time saved per day ... an approximate 7 percent increase in the number of person-hour savings per day relative to the first year of transitway operation. During the second year of transitway operation, two transitway-related accidents were reported. The accident rate on the Katy Transitway for the second year of operation was calculated to be 0.96 accidents per million vehicle miles (MVM). The number of disabled vehicles on the transitway increased substantially from about 5 to about 23 vehicles per month. The number of vehicles not eligible but were reported to use the transitway more than doubled. The amount of vehicle traffic on the freeway mainlanes in the morning and the afternoon periods during the second year of transitway operation increased by about 6 percent relative to the level in the year prior to the (CONTINUED ON BACK OF PAGE)					
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opening of the transitway. Total traffic volumes for the combined Katy Freeway (mainlanes plus transitway) for the morning and afternoon peak periods were shown to have increased similarly during this second year of transitway operation.

The presence of the transitway lane in the freeway median was not shown to have resulted in a higher number of accidents on the freeway mainlanes in either the first or second year of operation. A calculated accident rate of 1.34 accidents per MVM for the second year of operation for the Katy Freeway adjacent to the transitway is comparable to other Houston freeways.

**THE KATY FREEWAY TRANSITWAY:
EVALUATION OF THE SECOND YEAR OF OPERATION**

by

John M. Mounce
Research Engineer

T. Chira-Chavala
Engineering Research Associate

and

Stephen E. Ranft
Research Associate

Research Report 339-11

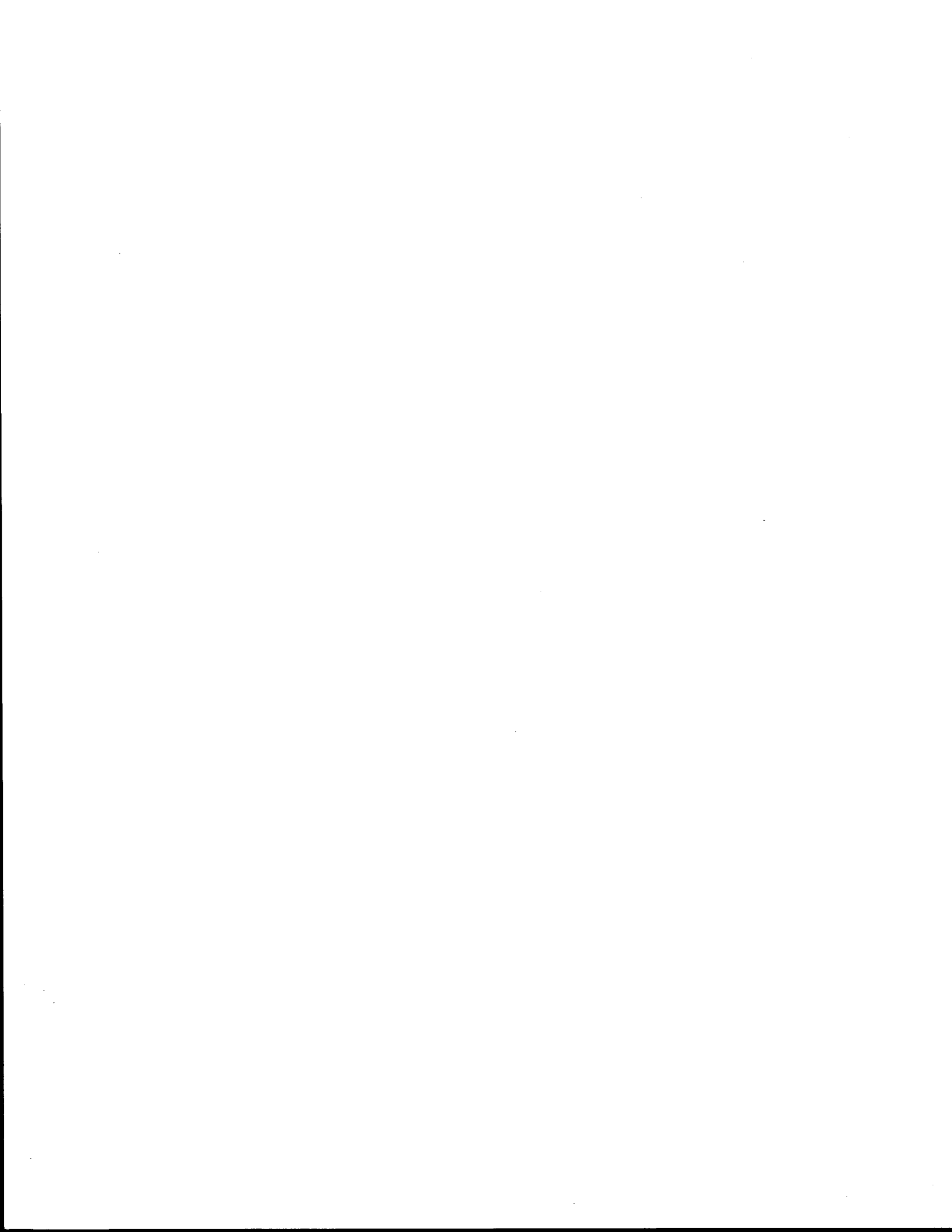
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of High Occupancy Vehicle Priority Treatments
Research Study Number 2-10-84-339

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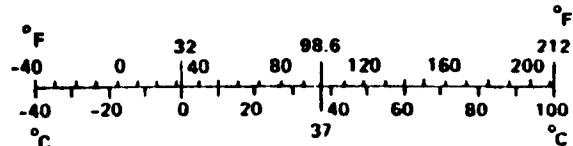
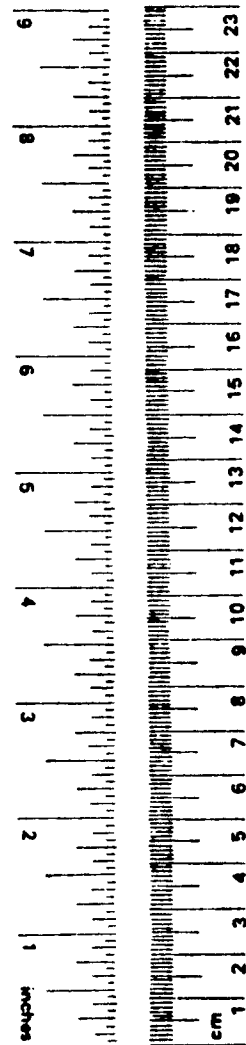
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

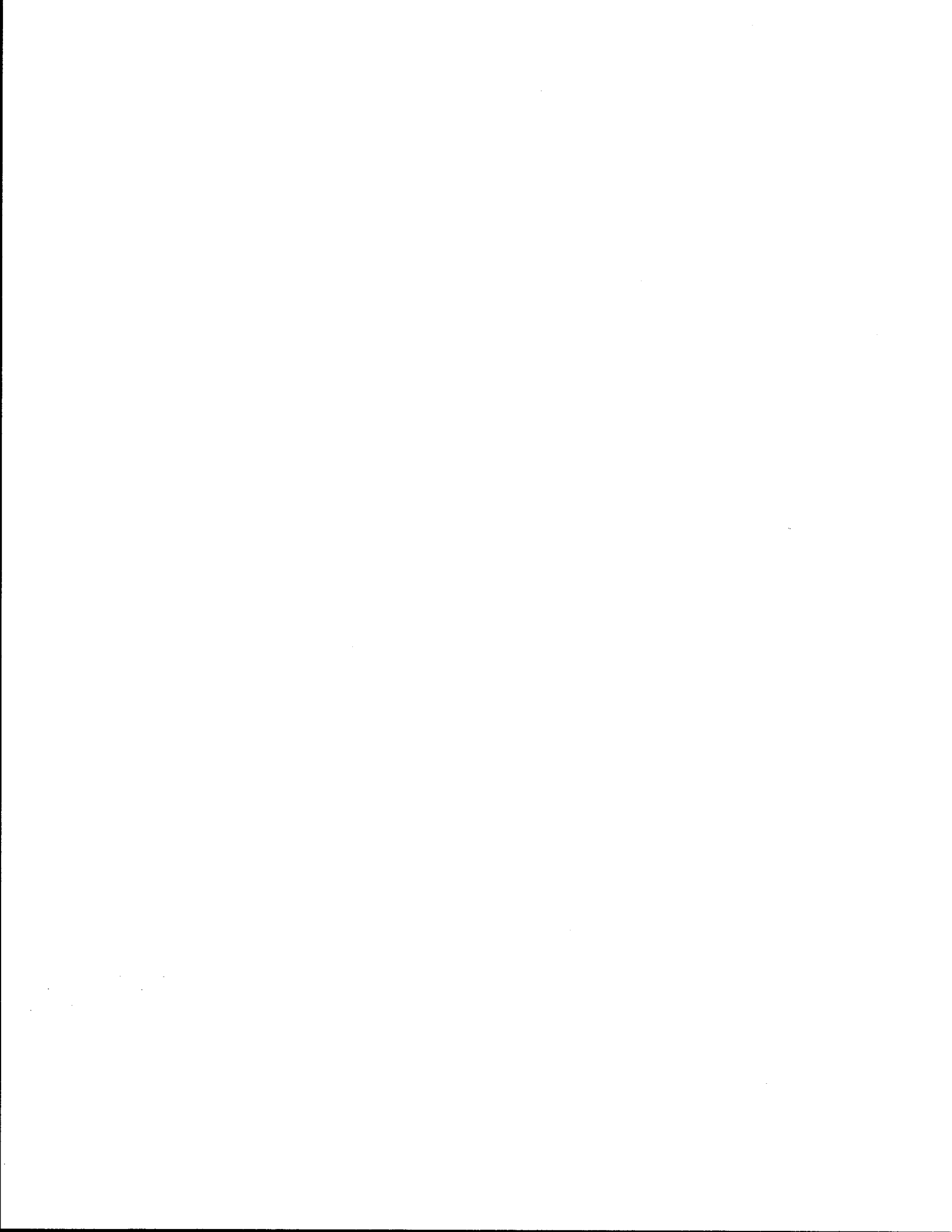
Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
AREA				
in ²	square inches	6.5	square centimeters	cm ²
ft ²	square feet	0.09	square meters	m ²
yd ²	square yards	0.8	square meters	m ²
mi 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

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)				
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



* 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.

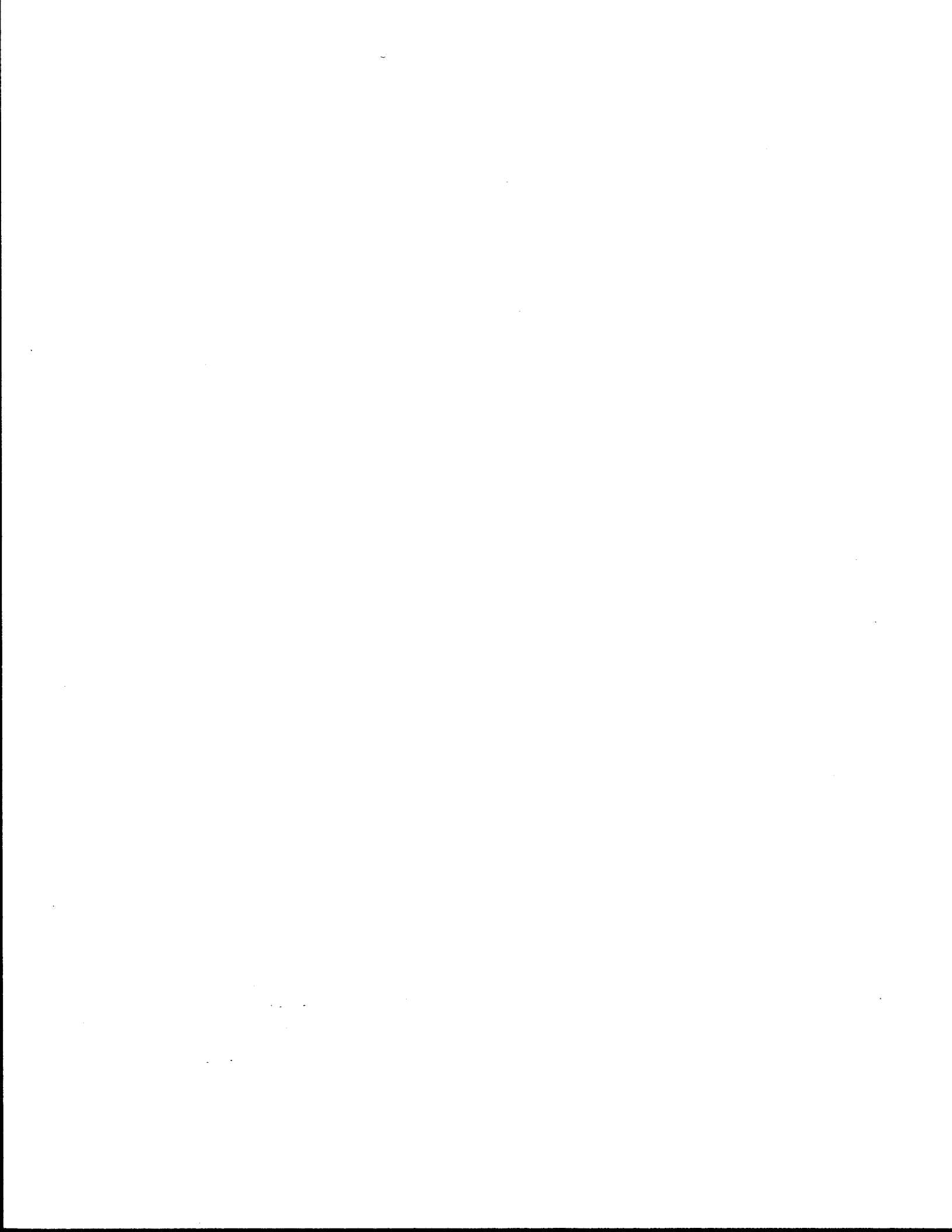


IMPLEMENTATION STATEMENT

This study was sponsored by the Texas State Department of Highways and Public Transportation as part of an overall effort entitled "Improving Urban Mobility Through Application of High Occupancy Vehicle Priority Treatments" - Research Study Number 2-10-84-339. An objective of this research is to evaluate for the Department the implementation of high occupancy vehicle priority treatment projects. An intent of these evaluations is to develop guidelines for planning, designing, and operating transitways on Texas freeways. This is the second evaluation report on the Katy Transitway.

DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the opinions, findings, and conclusions presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration or the Texas State Department of Highways and Public Transportation.



ABSTRACT

The operation of the Katy Freeway Transitway in the second year was evaluated. This ~~second year of the transitway~~ operation was characterized by a nine-month period when only authorized vehicles were allowed to use the transitway, followed by a 3-month period when the authorization was lifted, and vehicles with 2 or more persons were allowed on the transitway. The introduction of 2+ carpools resulted in the number of vehicles and persons using the transitway to increase to about 4,300 vehicles and nearly 14,000 persons per day, respectively.

Despite the many-fold increase in the number of vehicles on the transitway after 2+ carpools were introduced, the time savings for the transitway traffic relative to the traffic on the parallel freeway mainlanes remained substantial. The benefit in terms of time savings accrued to the transitway users during the second year of transitway operation was estimated to be 670 person-hours of time saved per day ... an approximate 7 percent increase in the number of person-hour savings per day relative to the first year of transitway operation.

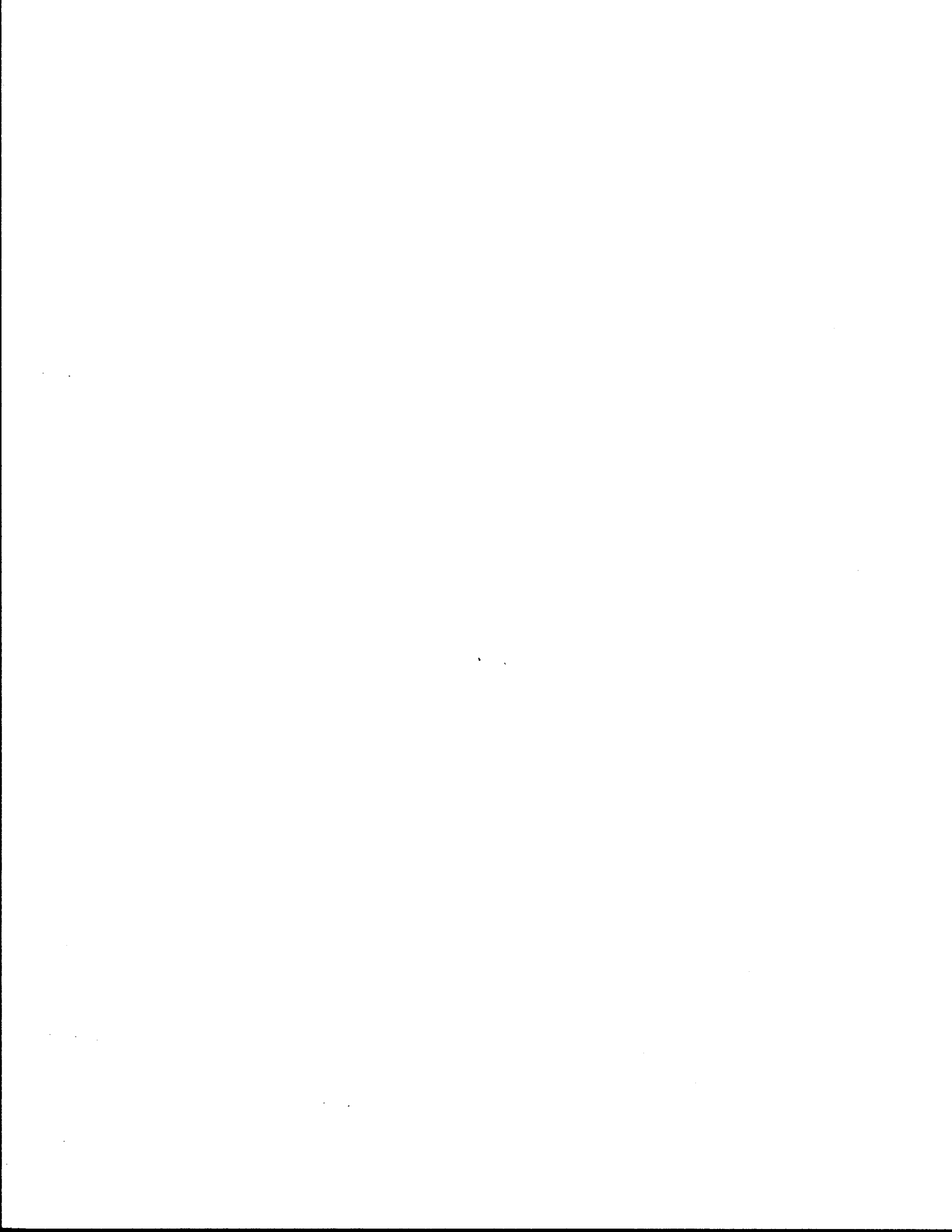
During the second year of transitway operation, two transitway-related accidents were reported. The accident rate on the Katy Transitway for the second year of operation was calculated to be 0.96 accidents per million vehicle miles (MVM). The number of disabled vehicles on the transitway increased substantially from about 5 to about 23 vehicles per month. The number of vehicles not eligible but were reported to use the transitway more than doubled.

The amount of vehicle traffic on the freeway mainlanes in the morning and the afternoon periods during the second year of transitway operation increased by about 6 percent relative to the level in the year prior to the opening of the transitway. Total traffic volumes for the combined Katy Freeway (mainlanes plus transitway) for the morning and afternoon peak periods were shown to have increased similarly during this second year of transitway operation.

The presence of the transitway lane in the freeway median was not shown to have resulted in a higher number of accidents on the freeway mainlanes in either the first or second year of operation. A calculated accident rate of 1.34 accidents per MVM for the second year of operation for the Katy Freeway adjacent to the transitway is comparable to other Houston freeways.

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SUMMARY

The operation of the Katy Freeway Transitway in the second year (from November 1985 to October 1986) was evaluated. This second year of the transitway operation was characterized by a nine-month period (November 1985 to August 10, 1986) when only authorized vehicles were allowed to use the transitway (i.e. buses, authorized vanpools and 3+ carpools), followed by a 3-month period (August 11, 1986 to October 31, 1986) when the authorization was lifted, and vehicles with 2 or more persons were allowed on the transitway. The introduction of 2+ carpools and alleviation of the authorization process resulted in the number of vehicles and persons using the transitway to increase to about 4,300 vehicles and nearly 14,000 persons per day, respectively. Peak-hour demand on the transitway was represented by approximately 1100 vehicles and 3600 passengers.

Despite the many-fold increase in the number of vehicles on the transitway the time savings for the transitway traffic relative to the traffic on the parallel freeway mainlanes remained substantial. In the morning peak hour (7:15 to 8:15 a.m.), the transitway traffic saved as much as 11 minutes for the eastbound journey. In the afternoon peak hour (4:30 to 5:30 p.m.), the transitway traffic saved as much as 5 minutes for the westbound journey.

The benefit in terms of time savings accrued to the transitway users during the second year of transitway operation was estimated to be about 1.35 million dollars per year, and about 670 person-hours of time saved per day. This represented an approximate 7 percent increase in the number of person-hour savings per day relative to the first year of transitway operation.

Since the introduction of 2+ carpools, and dropping of the authorization requirement the number of disabled vehicles on the transitway increased substantially from about 5 to about 23 vehicles per month. The number of vehicles not eligible but were reported to use the transitway more than doubled in the months following the introduction of 2+ carpools. About 50 percent of these vehicles were given citations for traffic violations.

During the second year of transitway operation, two transitway-related accidents were reported. Both accidents involved 2+ carpools -- one involved a 2+ carpool losing control in the rain while traveling on the transitway, and the other accident involved two 2+ carpools attempting to enter the transitway at the West Belt entrance at the same time. The accident rate on the Katy Transitway for the second year of operation was calculated to be 0.96 accidents per million vehicle miles (MVM).

The influence of the transitway on the traffic in the freeway mainlanes was shown to be small. After 2+ carpools were allowed on the transitway, vehicle occupancy rate on the mainlanes was observed to be 1.10 persons per vehicle. When 3+ carpool authorization was in effect, the occupancy rate on the mainlanes was 1.16 persons per vehicle. During the first year of transitway operation, this rate was 1.19 persons per vehicle. Before the transitway, this rate had been 1.28 persons per vehicle.

The amount of vehicle traffic on the freeway mainlanes in the morning and the afternoon periods during the second year of transitway operation increased by about 6 percent relative to the level in the year prior to the opening of the transitway; it was similar to the traffic level during the first year of transitway operation.

The presence of the transitway lane in the freeway median was not shown to have resulted in a higher number of accidents on the freeway mainlanes in either the first or second year of operation. A calculated accident rate of 1.34 accidents per MVM for the second year of operation for the Katy Freeway adjacent to the transitway is comparable to other Houston freeways.

For the combined Katy Freeway (mainlanes plus transitway), total traffic volumes for the 3-hour morning and the 3-hour afternoon periods were shown to have increased during the second year of transitway operation. Relative to the first year of transitway operation, total vehicle traffic in the second year increased by about 5 percent, while total person trips increased by 7 percent. The total daily average vehicle occupancy rate for the corridor was observed to be 1.39 persons per vehicle after the introduction of 2+ carpools. This was an increase from the 1.37 persons-per-vehicle level since 4+ carpools were first authorized, and an increase from the 1.28 persons-per-vehicle level prior to the opening of the transitway.

INTRODUCTION

The Katy Freeway (I-10W) is a major interstate highway serving travel demands in the western part of Houston and Harris County (Figure 1) extending as far west as 35 miles from downtown Houston. The Katy Freeway is primarily a six-lane freeway with an eight-lane section near I-610 (Figure 1). In 1986 the Katy Freeway carried average daily traffic (ADT) near 190,000 vehicles per day.

The need for an exclusive transitway on the Katy Freeway was justified because there had been no other major facilities proposed in this corridor at that time to accommodate future traffic growth. In 1978, the Texas State Department of Highways and Public Transportation (SDHPT) and the Metropolitan Transit Authority (METRO) of Harris County entered into a cooperative agreement to develop an exclusive, reversible, single-lane transitway in the median of the Katy Freeway (1). To date, contracts totaling \$25 million for the Katy Freeway Transitway construction have been awarded, with funding shared by SDHPT, METRO, and the Urban Mass Transportation Administration (UMTA).

The Katy Freeway Transitway is being developed in three phases (Figure 2). Phase I, the construction of the at-grade transitway lane between I-610 and West Belt Drive, was completed and opened to traffic on October 29, 1984. Phase II, which includes the construction of an at-grade transitway from West Belt Drive to State Highway 6 and an elevated transitway interchange at State Highway 6, is expected to be ready for operation by July 1987. Phase III includes the construction of the Addicks transitway interchange north ramp and the expansion and modification of the Addicks park-and-ride lot. The former became operational in July 1987, while the latter is to be completed by May 1988 (2).

The Katy Freeway Transitway, located in the median of the freeway, is separated from the freeway traffic by concrete median barriers (CMB's). The facility is reversible--operating eastbound toward downtown in the morning and westbound in the afternoon. The facility is typically 19.5 feet wide (Figures 3 and 4). The widths between the CMB's at locations with signs or



Figure 1. Katy Freeway (I-10W), Harris County

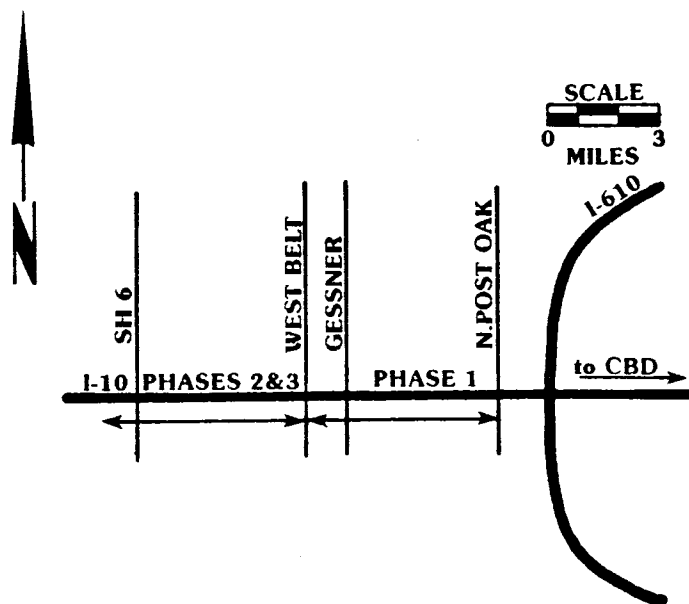


Figure 2. Katy Freeway Transitway Development Phases



Figure 3: Straight Section of Katy Transitway



Figure 4: Curved Section of Katy Transitway

lane control signals are usually reduced to 17.5 feet (Figure 5). Access to the transitway is handled differently at each terminal location. The interim western terminal near West Belt Drive is formed by a combination of CMB sections and construction barrels, complete with directional traffic signs (Figure 6). At the intermediate western terminal near Bunker Hill, CMB sections form slip ramps to provide access to, and egress from, the transitway from/to the inside freeway lanes (Figure 7). At the eastern terminal near I-610, an elevated flyover ramp leaves the median and ties into an arterial street (Figures 8 and 9) at the Post Oak and Old Katy Road intersection. At this intersection, vehicles leaving the transitway can either travel south toward City Post Oak and Greenway Plaza or continue east to re-enter the Katy Freeway in mixed-flow operation to travel toward the downtown area.

The Katy Freeway Transitway between Post Oak and Gessner Drive was opened to traffic on October 29, 1984. This provided a 4.7 mile transitway. On May 2, 1985, the transitway was extended from Gessner Drive to West Belt Drive, resulting in a total of 6.4 miles of transitway. During the first year of operation, only authorized vehicles (those vehicles meeting designated occupancy, license, and vehicle operating requirements and displaying an authorization permit) were allowed to use the transitway. The transitway was open to traffic from Monday through Friday (5:45 a.m. to 9:30 a.m. and 3:30 p.m. to 7:00 p.m.). During the first 12-month period, daily vehicles using the transitway increased from 238 to 386, while the daily person trips on the transitway increased from 4163 to 6147. These increases were accompanied by a twofold increase in the total number of vehicles utilizing the park-and-ride facilities at Mason, Addicks, and West Belt.

Kuo and Mounce (3) evaluated the operation of the Katy Freeway transitway during the first years (from November 1984 to October 1985) of operation and reported the following. There were benefits in travel time savings to transitway traffic of 7 and 8 minutes in the morning and in the afternoon, respectively. These time savings translated into an annual user benefit of \$1.23 million. The transitway was operating smoothly, with an average of less than 2 vehicles per month being disabled within the facility. When a vehicle was disabled, about 15 minutes were needed to detect and remove the

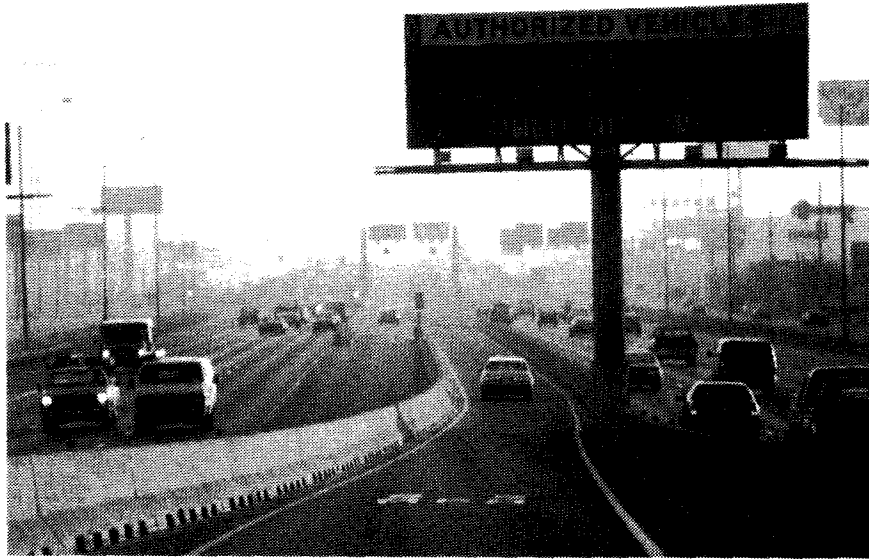


Figure 5: Reduced Width of Katy Transitway Due to Changeable Message Sign



Figure 6: Interim Westbelt Terminal

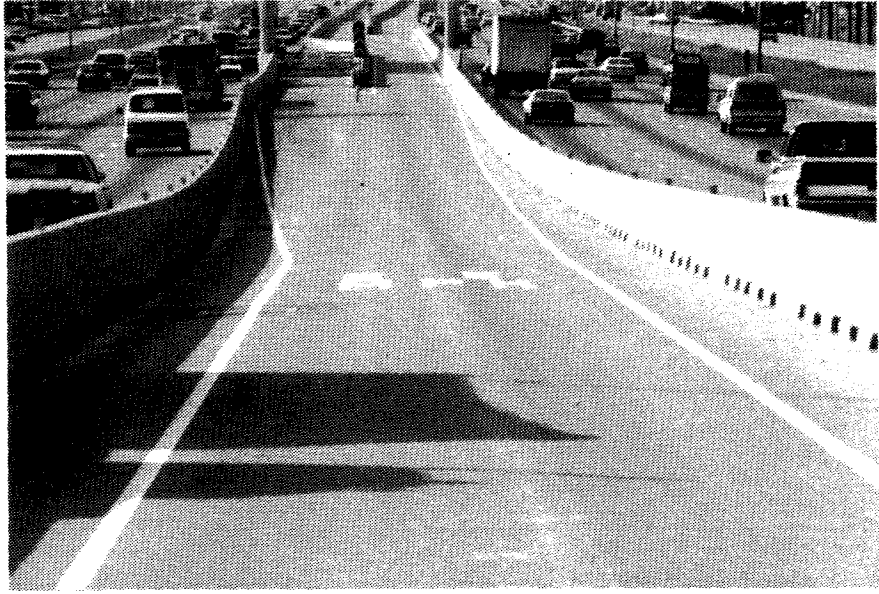


Figure 7: Gessner Slip Ramp



Figure 8: Elevated Flyover at Post Oak Terminal

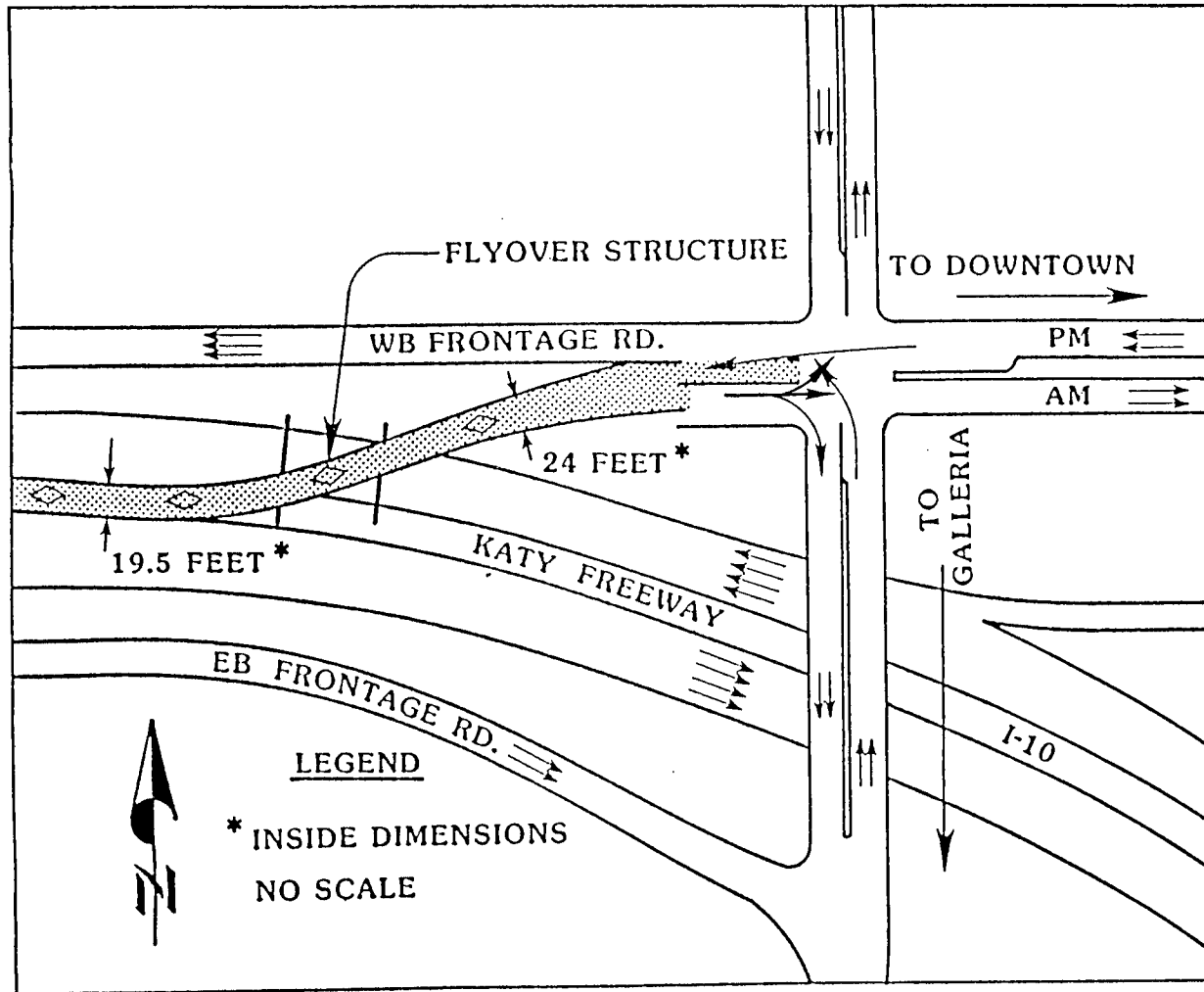


Figure 9. Eastern Terminal at Post Oak

vehicle. The impacts of the transitway on freeway operations were minimal. Freeway volumes and travel times did not change significantly, nor did the accident rates.

This report describes the operation of the Katy Freeway Transitway during the second year of operation (11/1/85 to 10/31/86). Included in the report are changes in the authorization process that have taken place, transitway traffic operational characteristics, transitway influence on the Katy Freeway and the Katy Freeway corridor, and benefits of the transitway. The report consists of four sections relative to the second year of operation: 1) transitway effects; 2) freeway effects; 3) transit effects; and 4) benefits.

TRANSITWAY EFFECTS DURING THE SECOND YEAR OF OPERATION

This section describes the following operational and traffic effects of the transitway during the second year of operation: changes in the authorization process; selected characteristics of the transitway users and non-users; transitway utilization; transitway peaking characteristics; transitway average occupancy rates; utilization of park-and-ride facilities; unauthorized vehicles and citations issued; disabled vehicles and delays on the transitway; travel times and speeds; and transitway-related accidents.

Changes in Authorization Process

Since October 29, 1984, the vehicle authorization process for the Katy Freeway Transitway has undergone several revisions. These revisions were implemented primarily to increase the utilization of the facility. Table 1 summarizes these revisions.

Table 1. Transitway Chronology

Date	Vehicles Allowed	Remark
October 29, 1984	Buses, authorized vanpools (minimum of 8 persons registered; minimum of 6 riders)	Opened from Post Oak to Gessner Drive
April 1, 1985	Buses, authorized vanpools and and authorized 4+ carpools	
May 2, 1985		HOV extended to West Belt Drive
July 29, 1985	Buses, authorized vanpools and authorized 4+ carpools with 3 passengers	Authorization of carpools still required at least 4 persons
September 1985	Buses, authorized vanpools and authorized carpools (some 3+ carpools were allowed)	METRO authorized some 3+ carpools
November 4, 1985	Buses, authorized vanpools and authorized 3+ carpools	Official date for authorized 3+ carpools
August 11, 1986	Vehicles with 2 or more persons except large trucks and motor- cycles	No authorization is required to use transitway

During the first five months of transitway operation, only buses and vanpools authorized by METRO and the SDHPT were allowed to use the facility. The authorization process involves several considerations, including driver instruction, vehicle inspection, certain insurance requirements, and a minimum number of registered occupants. Vehicles are required to display an authorization permit.

On April 1, 1985, the authorization was extended to automobiles carrying four or more persons (i.e. 4+ carpools). Initially, it was decided that, if an authorized carpool had fewer than four persons on any day for any reason, it would not be permitted into the transitway. This restriction was modified July 29, 1985, so that authorized carpools with at least three persons were permitted. However, four or more persons were still required to obtain the authorization.

On November 4, 1985, the authorization requirement was lowered to a minimum of three registered persons. Although the authorization of 3+ carpools did not officially commence until this date, some 3+ carpools had been authorized by METRO as early as September 1985.

Finally, on August 11, 1986, carpools with a minimum of two persons, in addition to buses and vanpools, were allowed to use the facility without prior authorization. Trucks, motorhomes, and motorcycles were still prohibited from using the transitway. In addition, the operating hours of the transitway were extended to 5:45 a.m. to 11:00 a.m. in the morning, and from 2:00 p.m. to 7:00 p.m. in the afternoon, Monday through Friday except holidays.

Characteristics of Katy Transitway Users and Non-Users

Some characteristics of the Katy Freeway Transitway users and non-transitway motorists before 2+ carpools were introduced onto the transitway were reported by Bullard (4). These findings are summarized in Table 2. The table indicates that the transitway carpool participants were very similar to the transitway non-users with regard to some socio-economic factors such as age, education, occupation, and sex. Some differences in age

and sex between the transitway bus users and the transitway non-users were indicated -- the bus users were younger on the average and more likely to be female than were the transitway non-users. There were also proportionally more females in the transitway vanpooler population than in the transitway non-user population.

Bullard (4) also reported trip origins by home zip codes of the transitway users and non-users. To a significant extent, the transitway users and non-users had similar trip origins. Of greater interest were their reported destinations (Table 2), which indicated significant differences among the transitway bus users, vanpoolers, carpoolers, and non-users. Almost all the bus users had destinations in the downtown area. Sixty percent of the transitway vanpoolers showed downtown as their destinations. About 50 percent of the transitway carpoolers had destinations in downtown, while only 33 percent of the transitway non-users had destinations in downtown.

Table 2. Personal Characteristics of Users and Non-Users of the Katy Freeway Transitway, April 1986

Characteristic	Transitway Users			Total	Non-Transitway Motorists
	Transit	Vanpool	3+ Carpool		
Age (years)					
50th Percentile	32	37	40		40
Sex					
Male	44%	51%	62%		66%
Female	56%	49%	38%		34%
Education (years)					
Average	15.4	15.3	15.3		15.9
Occupation					
Professional	46%	58%	45%		42%
Managerial	20%	14%	23%		26%
Clerical	26%	23%	15%		9%
Sales	4%	3%	6%		14%
Other	4%	2%	11%		9%
Trip Purpose					
% Work	97%	100%	100%		91%
Trip Frequency (days/week)					
5 or more	89%	100%*	97%		84%
Trip Destination					
Downtown	95%	60%	49%		33%
Galleria	0%	12%	15%		10%
Texas Medical Center	1%	7%	3%		3%
Greenway Plaza	0%	5%	---		4%
Other	4%	16%	33%		50%

Source: (4).

Transitway Utilization

Vehicle and occupancy counts (using 15-minute intervals) on the Katy Freeway Transitway were conducted once a month, typically on a Tuesday. These one-day counts were assumed to represent daily vehicle and passenger volumes using the transitway for the corresponding month. Daily vehicle volumes for each of the 12 months during the second year of operation are tabulated in Table 3 by buses, vanpools, carpools, and all vehicles. Daily transitway person trips for each of the 12 months during the second year of operation are shown in Table 4, by buses, vanpools, carpools, and total. Both tables indicate many trends, including the random month-to-month variations inherent in the transitway utilization. Figures 10 and 11 depict graphically this data for the AM peak periods.

Table 3. Daily Vehicles on the Katy Transitway During the Second Year of Operation,
Number of Daily Vehicles

Month	Buses		Vanpools		Carpools		Total		Total Daily Vehicles	Remarks
	AM	PM	AM	PM	AM	PM	AM	PM		
Nov. 85	72	68	75	85	82	73	229	226	455	Began 3+ carpool authorization
Dec. 85	70	67	74	83	92	83	236	233	469	
Jan. 86	76	73	66	79	97	88	239	240	479	
Feb. 86	79	78	65	73	106	93	250	244	494	
Mar. 86	81	78	62	72	107	83	250	233	483	
Apr. 86	83	77	64	76	110	94	257	247	504	
May 86	79	79	64	76	116	91	259	246	505	
Jun. 86	79	79	62	76	78	71	219	226	445	
Jul. 86	80	79	61	75	72	69	213	223	436	
Aug. 86	84	81	62	80	1606	1358	1752	1519	3271	
Sep. 86	86	81	62	73	1856	1571	2004	1725	3729	
Oct. 86	72	70	65	74	2145	1853	2282	1997	4279	

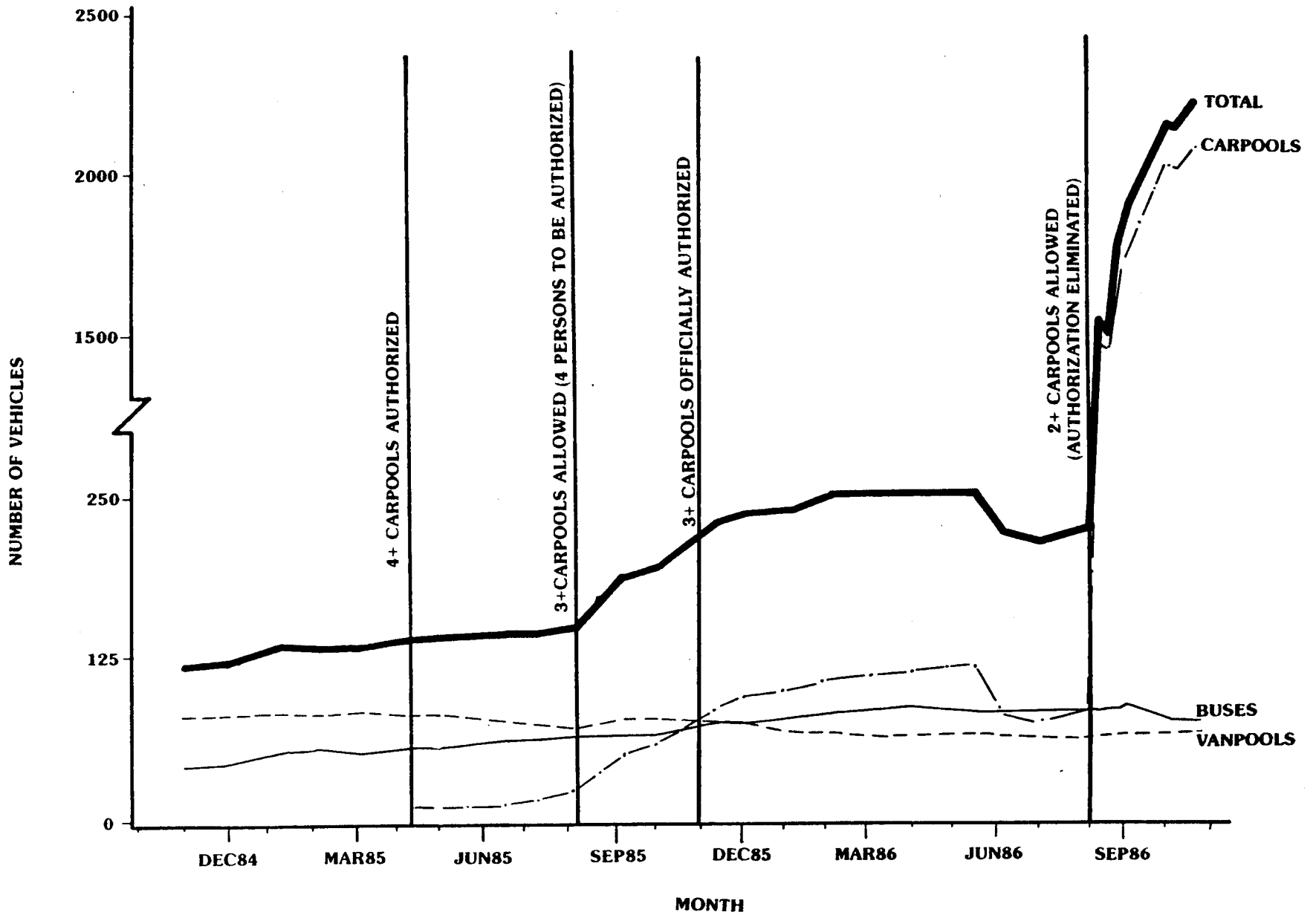


Figure 10. A.M. Peak-Period (5:45-9:30) Vehicle Utilization on Katy Freeway Transitway

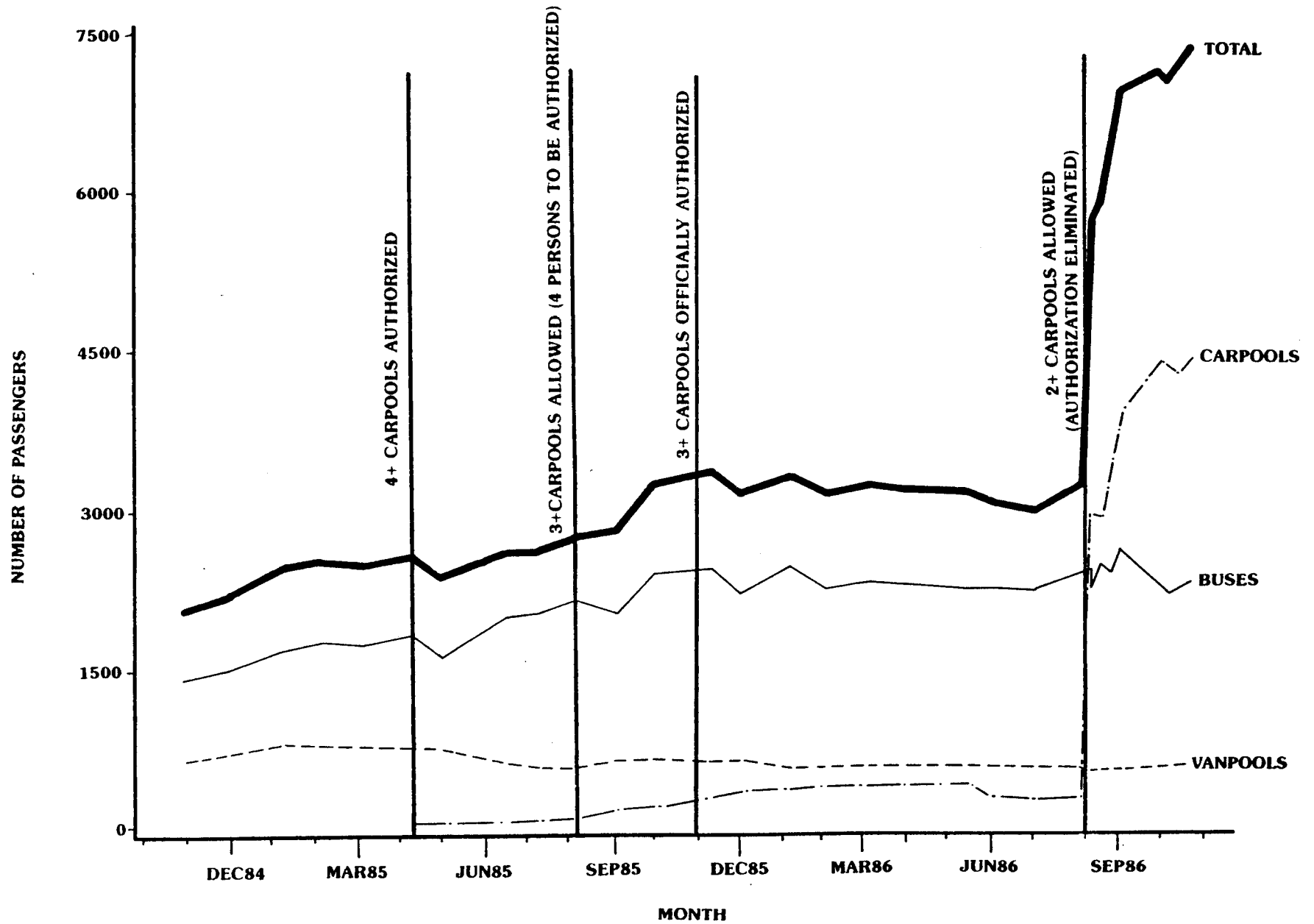


Figure 11. A.M. Peak-Period (5:45-9:30) Person Movement on Katy Freeway Transitway

Table 4. Daily Katy Transitway Passenger Trips During the Second Year of Operation,
Number of Passengers

Month	Buses		Vanpools		Carpools		Total		Total Daily Passengers	Remarks
	AM	PM	AM	PM	AM	PM	AM	PM		
Nov. 85	2440	2295	617	716	299	258	3356	3269	6625	Began 3+ carpool authorization
Dec. 85	2180	2210	625	706	337	295	3142	3211	6353	
Jan. 86	2450	2275	540	668	333	313	3323	3256	6579	
Feb. 86	2250	2185	541	611	366	320	3157	3116	6273	
Mar. 86	2300	2140	553	618	380	280	3233	3038	6271	
Apr. 86	2270	2032	548	632	378	328	3196	2992	6188	
May 86	2230	1880	553	669	387	311	3170	2860	6030	
Jun. 86	2245	2235	546	669	262	242	3053	3146	6199	
Jul. 86	2210	2215	535	664	238	232	2983	3111	6094	
Aug. 86	2485	2225	496	616	3499	2931	6480	5772	12252	
Sep. 86	2605	2265	489	551	4072	3415	7166	6231	13397	
Oct. 86	2195	2035	537	585	4589	3955	7321	6575	13896	

In order to assess the changes in transitway utilization over time, the daily vehicle and person-trip volumes for each month of the second year were compared to those for the same month of the first year. In this way, the effect of the random month-to-month variation in traffic volumes might be alleviated. Percent changes in vehicle and person-trip volumes in the second year relative to the first year of transitway operation were computed by month, as shown in Table 5. It can be seen that the daily number of buses for each month during the second year was considerably higher than the number for the same month of the first year, resulting in the average increase of almost 50 percent per month. On the other hand, the daily number of transitway vanpools in any one month during the second year was consistently lower than the number for the same month of the first year, resulting in the average decrease in the second year of 12 percent per month. It was noted

that, during the first twelve months of transitway operation, the monthly level of vanpools on the transitway did not change much even after the introduction of 4+ authorized carpools (3).

After the official authorization of 3+ carpools in November 1986, the level of vanpools on the transitway in February 1986 (Table 3) suddenly decreased by about 14 percent from the level recorded for October 1985, and remained at that level ever since. This decrease in the level of authorized vanpools might be attributable to a number of factors, such as several major

Table 5. Percent Changes* in Number of Buses, Vanpools, Total Vehicles, and Total Person Trips In the Second Year Relative to the First Year

Month	Buses	Vanpools	Total Vehicles	Total Persons
Nov. (85 vs. 84)	79.5%	0%	91.2%	59.1%
Dec. (85 vs. 84)	69.1	-3.1	93.0	42.9
Jan. (86 vs. 85)	65.6	-15.7	82.8	36.5
Feb. (86 vs. 85)	61.9	-16.9	87.8	21.6
Mar. (86 vs. 85)	57.4	-21.2	78.2	24.3
Apr. (86 vs. 85)	53.8	-15.7	80.0	20.6
May (86 vs. 85)	49.1	-16.7	76.6	22.9
Jun. (86 vs. 85)	30.6	-12.7	52.4	21.5
Jul. (86 vs. 85)	37.1	-11.1	46.8	16.6
Aug. (86 vs. 85)	35.2	-2.1	976.0	111.6
Sep. (86 vs. 85)	34.7	-16.1	899.7	129.1
Oct. (86 vs. 85)	17.4	-14.7	996.4	115.8
Average	49.3%	-12.2%	296.7%	51.9%

* Percent Change = (Second Year-First Year)/First Year. A positive value, therefore, denotes an increase, and a negative value denotes a decrease in the second year.

employee lay-offs by large companies (e.g. oil companies), reductions in vanpool cost contributions and incentives by employers (4), and a small degree of modal transfer from vanpools to authorized 3+ carpools. Bullard (4) reported that, out of the 191 transitway carpool participants surveyed in April 1986, 4 percent indicated that their previous mode of travel had been vanpools.

Table 5 also indicates that the total daily number of vehicles using the transitway for each month in the second year was higher than that for the same month in the first year. Before the introduction of 2+ carpools, the average increase in the daily number of total vehicles in the second year relative to the first year was about 77 percent per month. After the introduction of 2+ carpools, this increase was about 960 percent per month. The daily number of total person trips was also shown to have increased in the second year compared to the first year. Percentage-wise, however, the increases in daily total person trips were smaller than the increases in total daily vehicles. Before the introduction of 2+ carpools, total daily person trips in the second year relative to the first year increased about 30 percent per month on average. After the introduction of 2+ carpools, this increase was about 120 percent per month.

The number of carpools using the transitway increased since they were authorized, as shown in Table 6. This increase can be attributed to the following:

(a) The lowering of carpool occupancy requirements (twice) added new carpool traffic which had not been previously eligible due to insufficient numbers of occupants. Furthermore, the observed count data (Figure 12) indicate that the lowering of carpool occupancy requirements also brought about increases in the number of carpools with higher occupancies. It can be seen from Figure 12 that, when 3+ carpools were authorized, the number of 4+ carpools actually increased slightly. This increase leveled off after a couple of months until 2+ carpools were introduced. At this time, the number of 4+ carpools again rose slightly. Also, in the month that 2+ carpools were introduced, the number of 3+ carpools rose by threefold. It is estimated that the authorization process reduced transitway carpool demand by approximately 40%.

(b) Growth with time was observed for both 3+ and 4+ carpools, particularly in the initial 4 to 7 months after they were authorized, as shown in Figure 12. For 3+ carpools, this growth was relatively small in magnitude compared to the sharp increase brought about by lowering the occupancy requirement to 2 persons.

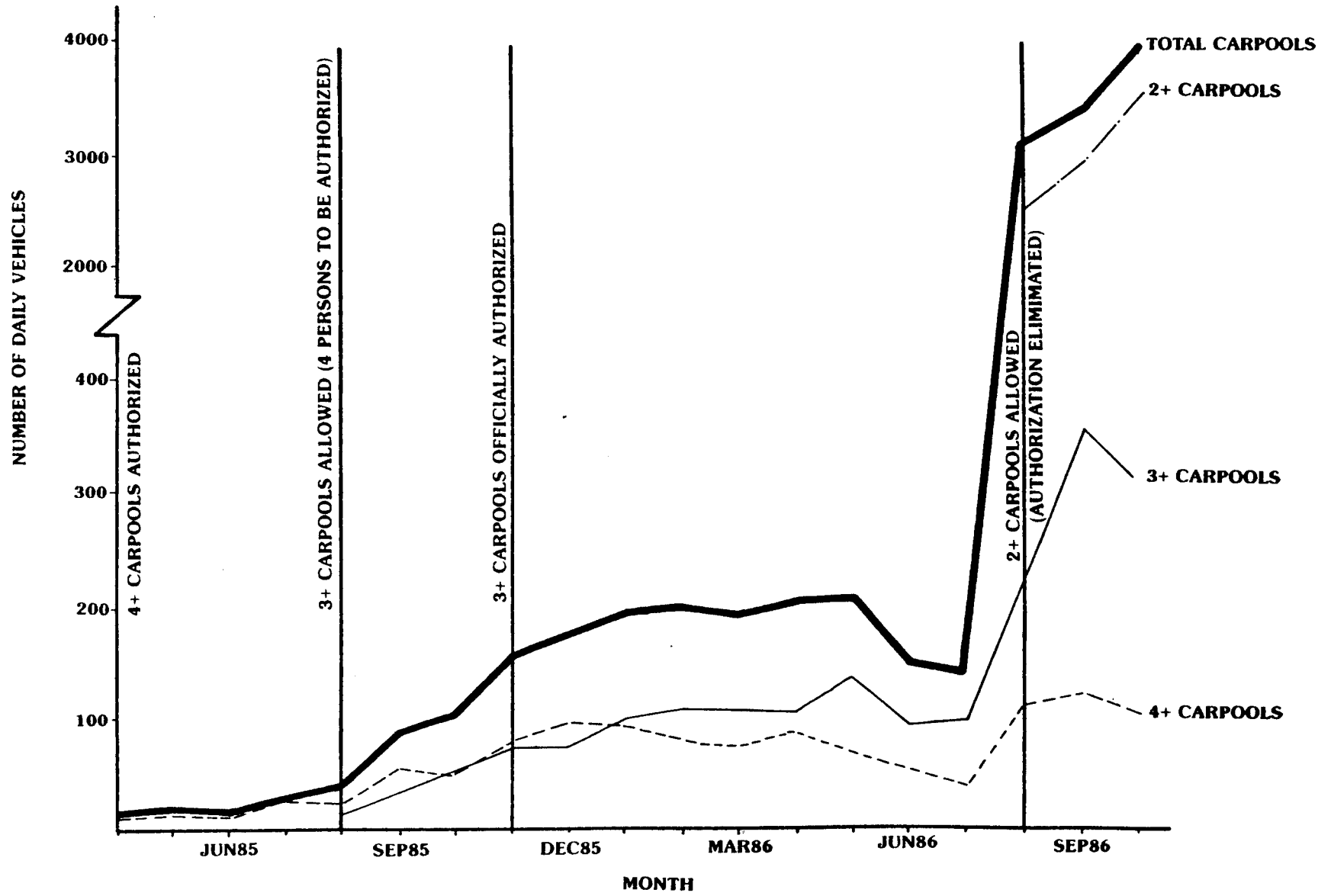


Figure 12. Number of Daily Carpools on Katy Freeway Transitway

Table 6. Daily Number of Carpools Observed on Katy Freeway Transitway Since Carpools Were Allowed

Month	Daily Number of Carpools				Remark
	4+	3+	2+	Total	
Apr. 85	10	NA	NA	10	4 person carpools
May 85	13	NA	NA	13	
Jun. 85	11	1	1	13	
Jul. 85	25	1	2	28	
Aug. 85	23	12	2	37	3+ carpools were allow although 4 persons were required for authorization
Sep. 85	55	32	1	88	
Oct. 85	49	52	1	102	
Nov. 85	79	75	1	155	3+ carpools officially started
Dec. 85	98	74	3	175	
Jan. 86	83	100	2	185	
Feb. 86	81	110	8	199	
Mar. 86	76	107	7	190	
Apr. 86	88	106	10	204	
May 86	65	138	4	207	
Jun. 86	52	95	2	149	
Jul. 86	39	101	1	141	
Aug. 86	108	266	2590	2964	Authorization no longer required, 2+ carpools started
Sep. 86	123	359	2945	3427	
Oct. 86	106	311	3581	3998	

Table 7: Occupancy Rates on Katy Freeway Transitway

Average Occupancy Rate (Passenger/Vehicle)

Vehicle Type	First Year	Second Year
Buses	34.08	29.09
Vanpools	8.83	8.39
Carpools	3.72	2.35
Weighted Average	16.74	6.20

Source: (2).

The above findings do not indicate any evidence of modal competition (or transfer) among 4+, 3+, and 2+ carpools. Even though the lowering of carpool occupancy requirements was shown to have brought about increases in carpools at all occupancy levels, the actual effects of the change to allow 2+ carpools on the transitway is very difficult to determine since the authorization process was dropped at the same time. The number of 2+ carpools using the transitway was steadily increasing during the initial 3 months.

Transitway Peaking Characteristics

Relative frequencies of 15-minute volume counts for buses, vanpools, and carpools using the transitway on a typical day in June 1986 (authorized 3+ carpools were in effect) are shown in Figure 13. Figure 13 indicates that about 60 percent of the transitway buses in the morning operated between 6:30 a.m. and 7:45 a.m., and that its morning peak volume occurred at 7:30-7:45 a.m. In the afternoon, the transitway buses were more spread out than in the morning, and 65 percent of the afternoon buses were observed from 4:30 p.m. to 6:00 p.m.

Figure 13 indicates that, in the morning, peak vanpool volume occurred from 6:45 a.m. to 7:00 a.m., and that about 80 percent of the morning vanpools were observed from 6:30 a.m. to 7:30 a.m. In the afternoon, there were 2 peaks for vanpools, one from 4:30 p.m. to 4:45 p.m. and the other from 5:15 p.m. to 5:30 p.m.

Figure 13 indicates that 3+ carpool volumes peaked between 6:45 a.m. and 7:30 a.m., and that 80 percent of the morning 3+ carpools were observed from 6:30 a.m. to 7:45 a.m. In the afternoon, 3+ carpools peaked between 4:45 p.m. 5:00 p.m. The number of the afternoon carpools was substantial between 4:00 p.m. and 6:00 p.m., and this 2-hour period accounted for almost 90 percent of the afternoon 3+ carpools.

On August 11, 1986, 2+ carpools were allowed on the transitway, and the transitway operating hours were extended from 5:45 a.m. to 11:00 a.m. and from 2:00 p.m. to 7:00 p.m. The introduction of 2+ carpools did not significantly change the peaking characteristics of buses or vanpools using the transitway. However, differences in the peaking characteristics of the transitway carpools before and after 2+ carpools were observed. Relative

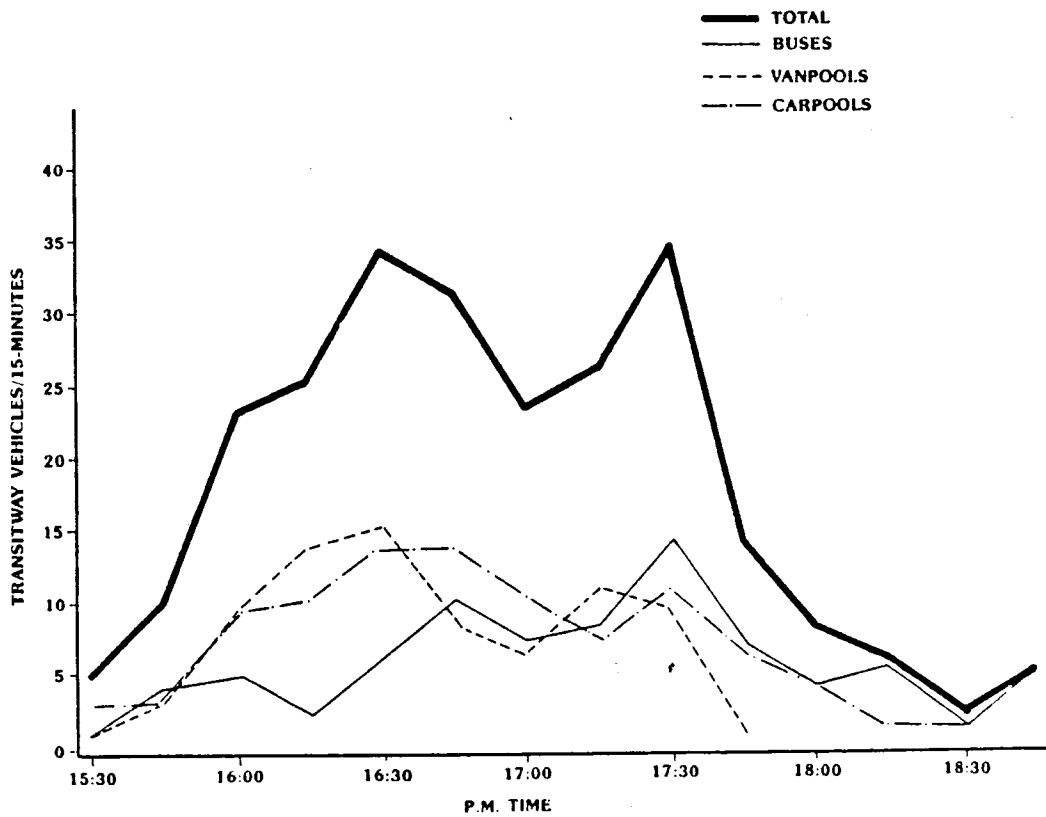
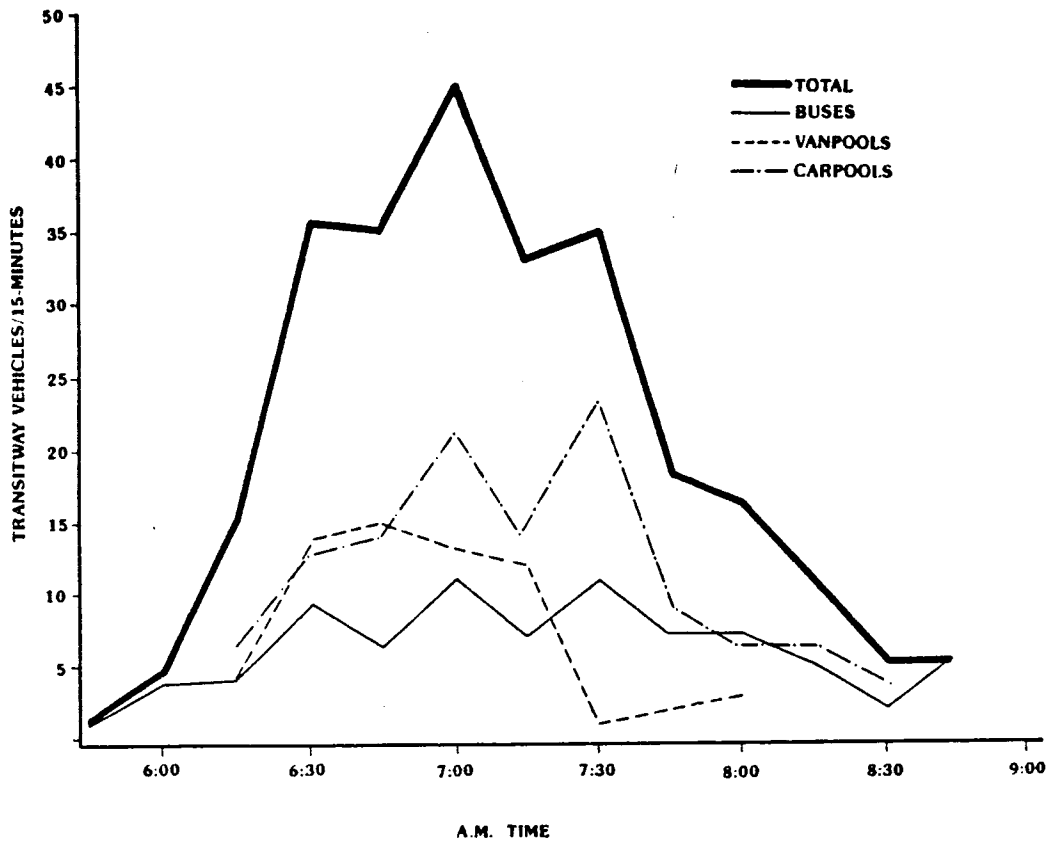


Figure 13. Typical Morning and Afternoon Peak-Period Vehicle Distribution on Katy Transitway

frequencies of 15-minute 2+ carpool volumes for a typical day in September 1986 were plotted for the morning and the afternoon as shown in Figure 14. Comparing Figure 14 (after 2+ carpools) to Figure 13 (before 2+ carpools) reveals that the peaking characteristics of carpools in the morning and in the afternoon had changed since 2+ carpools were introduced--the peak volumes after 2+ carpools occurred later than those before 2+ carpools (i.e. 7:30 a.m. to 7:45 a.m. in the morning and 5:15 p.m. to 5:30 p.m. in the afternoon). After 2+ carpools were introduced, almost 90 percent of the morning carpools were observed from 6:30 a.m. to 9:15 a.m., and about 85 percent of the afternoon 2+ carpools were observed from 4:00 p.m. to 6:30 p.m.

Transitway Occupancy Rates

Occupancy rates (number of persons per vehicle) on the Katy Freeway Transitway during the first year and the second year of operation are shown in Table 7 for buses, vanpools, carpools, and all vehicles. The occupancy rate for buses during the second year decreased by about 15 percent relative to the rate for the first year, due at least partly to a substantial increase in the number of transitway buses in the second year. The occupancy rate for vanpools during the second year decreased by less than 5 percent relative to the rate for the first year. As expected, the occupancy rate for carpools during the second year was considerably lower than that during the first year (a decrease of about 37 percent) due to the lowerings of the vehicle occupancy requirements. Overall, the average weighted occupancy rate on the transitway dropped from 17.52 persons per vehicle in the first year to 6.20 persons per vehicle in the second year. This decrease in occupancy rate resulted from the significant increase in carpools utilizing the transitway.

Utilization of Park-and-Ride Facilities

There were 3 park-and-ride lots operating within the Katy Freeway corridor during the second year of operation. They were Kingsland park-and-ride lot, which opened in November 1985 after the lease for Mason park-and-ride lot expired, Addicks park-and-ride lot at SH 6 which opened in January 1982, and West Belt park-and-ride lot which opened in January 1985. The number of vehicles which could be accommodated by Kingsland, Addicks, and

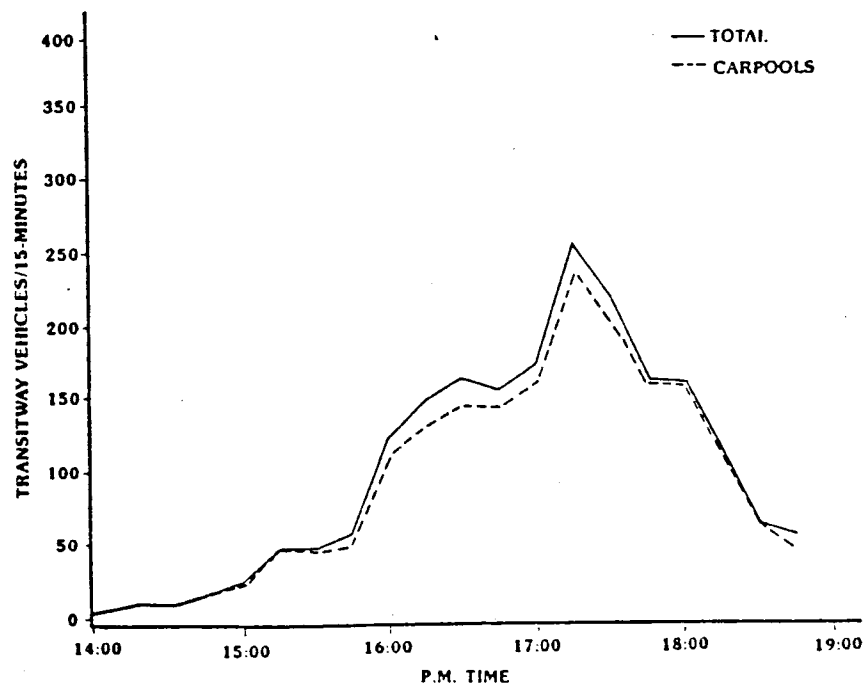
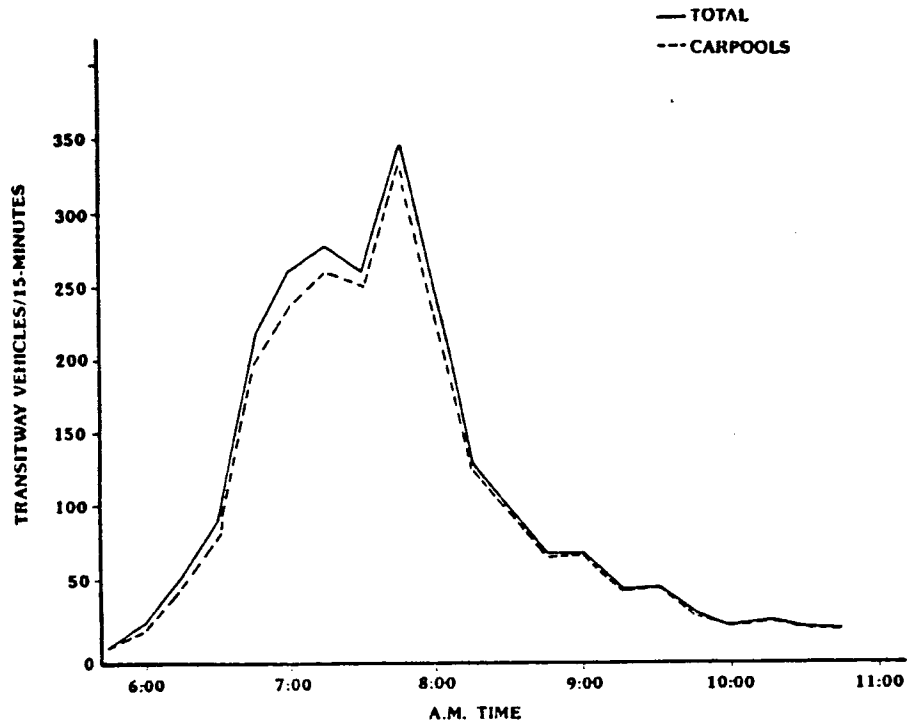


Figure 14. Typical Morning and Afternoon Peak-Period Carpool and Total Vehicle Distribution on Katy Transitway

West Belt park-and-ride lots was 1326, 1119, and 1111 vehicles, respectively. The locations of these facilities are shown in Figure 15.

The daily number of vehicles using the 3 park-and-ride facilities is summarized for each month in Table 8 and shown graphically in Figure 16. The average daily utilization of these facilities during the second year of transitway operation was 266, 647, and 255 vehicles for Kingsland, Addicks, and West Belt lots, respectively. These averages represented increases of 19, 8, and 17 percent over the utilization levels in the final month of the first year (October 1985). It was noted that the demand for these facilities was below the capacity of the lots, particularly at the Kingsland and West Belt lots.

Unauthorized Vehicles and Citations Issued on Transitway

The transitway police officers are on duty at the eastern terminal (Post Oak terminal) to handle emergencies and to warn or to ticket unauthorized patrons using the transitway. METRO keeps records of the number of unauthorized vehicles that entered the transitway. In the morning, unauthorized vehicles in the eastbound direction would not be seen or stopped by the transitway police officers for citations until they exit the transitway at Post Oak. In the afternoon, unauthorized vehicles in the westbound direction might be: 1) stopped and turned away before they enter the transitway at Post Oak; 2) continue on the transitway and later be stopped in the transitway; or 3) not detected. Table 9 shows a summary of the monthly number of unauthorized vehicles on the transitway in the morning and in the afternoon, as well as the number of citations issued to these vehicles during the first 2 years. Also shown in the table is the calculated violation rate (unauthorized users/total users) expressed as a percent of total vehicles using the transitway.

As expected, the number of unauthorized vehicles reported for the afternoon was much lower than that for the morning because many such vehicles were turned away in the afternoon before entering the transitway. The table also indicates that reported observation and apprehension of unauthorized vehicles varied from month to month.

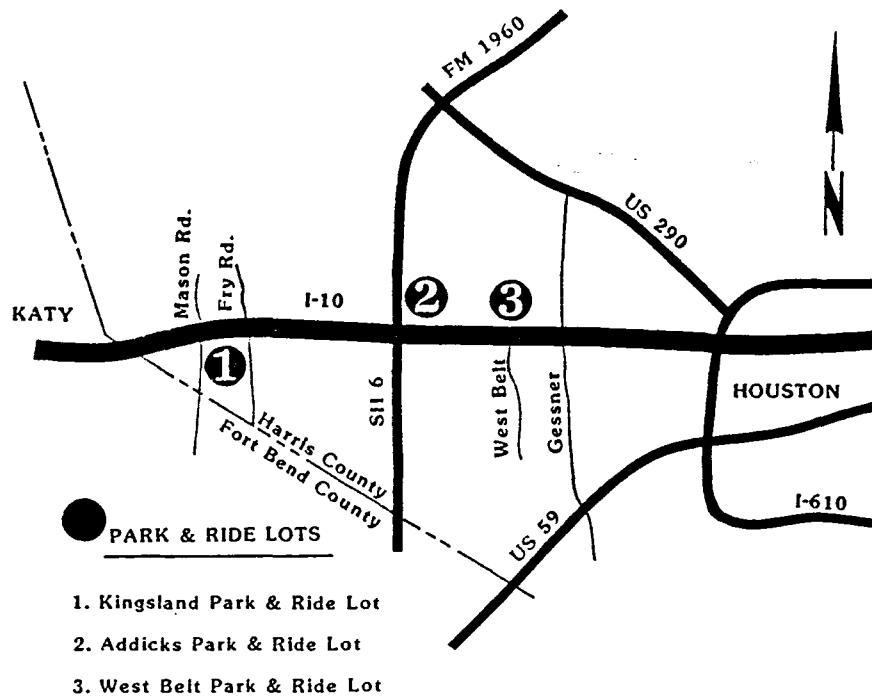


Figure 15. Park-and-Ride Facilities for Katy Freeway Corridor

Table 8. Daily Utilization of Katy Freeway Park-and-Ride Facilities

Daily Number of Parked Vehicles

Month	Kingsland	Addicks	West Belt	Total
Nov. 85	246	623	253	1122
Dec. 85	250	573	235	1058
Jan. 86	282	680	250	1212
Feb. 86	263	694	264	1221
Mar. 86	272	721	270	1263
Apr. 86	278	651	268	1197
May 86	265	684	264	1213
Jun. 86	279	602	269	1150
Jul. 86	274	664	242	1180
Aug. 86	255	602	234	1091
Sep. 86	264	639	242	1145
Oct. 86	268	635	232	1135
Average	266	647	252	1166

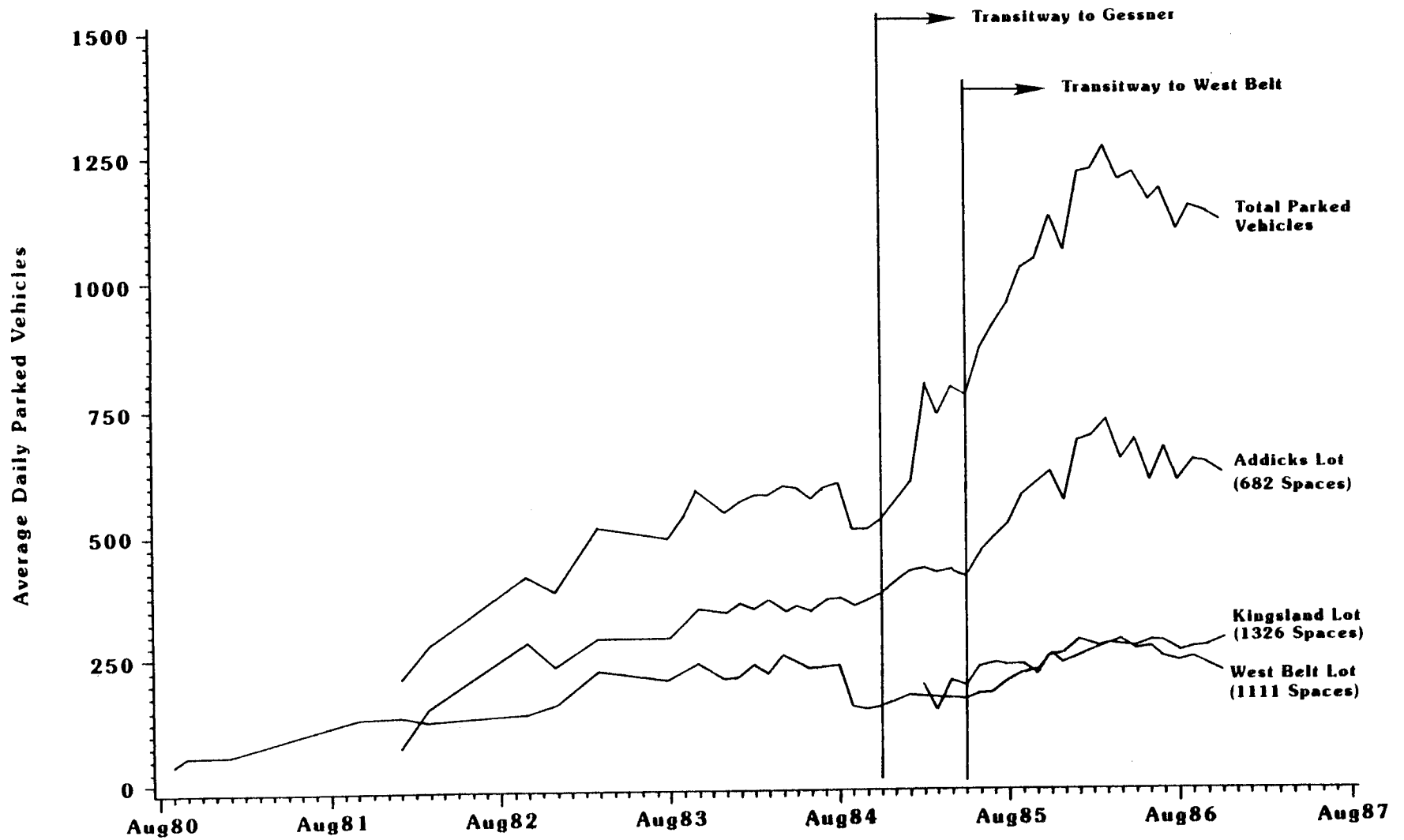


Figure 16. Daily Utilization of Katy Freeway Park-and-Ride Facilities

Table 9. Monthly Summary of Unauthorized Vehicles and Citations Issued on Katy Freeway Transitway

Month	Number of Unauthorized Vehicles		Number of Citations	Violations Per Total Vehicles (%)	Remark
	AM	PM			
Nov. 84	7	0	6	0.15	opening month 4+ carpools were authorized some 3+ carpools were authorized
Dec. 84*	1	1	1	0.04	
Jan. 85	4	1	2	0.10	
Feb. 85	7	0	0	0.13	
Mar. 85	5	0	1	0.02	
Apr. 85	2	2	1	0.06	
May 85	9	0	2	0.16	
Jun. 85	11	1	4	0.19	
Jul. 85	14	0	4	0.21	
Aug. 85	7	2	1	0.15	
Sep. 85	30	3	10	0.38	
Oct. 85	29	8	9	0.50	
First Year Total	126	18	41	0.20	
Nov. 85	43	0	10	0.50	3+ carpools were authorized 2+ carpools were allowed
Dec. 85	29	2	2	0.30	
Jan. 86**	20	0	7	0.21	
Feb. 86**	13	8	6	0.20	
Mar. 86**	30	3	5	0.31	
Apr. 86	54	0	9	0.51	
May 86	48	2	13	0.47	
Jun. 86	54	2	8	0.57	
Jul. 86	44	1	2	0.49	
Aug. 86	192	24	4	0.31	
Sep. 86	29	9	20	0.04	
Oct. 86	90	0	53	0.12	
Second Year Total	646	51	139	0.21	

* Represents only those violators observed and apprehended by Metro Transit Police.

** Incomplete records for the month.

Disabled Vehicles, Towed Vehicles and Delays on the Transitway

Operation of the transitway, at the present time, is controlled manually by an on-site METRO crew. The crew consists of a transit police officer, a wrecker driver, and a traffic control worker. These persons open the transitway for the eastbound traffic by 5:45 a.m. and close the transitway at 11:00 a.m. In the afternoon, the transitway is open in the westbound direction between 2:00 and 7:00 p.m. The wrecker and the driver are situated at the western transitway terminal near Gessner Drive to handle emergencies and to remove immobile vehicles stranded on the facility.

The number of disabled vehicles on the transitway was relatively small. In the second year of transitway operation, the disabled rate for buses was 2.4 buses per month. For vanpools, the rate was much lower (0.4 vanpools per month). Before 2+ carpools were allowed, the disabled rate for carpools was 1.1 carpools per month. After 2+ carpools, this rate rose to 18 carpools per month. Table 10 shows a summary of disabled vehicles on the transitway during the second year of operation. Breakdown rates by month are also presented, expressed as a percentage of breakdowns per vehicle-mile of transitway travel.

Table 10. Summary of Disabled and Towed Vehicles on Katy Freeway Transitway

Month	Number of Disabled Vehicles				Vehicle Miles Traveled Per Breakdown	Remark
	Buses	Vanpools	Carpools and Private Vehicles	Total		
Nov. 85	3	1	0	4	13,832	3+ carpools authorized
Dec. 85	3	0	0	3	22,012	
Jan. 86	5	0	1	6	10,219	
Feb. 86*	2	0	1	3	22,131	
Mar. 86	1	1	0	2	22,669	
Apr. 86	2	0	3	5	13,548	
May 86	3	0	1	4	16,968	
Jun. 86*	3	0	2	5	12,531	
Jul. 86	6	3	2	11	5,327	
Aug. 86	0	0	11	11	39,966	
Sep. 86	0	0	21	21	26,139	
Oct. 86	1	0	22	23	21,432	
Monthly Average	2.4	0.4	5.3	8.2	18,898	

* Incomplete records for the month.

Disabled vehicles on the transitway might require towing, quick assistance or remedies (e.g. reinflating low tires), pushing (by a METRO pickup truck) out of the facilities, or no assistance from the METRO crew. Delays (as defined by transitway operation limiting speed to less than 55 mph) to other vehicles on the transitway occurred when vehicles became disabled on the transitway or when they were involved in incidents that needed to be cleared. During the second year of transitway operation, there were a total of 98 vehicles which were disabled or involved in incidents on the transitway. Of these, 47 vehicles did not cause delays to other vehicles, while the other 51 vehicles did. The delays ranged from one minute to over an hour. Figure 17 shows a cumulative frequency plot of delay times on the transitway of these 98 vehicles. The mean delay was 8 minutes, and the standard deviation was 13.6 minutes. The figure indicates that 48 percent of the disabled vehicles on the transitway caused no delay, 70 percent caused a less than 10 minute delay, 84 percent caused a less than 20 minute delay, and 98 percent caused a less than 30 minute delay.

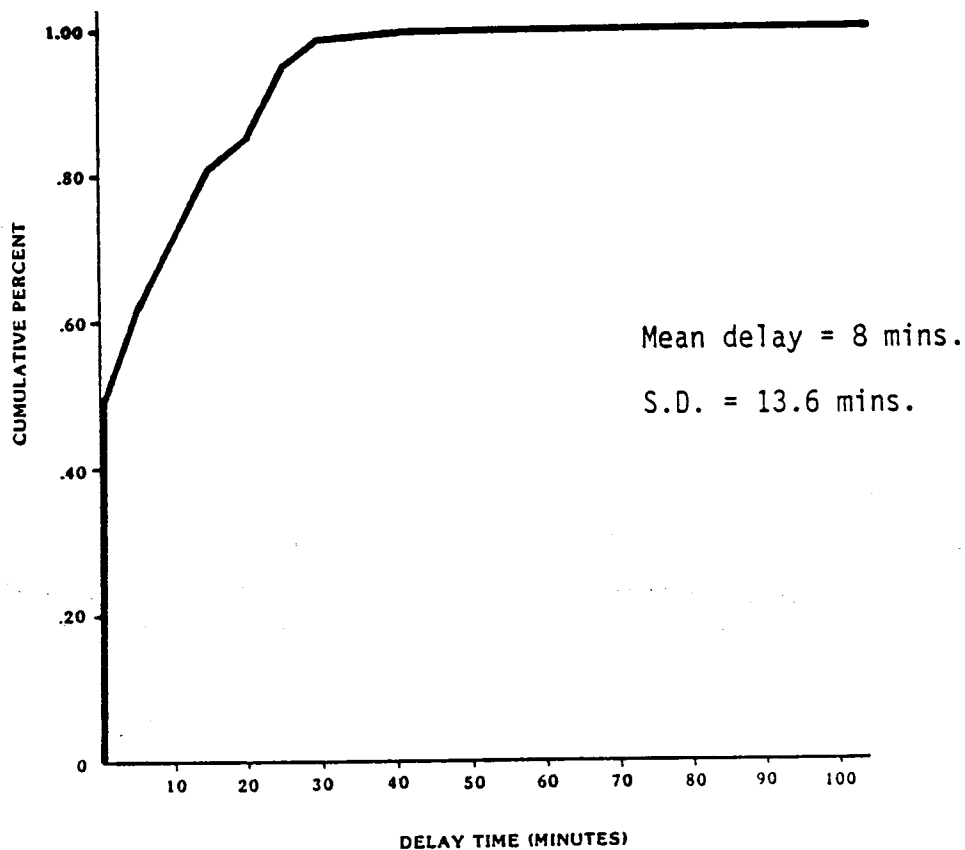


Figure 17. Cumulative Distribution of Delay Times for Disabled Vehicles on Katy Transitway

Travel Time and Speed Performance for Transitway Traffic

TTI conducts travel time and travel speed studies every three months for both the Katy Freeway traffic and the Katy Transitway traffic. Typically, the travel runs start at beyond the terminal limits of the operational transitway. Travel times for the Katy Freeway traffic and the Katy Transitway traffic are recorded by investigators inside TTI study vehicles which travel in the middle lane of the Katy freeway (or on the transitway, as is the case) and move at speeds similar to speeds of the traffic in that lane. Average travel speeds for individual freeway (or transitway) sections are obtained by dividing the lengths of these sections by the travel times. For the quarterly travel time studies, each quarter consists of a one-day survey which is comprised of several runs in the morning in the eastbound direction (6:00-9:30 a.m.) and in the afternoon in the westbound direction (3:30-7:00 p.m.).

Average travel times and speeds for the Katy Freeway traffic and for the Katy transitway traffic during the second year of transitway operation were calculated by sections. Four sections were utilized between SH 6 and S.P.R.R. to establish average travel times and speeds. These sections are shown in Figure 18 and defined by mileage in Table 11.

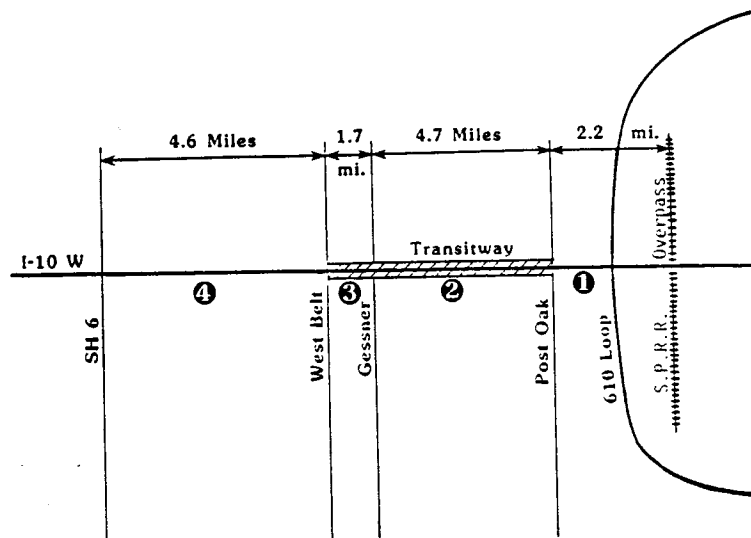


Figure 18. Section Limits for Travel Runs

Table 11. Section Limits for Travel Time Runs

Section Number	Route for Transitway Travel	Route for Freeway Travel
1	On Katy Road between Post Oak and the S.P.R.R. overpass of I-10 (2.2 miles)	On Katy Freeway between Post Oak and the S.P.R.R. overpass of I-10 (2.2 miles)
2	On transitway lane between Post Oak and the Gessner slip ramp (4.7 miles)	On Katy Freeway between Post Oak and the Gessner slip ramp (4.7 miles)
3	On transitway lane between the Gessner slip ramp and the Westbelt slip ramp (1.7 miles)	On Katy Freeway between the Gessner slip ramp and the Westbelt slip ramp (1.7 miles)
4	A common route on Katy Freeway between the Westbelt slip ramp and SH 6 (4.6 miles)	

Source: METRO AVL Weekly Reports.

Table 12 shows a summary of a.m. peak-direction (eastbound) average travel times and speeds on the 4 sections for the transitway and the freeway traffic by 3 time periods--6:15 to 7:15 a.m., 7:15 to 8:15 a.m., and 8:15 to 9:15 a.m. Also shown are the standard deviations of the travel times within those time periods. Transitway traffic traveling from SH 6 to S.P.R.R. (a total distance of 13.2 miles) would, on the average, save about 11 minutes during the morning peak hour between 7:15 and 8:15 a.m. compared to the freeway traffic. The average time savings by the transitway traffic for the periods from 6:15 to 7:15 a.m. and from 8:15 to 9:15 a.m. were considerably less (about 3.6 and 1.2 minutes, respectively). Figure 19 shows a plot of total travel time from SH 6 to S.P.R.R. against the actual time-of-day for transitway and freeway traffic streams for every one-half hour. The figure indicates that, outside the period between 6:30 a.m. and 8:45 a.m., there was no time saving by choosing the transitway over the freeway.

In addition to the savings in mean travel times, the transitway was more reliable and predictable in terms of travel times than was the freeway. This was clearly indicated by the much smaller standard deviations of travel times on the transitway sections than on the freeway sections. Furthermore, the standard deviations of travel times on the transitway were within a very small range regardless of the travel distance or the time-of-day. On the

freeway, the standard deviations of travel times were higher between 7:15 and 8:15 a.m. (the peak hour) than any other time; they were also higher for longer travel than for shorter travel. Standard deviations of travel times provide measures of how well travel times by the freeway and by the transitway may be predicted. The benefits of the transitway in terms of travel times are twofold: reduced average travel times and a much smaller range of travel times.

Table 12 also shows average eastbound travel speeds for the 4 sections. Average travel speeds on the transitway lane were not sensitive to peak

Table 12. Summary of Travel Times and Speeds on Katy Transitway and Freeway for AM Peak Direction (Eastbound)

Section	Time-of-Day	Average Travel Time (mins.)		Standard Deviation of Travel Times (mins.)		Average Speed (mph)	
		Transitway	Freeway	Transitway	Freeway	Transitway	Freeway
1	6:15-7:15am	4.61	2.52	0.04	0.24	29	52
	7:15-8:15am	4.69	2.76	0.02	0.90	28	48
	8:15-9:15am	4.53	2.32	0.15	0.02	29	57
2	6:15-7:15am	5.00	8.90	0.14	2.77	56	32
	7:15-8:15am	5.08	12.87	0.28	4.46	56	22
	8:15-9:15am	4.83	7.19	0.01	1.27	58	39
3	6:15-7:15am	1.83	3.67	0.01	1.87	56	28
	7:15-8:15am	1.88	7.08	0.15	2.50	54	15
	8:15-9:15am	1.68	2.76	0.04	1.34	61	37
4	6:15-7:15am	10.16	10.16	2.23	2.23	27	27
	7:15-8:15am	15.66	15.66	3.19	3.19	18	18
	8:15-9:15am	5.94	5.94	1.26	1.26	46	46
Overall	6:15-7:15am	21.60	25.25	-	6.49	37	31
	7:15-8:15am	27.35	38.37	-	5.97	29	21
	8:15-9:15am	16.98	18.21	-	3.84	47	43

Sources: TTI Surveys.

traffic period or locations within the corridor. The average travel speeds on the transitway were mostly between 55-60 mph. Average travel speeds on

the freeway mainlanes varied widely, from 15 mph to 57 mph, depending on the time of day and the locations. Average travel speeds on the freeway were particularly low during the morning peak hour (from 7:15 to 8:15 a.m.). Figure 20 shows plots of average eastbound speeds over the entire 13.2 miles from SH 6 to S.P.R.R. during the peak hour (7:15-8:15 a.m.) of a typical day for both the transitway and the freeway traffic.

Table 13 summarizes average travel times and speeds over the 4 sections for the p.m. peak-direction (westbound) by 3 time periods 3:30-4:30 p.m., 4:30-5:30 p.m., and 5:30-6:30 p.m., for both the transitway and the freeway traffic. The average time saving for the transitway traffic over the freeway traffic in traveling from S.P.R.R. to SH 6 was over 5 minutes during the peak hour (4:30 to 5:30 p.m.). The time saving was almost 5 minutes between 5:30 and 6:30 p.m. However, between 3:30 and 4:30 p.m., the overall travel time for the transitway traffic was actually 0.6 minutes higher than that for the freeway traffic. Figure 21 shows plots of average total travel time by time-of-day for the transitway and the freeway traffic by one-half-hour intervals. The figure indicates that, outside the period between 4:15 p.m. and 6:30 p.m., there was no time saved by using the transitway to travel from S.P.R.R. to SH 6.

As with the eastbound traffic in the a.m. peak, the standard deviations of travel times on the transitway lane were much lower than those on the freeway mainlanes. Whereas the standard deviations of travel times on the freeway were sensitive to the peak period and the length of travel, the travel times on the transitway were not. Therefore, the transitway offered faster travel speeds and a higher degree of time reliability than did the freeway.

Table 13 also indicates that the average travel speed on the transitway lane was 56-59 mph, and that these speeds were not sensitive to the peak hour or the locations within the corridor. On the other hand, average travel speeds on the freeway mainlanes varied widely from 20 mph to 59 mph, depending on the time of day and the locations. Average travel speeds for the freeway mainlanes were particularly low between 4:30 p.m. and 6:30 p.m. Figure 22 shows plots of the westbound average travel speeds from S.P.R.R. to

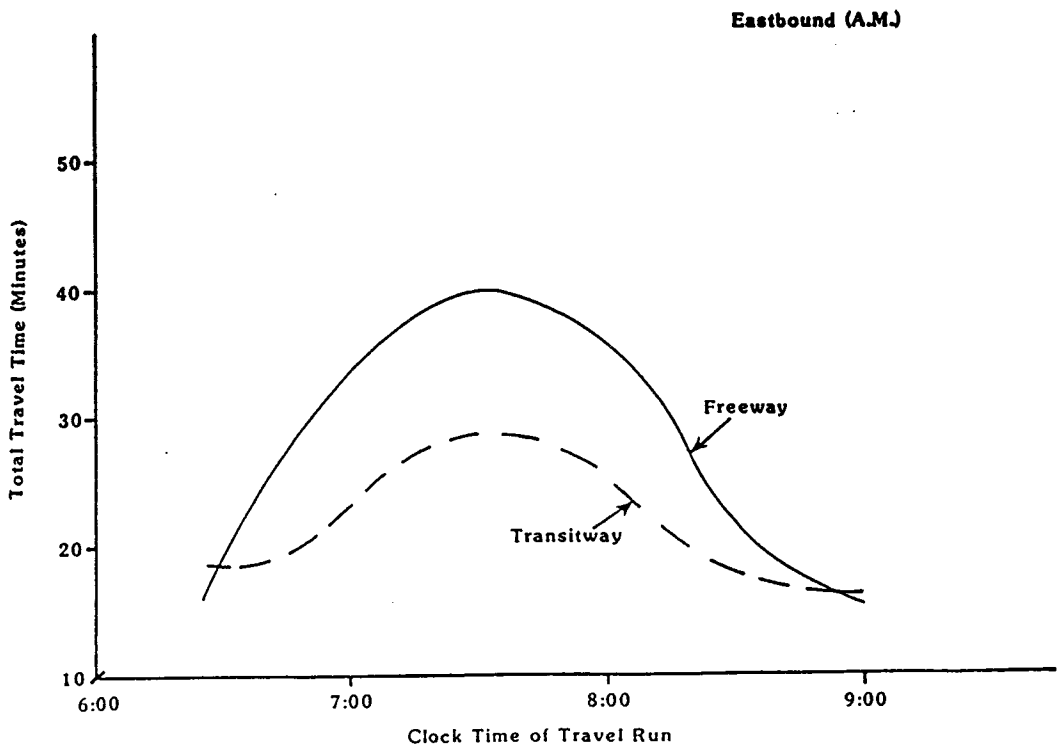


Figure 19. Eastbound Travel Time for Transitway and Freeway Traffic in the Morning

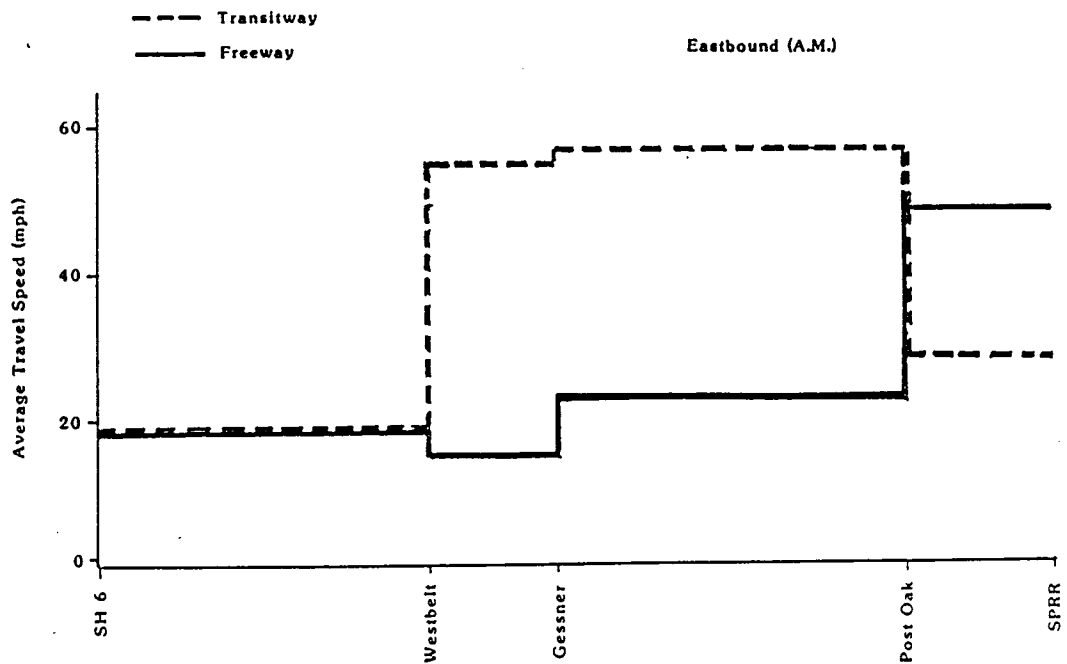


Figure 20. Eastbound Travel Speed Profile for Transitway and Freeway Traffic Between 7:15 and 8:15 A.M.

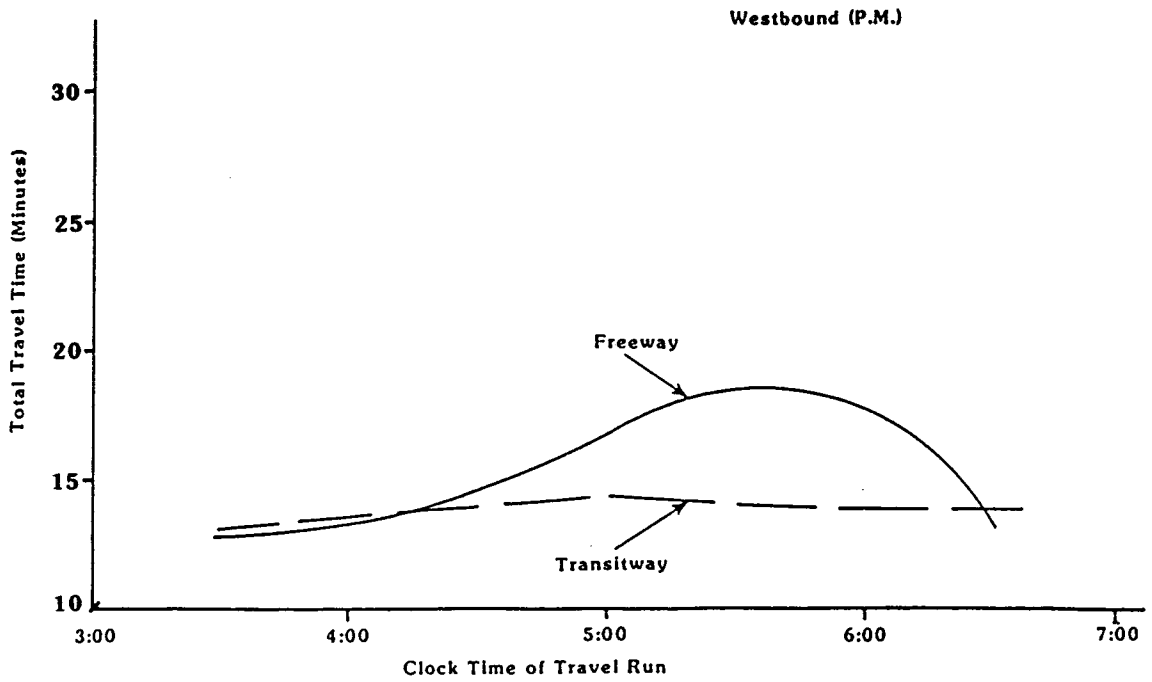


Figure 21. Westbound Travel Time for Transitway and Freeway Traffic in the Afternoon

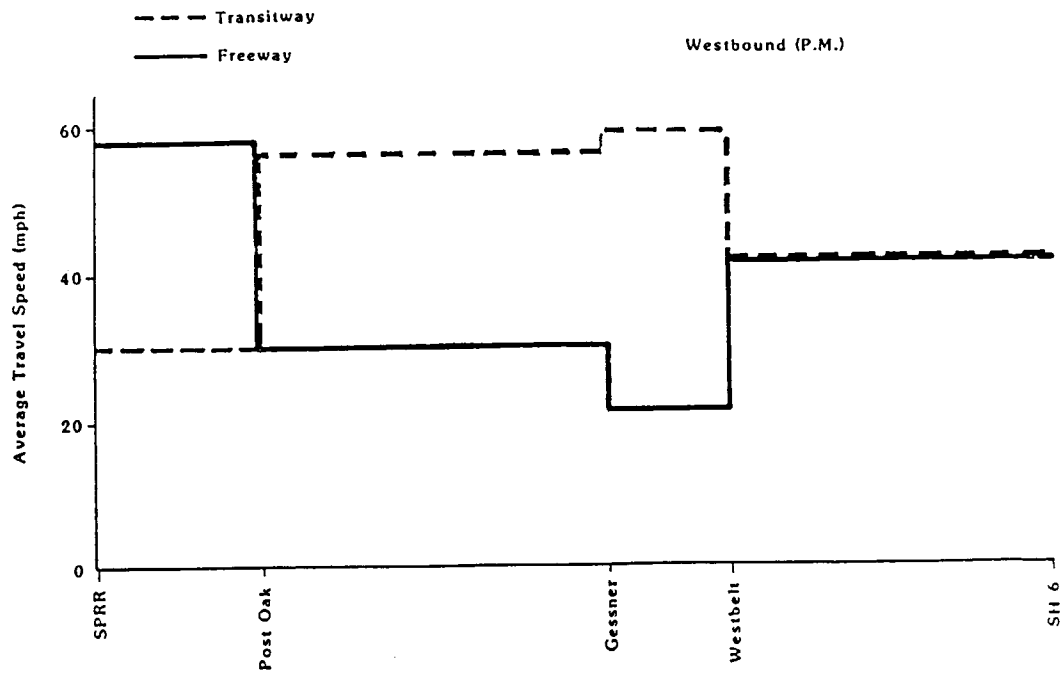


Figure 22. Westbound Travel Speed Profile for Transitway and Freeway Traffic Between 4:30 and 5:30 P.M.

SH 6 during the peak hour (4:30 - 5:30 p.m.) for the transitway and the freeway traffic streams.

Table 13. Summary of Travel Times and Speeds on Katy Transitway and Freeway for the PM Peak Direction (Westbound)

Section	Time-of-Day	Average Travel Time (mins.)		Standard Deviation of Travel Times (mins.)		Average Speed (mph)	
		Transitway	Freeway	Transitway	Freeway	Transitway	Freeway
1	3:30-4:30pm	4.43	2.31	0.06	0.06	30	57
	4:30-5:30pm	4.54	2.28	0.18	0.11	29	58
	5:30-6:30pm	4.40	2.23	0.04	0.01	30	59
2	3:30-4:30pm	4.84	5.41	0.05	0.43	58	52
	4:30-5:30pm	5.01	9.34	0.11	3.95	56	30
	5:30-6:30pm	4.83	8.52	0.18	5.74	58	33
3	3:30-4:30pm	1.73	2.64	0.01	0.50	59	39
	4:30-5:30pm	1.73	4.78	0.04	1.32	59	21
	5:30-6:30pm	1.75	4.98	0.17	1.93	58	20
4	3:30-4:30pm	5.60	5.60	0.42	0.42	49	49
	4:30-5:30pm	6.68	6.68	0.51	0.51	41	41
	5:30-6:30pm	6.49	6.49	0.70	0.70	43	43
Overall	3:30-4:30pm	16.60	15.96	-	0.41	48	50
	4:30-5:30pm	17.96	23.08	-	4.83	44	34
	5:30-6:30pm	17.47	22.24	-	8.07	45	36

Sources: TTI Surveys.

Transitway-Related Accidents

There were few accidents which were transitway-related or happening within the transitway. Between 11/1/84 and 10/31/85 (the first year of operation), there were 4 transitway-related accidents. Between 11/1/85 and 10/31/86 (the second year of operation), there were 2 transitway-related accidents, all involving 2+ carpools. The following is a case-by-case summary of these 6 accidents, 5 of which occurred at the West Belt or the Gessner terminals.

October 8, 1986: The accident occurred at 3:30 p.m. and involved a westbound 2+ carpool on the transitway losing control and hitting the CMB (south wall) in the rain. The accident happened on the transitway between Bingle and Voss. No injuries were reported.

September 4, 1986: The accident occurred at 10:06 a.m. at the West Belt transitway entrance. It involved two eastbound 2+ carpools attempting to enter the transitway at the same time. While one of the carpools was attempting to enter the transitway, the other carpool, traveling in the middle lane of the freeway, attempted to do likewise. The latter forced the former to crash into the north gate of the entrance. No injuries were reported. The weather at the time of accident was good.

August 1, 1985: The accident occurred outside the transitway at 5:25 a.m. near the West Belt transitway entrance. A vehicle was hit in the rear by another vehicle in the freeway lane near the West Belt gate, causing it to be pushed into the West Belt entrance. The pushed vehicle in turn hit the transitway wrecker unit. A minor injury was reported. The weather at the time of accident was good.

February 21, 1985: The accident occurred at 5:06 p.m. at the Gessner transitway exit. It involved a westbound car in the median lane of the freeway swerving and striking a bus which was in the process of merging into the freeway after exiting the transitway. One minor injury was reported. The weather at the time of accident was good.

December 27, 1984: The accident occurred at 5:50 p.m. at the Gessner transitway entrance gate. An eastbound car on the Katy Freeway lost control and struck the guardrails of the transitway entrance gate. It was deflected from the guardrails and struck another eastbound car on the freeway. No injuries were reported. The weather at the time of accident was good.

December 11, 1984: The accident occurred at 6:10 p.m. at the Gessner transitway entrance gate. An eastbound car on the Katy Freeway struck the guardrails at the transitway gate. No injuries were reported. The weather at the time of accident was good but the light condition was dark.

The accident rate for the Katy Freeway Transitway in the second year of operation is calculated to be 0.96 accidents per million vehicle miles (MVM). For the same time period (November, 1985 to October, 1986) the North Freeway Transitway experienced an accident rate of 1.07 accidents/MVM.

This accident rate was less than that exhibited by the adjacent Katy Freeway mainlanes of 1.34 accidents/MVM for the same corresponding period of months. This rate was also considerably less than the accident rate of 8.52 accidents/MVM for the first year of transitway operation. This difference is due to a 50% reduction in accidents (four to two) combined with a 400% increase in vehicle miles of travel on the transitway.

FREEWAY EFFECTS DURING SECOND YEAR OF OPERATION

This section describes traffic volumes, vehicle occupancy rates, travel speeds, 15-minute flow rates, and accident experience on the Katy Freeway mainlanes. These characteristics were compared among 3 time periods: the year before the opening of the transitway; during the first year of transitway operation; and during the second year of transitway operation.

Traffic Volumes on Freeway Mainlanes

Quarterly traffic volumes on the Katy Freeway mainlanes during the 3-hour morning peak period (6:30 to 9:30 a.m.) and the 3-hour afternoon peak period (4:00 to 7:00 p.m.) are shown in Tables 14 and 15, respectively. The tables include both the number of vehicle and person trips on the mainlanes for the year before the transitway, during the first year of transitway operation, and during the second year of transitway operation. These mainlane volumes were measured near the transitway entrance/exit ramp at Gessner. As can be seen, these volumes do not approach capacity levels due to the severe congestion experienced throughout the peak periods (queueing conditions in level-of-service "F").

Tables 14 and 15 indicate that the year-to-year changes in traffic volumes on the mainlanes, as represented by the annual average volumes, for the morning and the afternoon periods were very similar. For vehicle traffic on the mainlanes, the volume, averaged over the morning and the afternoon, during the first year of transitway operation rose by about 6 percent relative to the volume in the year preceding the transitway. Since then, the increase in vehicle traffic on the mainlanes was small. For person traffic on the mainlanes, however, the volume averaged over the morning and the afternoon during the first year of transitway operation decreased by nearly 3 percent relative to the volume in the year preceding the transitway. Since then, the decrease in person traffic on the mainlanes was small.

Table 14. Eastbound Flows on Katy Freeway Mainlanes Between 6:30 and 9:30am*

Month	Before Transitway 11/1/83 to 10/31/84		First Year of Transitway 11/1/84 to 10/31/85		Second Year of Transitway 11/1/85 to 10/31/86	
	# Vehicles	# Persons	# Vehicles	# Persons	# Vehicles	# Persons
December	10851	13347	11356	13011	13840	1589
March	11167	13392	11948	13214	10791	11926
June	11062	13970	12012	13930	11814	13449
September	10729	13110	12145	13565	12700	13794
Annual Average	10952	13455	11865	13430	12286	13767

* Measured near Gessner entrance/exit of transitway mainlane; level-of-service "F".

Table 15. Westbound Flows on Katy Freeway Mainlanes Between 4:00 and 7:00pm*

Month	Before Transitway 11/1/83 to 10/31/84		First Year of Transitway 11/1/84 to 10/31/85		Second Year of Transitway 11/1/85 to 10/31/86	
	# Vehicles	# Persons	# Vehicles	# Persons	# Vehicles	# Persons
December	12250	16176	12608	15109	11876	14363
March	12347	16425	12597	15097	12051	14410
June	10730	14715	11877	14540	11474	13523
September	11651	15170	12116	14680	13056	14522
Annual Average	11745	15622	12300	14857	12114	14204

* Measured near Gessner entrance/exit of transitway mainlane; level-of-service "F".

Occupancy Rates On Freeway Mainlanes

Vehicle occupancy rates on the Katy Freeway mainlanes since November 1983 are plotted in Figure 23. The figure indicates that the mean vehicle occupancy rate on the freeway, averaged over the morning and the afternoon, before the opening of the Katy Transitway was about 1.28 persons per vehicle. Occupancy rates dropped sharply after the transitway became operational in November 1984 to the mean rate of 1.19 persons per vehicle. When 3+ carpools were authorized in November 1985, the mean rate became 1.16 persons per vehicle. After 2+ carpools were allowed in August 1986, the mean occupancy rate decreased to 1.10 persons per vehicle.

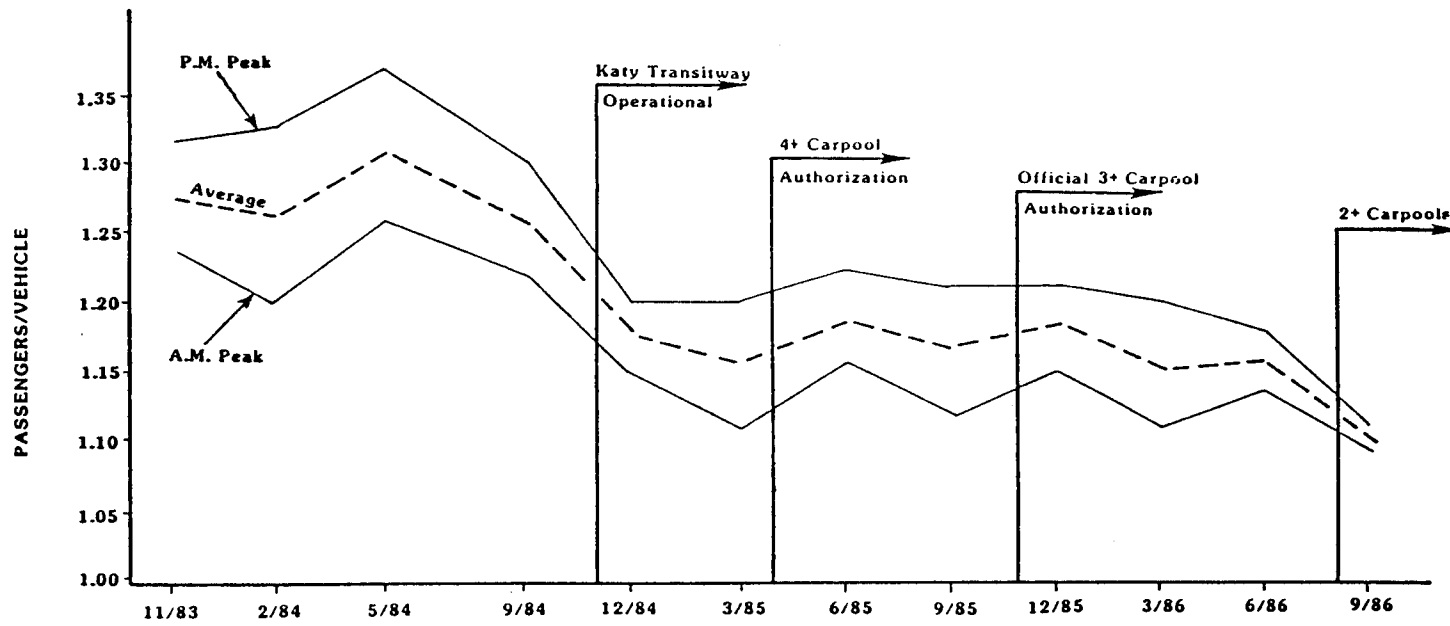


Figure 23. Freeway Mainlane Occupancy Rates

Average Travel Speeds and 15-Minute Flow Rates on Freeway Mainlanes

Traffic flows on the Katy Freeway mainlanes were investigated in terms of average travel speeds and 15-minute flow volumes for the morning and the afternoon periods. Traffic surveys conducted by TTI in the following months were examined to represent 4 different time periods: 1) Before transitway operation -- June, 1983; 2) First year of transitway operation -- June, 1985; 3) Second year of transitway operation with 3+ carpool authorization -- June, 1986; and, 4) Second year of transitway operation with 2+ carpools allowed and no authorization -- September, 1986.

Figures 24 and 25 show plots of average travel speeds and plots of the morning 15-minute volumes in the eastbound direction for the Katy Freeway, respectively, as measured near Gessner entrance/exit of transitway (Level-of-Service "F"). Figure 24 shows that average travel speeds on the Katy Freeway mainlanes between 6:00 and 7:00 a.m. as well as between 8:15 and 9:30 a.m. improved in the second year relative to those in the first year of transitway operation. Only one day of traffic data was recorded for each of the 4 time periods; therefore, the random variations inherent in the traffic conditions make it difficult to be conclusive about the transitway influence on the traffic flow characteristics (speeds and flow rates) of the Katy Freeway mainlanes in the morning. Both Figures 24 and 25 nonetheless indicate that the traffic conditions in the morning, as measured by average travel speeds and 15-minute flow volumes, were at least as good in the second year as those in the first year of transitway operation or before the opening of the transitway (slightly more vehicles at essentially the same speed).

Figure 26 additionally emphasizes this observation as shown over the entire freeway length of study (SH 6 to SPRR). This figure depicts average mainlane travel speed by section for the a.m. peak period (eastbound direction). As can be seen, little change in travel time was indicated before and after introduction of the transitway.

For the afternoon period, Figures 27 and 28 show plots of average travel speeds and 15-minute flow volumes in the westbound (p.m.) direction on the Katy Freeway, respectively, again measured near Gessner. The figures

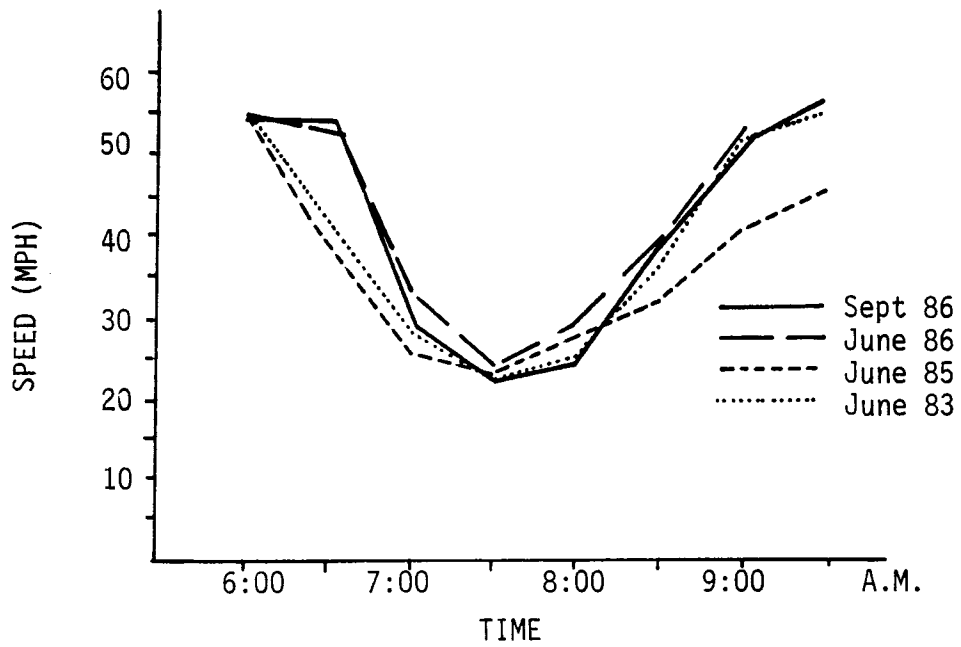


Figure 24. Freeway Mainlane Eastbound Travel Speeds Between 6:00 and 9:30 A.M.

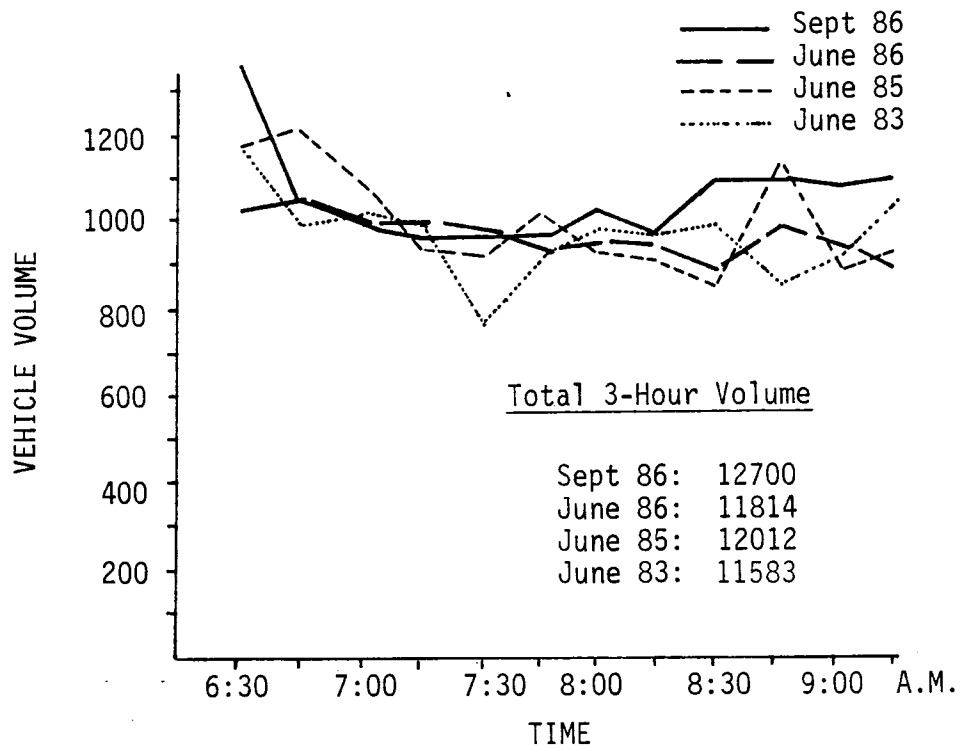


Figure 25. Freeway Mainlane Eastbound 15-Minute Flow Volumes

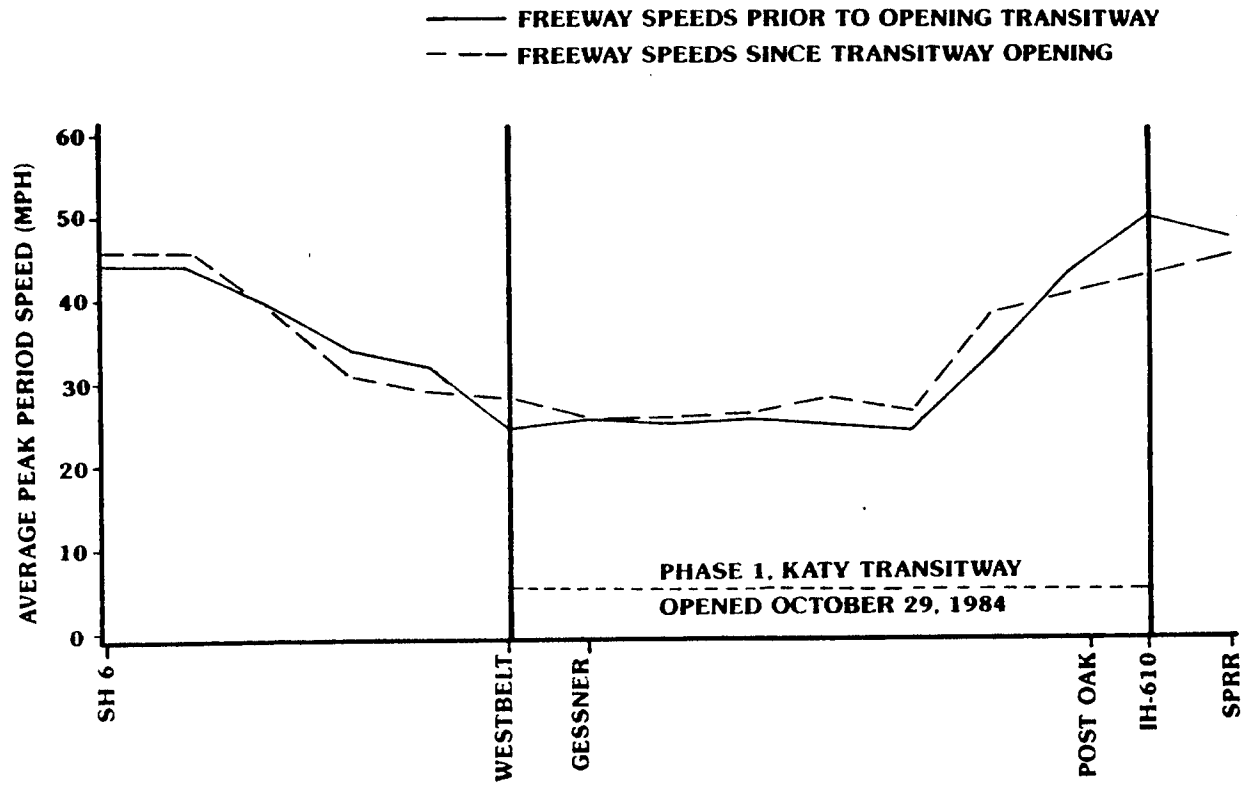


Figure 26. Freeway Mainline Eastbound Travel Speeds by Section

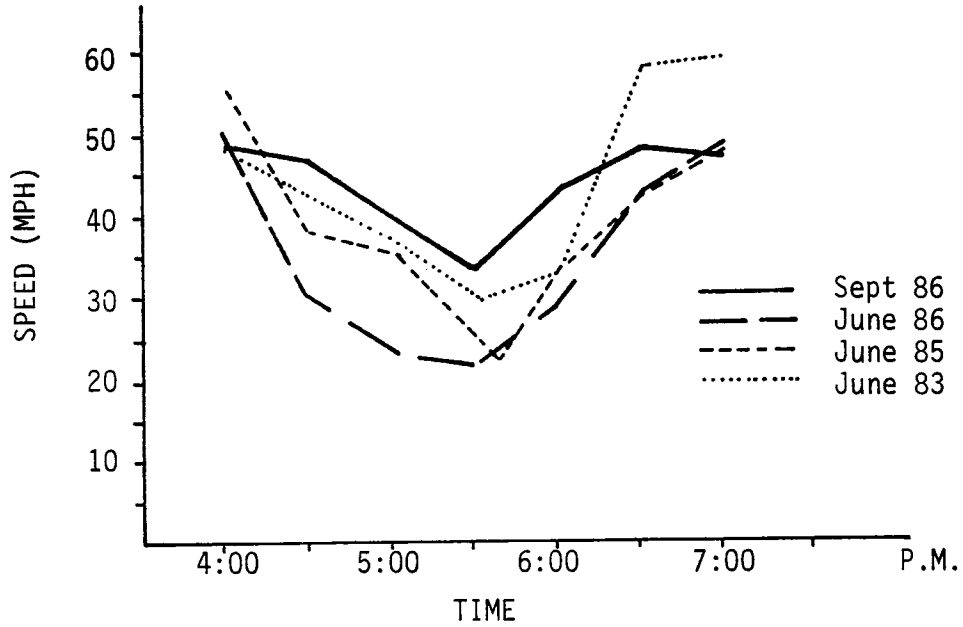


Figure 27. Freeway Mainlane Westbound Travel Speeds Between 4:00 and 7:00 P.M.

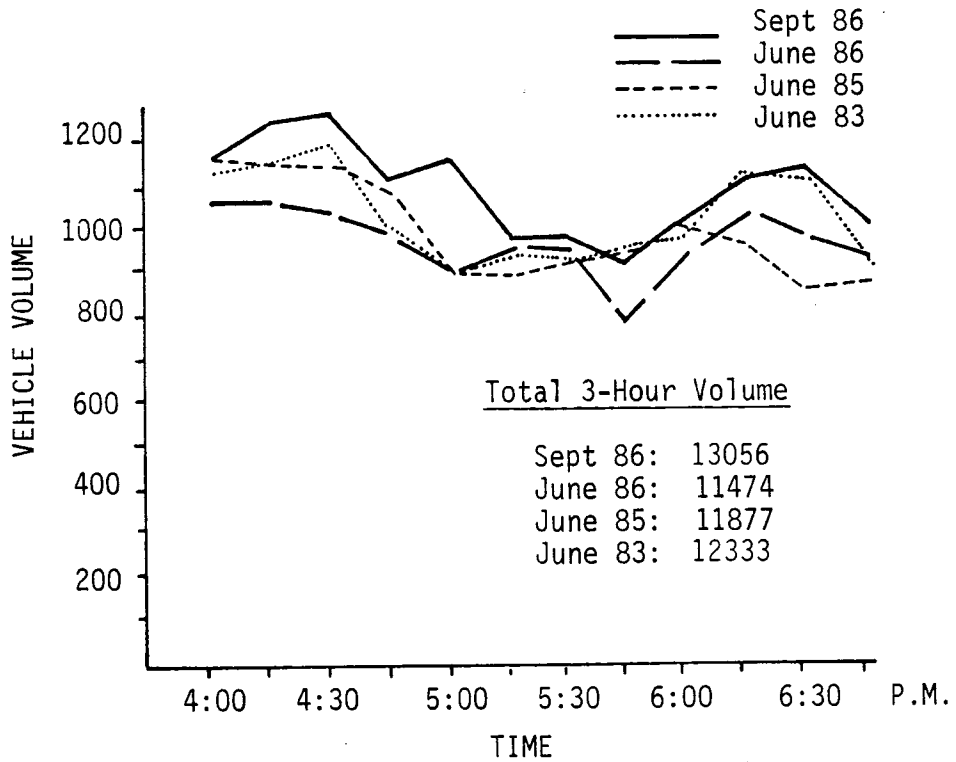


Figure 28. Freeway Mainlane Westbound 15-Minute Flow Volumes

indicate that the traffic conditions in the afternoon on the Katy Freeway after 2+ carpools were introduced were better than the traffic conditions in the other 3 time periods, as illustrated by higher average travel speeds and 15-minute flow volumes. However, as mentioned previously, the random variations inherent in the traffic conditions and the single-day traffic observations made it difficult to further generalize the results.

Accidents on Freeway Mainlanes

The number of reported accidents on the Katy Freeway mainlanes since 1982 are shown in Table 16. The table compares the number of accidents before the transitway construction, during the construction, during the first year and the second year of transitway operation. Because the numbers of reporting days for these 4 time periods were not the same, the numbers of reported accidents were adjusted to reflect the numbers of accidents per year (365 days) in order to provide a common basis for comparison. The table indicates that, during the transitway construction, the number of accidents per year went up by 10.5 percent relative to the level before the transitway construction. During the first year of transitway operation, however, the number of accidents decreased by about 18 percent from the level during the transitway construction. During the second year of transitway operation, the number of accidents again decreased by nearly 19 percent compared with the number in the first year of transitway operation. The calculated accident rate is 1.34 accidents/MVM for the comparable length of Katy Freeway (6.4 miles) adjacent to the transitway.

Total Traffic on Katy Freeway

Tables 17 and 18 show the volumes of vehicles and persons on the combined Katy Freeway mainlanes and transitway for the 3-hour morning period (6:30-9:30 a.m.) and the 3-hour afternoon period (4:00-7:00 p.m.) for the year preceding the transitway opening, the first year of transitway operation, and the second year of transitway operation. This data was measured near the Gessner entrance/exit on the transitway. As stated before, the freeway mainlanes are highly congested (Level-of-Service "F") at this location during the peak periods.

Table 16. Number of Accidents on the Katy Freeway Between Westbelt Drive and Washington Avenue

Year	Number of Reported Accidents	Number of Reporting Days	Adjusted Number of Accidents (per 365 days)	Accident/ Million Vehicle-Miles	% Changes from Preceding Year
6/82 - 5/83 Before Transitway	754	365	754	1.53	-
6/83 - 10/84 During Construction	1182	518	833	1.68	+10.5
11/84 - 9/85 First Year	626	334	684	1.36	-17.9
11/85 - 10/86	556	365	556	1.34	-18.7

Table 17. Eastbound Flows on Katy Freeway Corridor* Between 6:30 and 9:30am (At Bunker Hill)

Month	Before Transitway 11/1/83 to 10/31/84		First Year of Transitway 11/1/84 to 10/31/85		Second Year of Transitway 11/1/85 to 10/31/86	
	# Vehicles	# Persons	# Vehicles	# Persons	# Vehicles	# Persons
December	10851	13347	11465	14979	14061	18799
March	11167	13392	12067	15449	11024	14964
June	11062	13970	12140	16364	12014	16239
September	10729	13110	12316	16148	14541	20358
Annual Average	10952	13455	11997	15735	12910	17590

* Katy Freeway corridor includes the freeway mainlanes and the transitway.

Table 18. Westbound Flows on Katy Freeway Corridor* Between 4:00 and 7:00pm (At Bunker Hill)

Month	Before Transitway 11/1/83 to 10/31/84		First Year of Transitway 11/1/84 to 10/31/85		Second Year of Transitway 11/1/85 to 10/31/86	
	# Vehicles	# Persons	# Vehicles	# Persons	# Vehicles	# Persons
December	12250	16176	12730	17276	12088	17413
March	12347	16425	12729	17510	12266	17304
June	10730	14713	12019	16959	11694	16562
September	11651	15170	12291	17549	14591	20165
Annual Average	11745	15622	12442	17324	12660	17861

* Katy Freeway corridor includes the freeway mainlanes and the transitway.

The tables indicate that the year-to-year changes in the total freeway traffic volumes in the morning and in the afternoon periods, as measured by the annual average volumes, followed similar trends. For total freeway vehicle traffic, the volume in the first year of transitway operation during the morning and the afternoon periods increased, on the average, by about 8 percent from the level in the year prior to the opening of the transitway. Compared with the traffic volume in the first year of transitway operation, the volume in the second year increased by about 5 percent. However, when comparing September, 1984 (before transitway) to September, 1986 (after 2+ carpools allowed) total daily freeway volume shows an increase of 30%.

For person movement, the magnitude of the increases (averaged over the morning and the afternoon periods) was even larger: 15 percent during the first year of transitway operation, and another 7 percent in the second year of transitway operation. And, when comparing the person movement between September, 1984 to September, 1986, an increase of approximately 45% is exhibited.

Occupancy Rate for Total Katy Freeway

For the total Katy Freeway (mainlanes plus transitway), vehicle occupancy rates rose steadily since the Katy Transitway opened in November 1984. Figure 29 shows plots of vehicle occupancy rates since November 1983 for the morning period (6:30-9:30 a.m.), the afternoon period (4:00-7:00 p.m.), and the total daily. The figure indicates that vehicle occupancy rates in the morning were always lower than those in the afternoon. The total daily occupancy rate before the opening of the transitway was around 1.28 persons per vehicle. The rate rose to about 1.33 persons per vehicle after the transitway was open. The occupancy rate rose further to about 1.37 persons per vehicle after 4+ carpools were authorized and remained at that level until 2+ carpools were allowed. Since then, the total daily occupancy rate was 1.39 persons per vehicle.

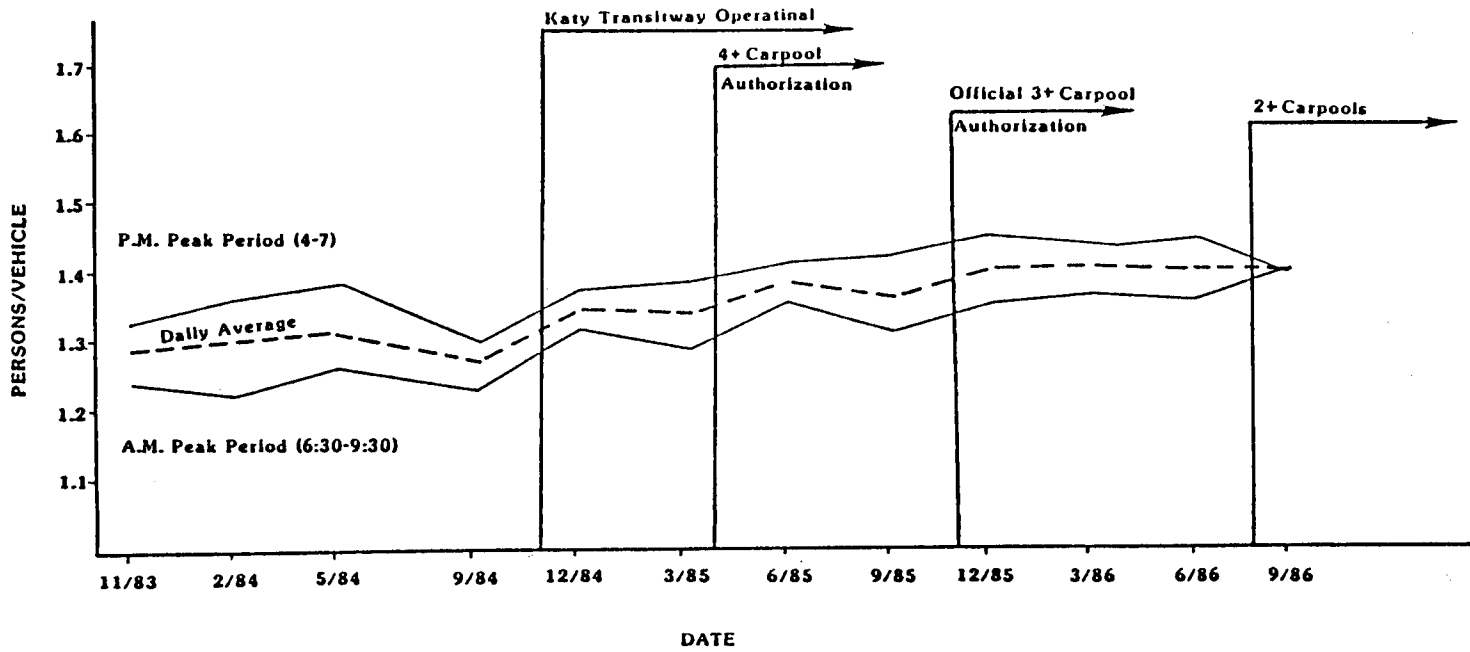
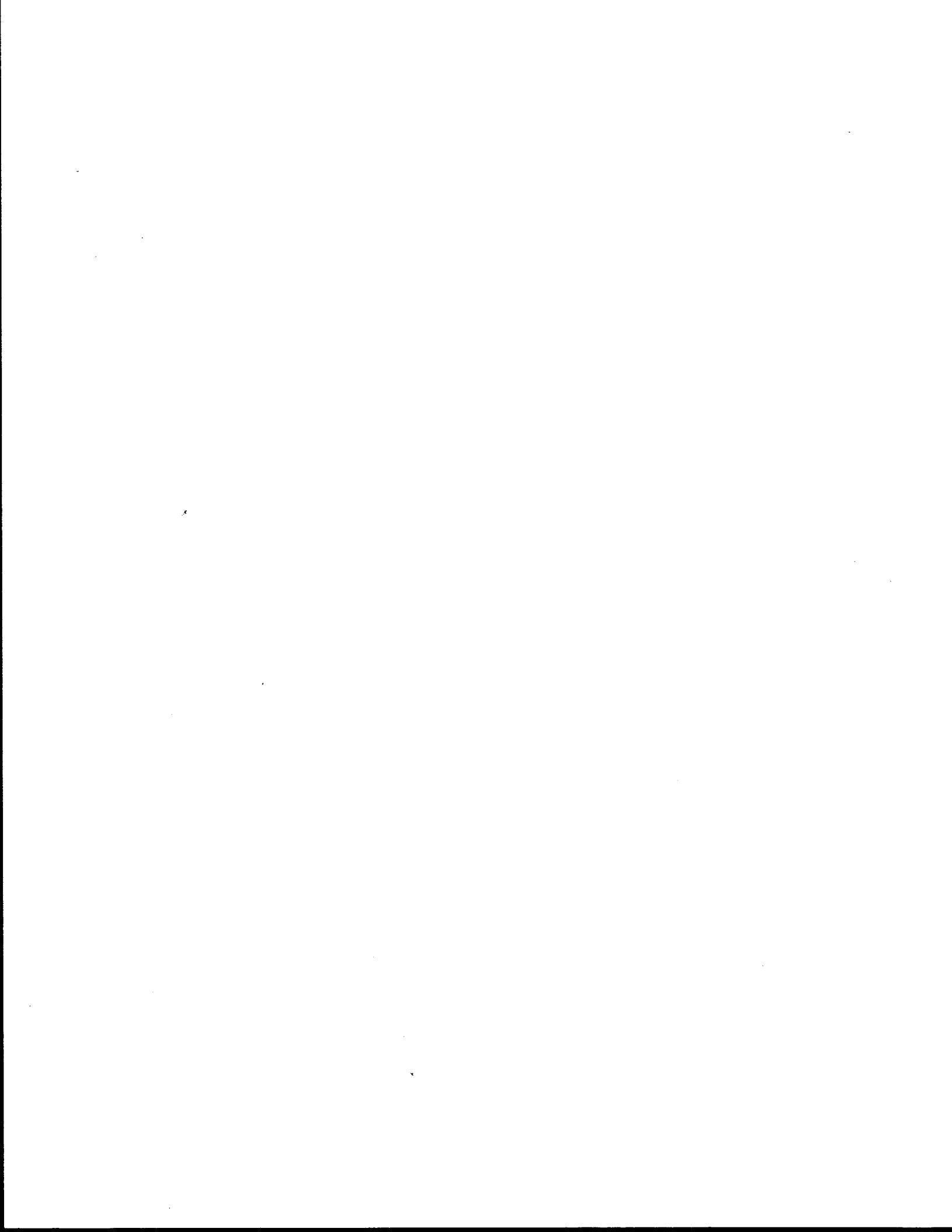


Figure 29. Katy Freeway Corridor (Combined Freeway and Transitway) Occupancy Rates



TRANSIT EFFECTS DURING SECOND YEAR OF OPERATION
Transit Service and Ridership

Previous reports have shown that provision of priority treatment on a freeway can essentially double the bus transit mode split for work trips destined to downtown. These mode splits are in the range of 15% to 20% at park-and-ride lots in corridors without priority treatment; bus mode split at park-and-ride lots with priority treatment tend to be in excess of 30%.

Mode split data for the I-10 Katy Transitway are shown in Table 19. This mode split is measured at Bunker Hill, which is the last opportunity to enter the transitway. Table 19 shows a.m. work trips to the major activity centers; the percentage of those trips that are on the freeway and on the transitway are also shown.

Table 19. Mode Split for a.m. Peak-Period Person Trips, I-10 Katy
 Freeway at Bunker Hill

Destination	Freeway Mainlanes	Transitway				Total
		Total	Bus	Van	2+ Carpool	
Downtown	5600 (59%)	3830 (41%)	1630	360	1840	9430
City Post Oak	3200 (76%)	990 (24%)	0	70	920	4190
Greenway Plaza	1000 (75%)	340 (25%)	0	20	320	1340
Texas Med. Center	1000 (81%)	230 (19%)	20	30	180	1230
Other	5300 (78%)	1470 (22%)	70	70	1330	6770
Total	16100 (70%)	6860 (30%)	1720	550	4590	22960

Source: Texas Transportation Institute Surveys, October 1986.

Data presented previously in Figure 16 are indicative of the impact of a transitway on mode split. In effect, provision of a transitway resulted in a 100% increase in the number of vehicles parking in corridor park-and-ride facilities.

This increase is further indicated by Figure 30. That figure shows bus volumes and bus ridership before and after the opening of the transitway. In effect, that transitway allowed Metro to double the volume of buses being operated without greatly impacting the average occupancy per bus.

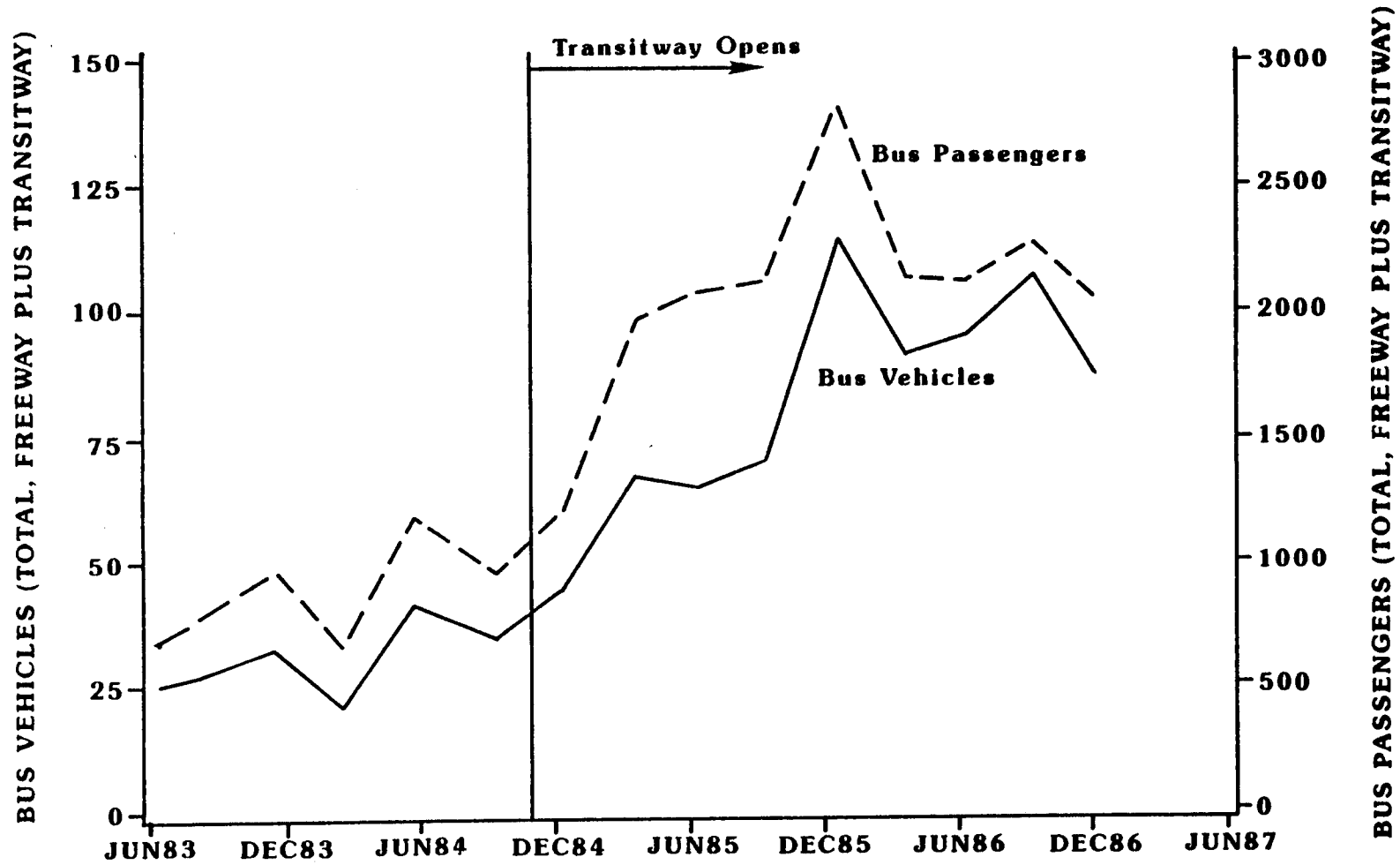


Figure 30. A.M. Peak-Period (5:45 - 9:30 a.m.) Bus Vehicle and Bus Passenger Trips, at Bunker Hill Combined Katy Freeway and Transitway

BENEFITS OF TRANSITWAY

Based on Tables 12 and 13, which show comparative travel times for the transitway and the freeway traffic streams between SH 6 and S.P.R.R., the time-saving benefit accrued to all bus passengers, vanpool and carpool occupants using the transitway as opposed to the parallel freeway mainlanes during the second year of operation was computed. The amount of time saved was computed based on the average time savings for the 3 time periods in the morning (eastbound) and the 3 time periods in the afternoon (westbound) as shown in Table 20. Time-of-day outside those shown in Table 20 were not considered in calculating the benefit because commuters, on the average, were not shown to have saved time by choosing the transitway over the parallel freeway mainlanes. In fact, outside these 6 time periods, slight increases in travel times for the transitway traffic were indicated. Therefore, the benefit in person-hours saved as shown in Table 20 was the upper bound of time-savings benefit in using the transitway instead of the parallel freeway mainlanes. However, Table 19 does not consider the travel time savings that accrue to transitway users due to incidents on the freeway.

Table 20. Estimate of Person-Hours Saved by the Transitway During the Second Year of Operation (11/1/85 to 10/31/86)

Time	Direction of Travel	Time Saved Per Trip by Using Transitway (minutes)	Annual* Total Person Trips	Annual Time Saved (Person Hours)
6:15-7:15am	Eastbound	+3.65	416,333	25,327
7:15-8:15am	Eastbound	+11.02	445,542	81,831
8:15-9:15am	Eastbound	+1.23	108,896	2,232
3:30-4:30pm	Westbound	-0.64	194,021	-2,070
4:30-5:30pm	Westbound	+5.12	439,792	37,529
5:30-6:30pm	Westbound	+4.77	284,813	22,643
Total			1,889,397	167,492

*These were estimated from the monthly surveys conducted by TTI. The figures included bus passengers, vanpool and carpool occupants. The figures assumed 251 days of Transitway operation from 11/1/85 to 10/31/86.

Placing a value of \$8.03 per person-hour of delay (6), the total travel time saving during the second year of transitway operation (from 11/1/85 to 10/31/86) translated into an annual benefit of \$1.35 million. This benefit was based on 250 days of transitway operation (52 weeks, 5 days/week, and 10 holidays). The benefit per day was 670 person-hours saved. This represented an approximate 7 percent increase in the number of person-hours saved for the second year relative to the first year of transitway operation.

SUMMARY AND CONCLUSIONS

The Katy Transitway between Post Oak and Gessner Drive was opened to traffic on October 29, 1984. This provided a 4.7 mile transitway. On May 2, 1985, the transitway was extended from Gessner Drive to West Belt Drive, resulting in a total of 6.4 miles of transitway. Initially, during the first year of operation, only 4+ authorized vehicles were allowed to use the facility.

During the first year of operation, daily vehicles using the transitway increased from 238 to 386 while the daily person trips on the transitway increased from 4163 to 6147. There were benefits in travel time savings to transitway traffic of 7 and 8 minutes in the morning and in the afternoon, respectively. These time savings translated into an annual user benefit of \$1.23 million. The transitway was operating smoothly, with an average of less than 2 vehicles per month being disabled within the facility. The impacts of the transitway on freeway operations were minimal. Freeway volumes and travel times did not change appreciably, nor did accident rates.

The second year of transitway operation was characterized by a nine-month period (November 1985 to August 10, 1986) when only authorized vehicles were allowed to use the transitway (i.e., buses, authorized vanpools and 3+ carpools), followed by a 3-month period (August 11, 1986 to October 31, 1986) when the authorization was removed and 2+ carpools were allowed to use the transitway. The introduction of 2+ carpools and alleviation of the authorization process resulted in the number of vehicles and persons using the transitway to increase to about 4300 vehicles and nearly 14,000 persons per day, respectively. Peak-hour demand on the transitway was represented by approximately 1100 vehicles and 3600 passengers.

The time savings for the transitway traffic relative to traffic on the parallel freeway mainlanes remained substantial, averaging between 5 and 11 minutes depending on time period and direction of travel. The benefit in terms of time savings accrued to the transitway users during the second year of transitway operation was estimated to be about \$1.35 million per year, and about 670 person-hours of savings per day. This represented an approximate 7

percent increase in the number of person-hour savings per day relative to the first year of transitway operation.

The introduction of 2+ carpools and dropping of the authorization requirement brought about some minor operational problems. The disabled vehicle rate on the transitway increased to about 23 vehicles per month, about 50 percent of which required towing. The number of vehicles using the transitway in violation of the occupancy requirement increased more than twofold.

The accident rate on the transitway during the second year of operation was calculated to be 0.96 accidents per million vehicle miles (MVM) which was a substantial decrease over the first year (8.52 accidents per MVM). This compares to an accident rate on the adjacent freeway mainlanes of 1.34 accidents per MVM during the second year of transitway operation.

The transitway and the freeway mainlanes combined carried 5 percent more vehicles and 7 percent more persons in the second year than in the first year of transitway operation. Traffic flow conditions on the freeway mainlanes, as measured by average operating speeds, have remained essentially the same when compared to pre-transitway operations; while person movement has increased by approximately 45 percent.

Table 21 provides a summary of performance measures of the Katy Transitway during the first and second years of operation. As can be seen, there were significant increases in both vehicle and passenger demand and decreases in accident and breakdown rates.

As the Katy Freeway transitway is extended farther west to State Highway 6, the reduction in travel times for the transitway traffic will be more substantial, and greater utilization of the transitway as well as the park-and-ride facilities is anticipated.

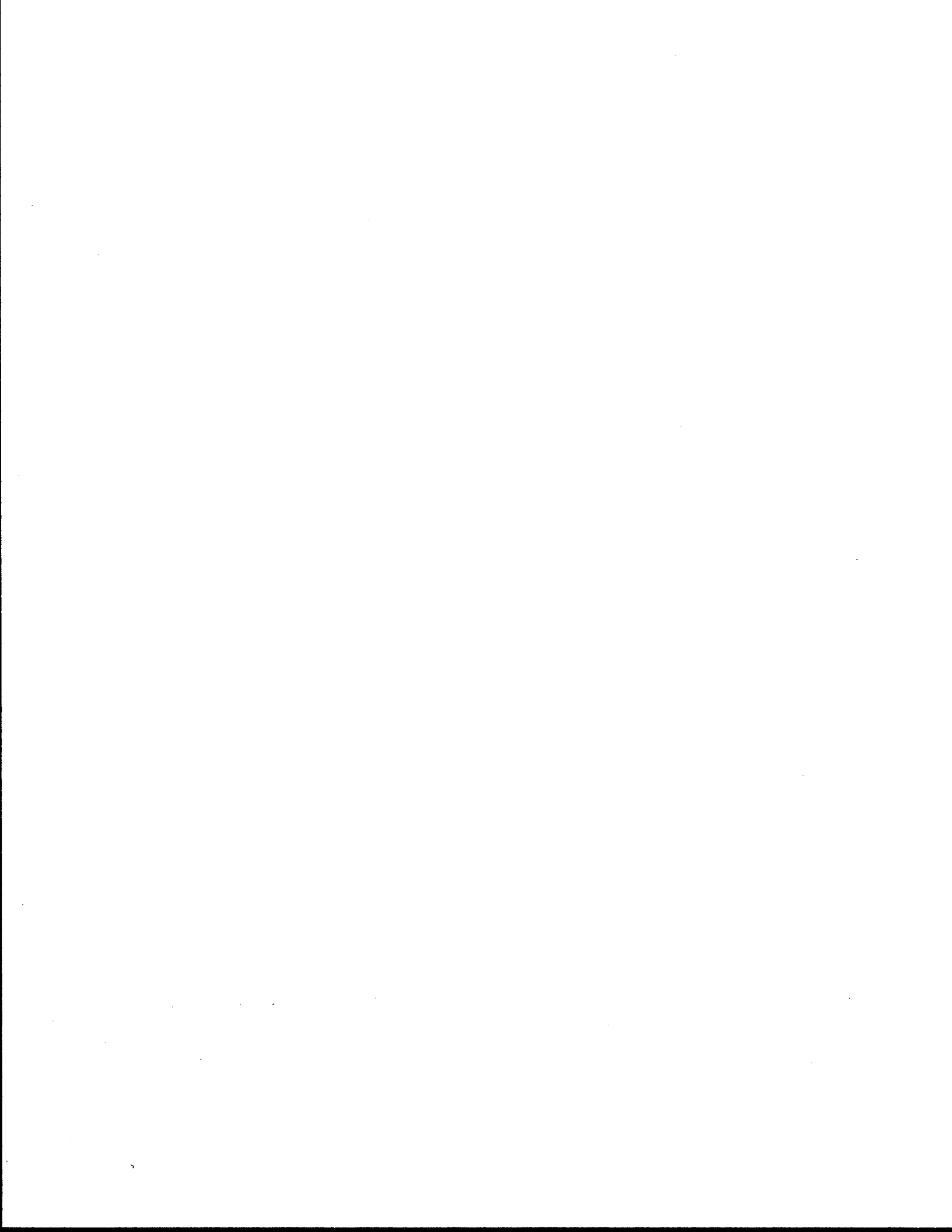
Table 21. Summary of Katy Transitway Performance Measures

Performance Measure	11/84 to 10/85 ¹	11/85 to 10/86 ²	Change
Total Vehicle Demand			
Buses	26,376	38,871	
Vanpools	40,662	35,784	
Carpools	6,214	250,887	
TOTAL	73,252	325,542	+344%
Total Vehicle Miles of Travel			
Buses	168,806	248,774	
Vanpools	260,237	229,018	
Carpools	39,770	1,605,677	
TOTAL	468,813	2,083,469	+344%
Total Passenger Demand			
Buses	902,370	1,126,300	
Vanpools	360,570	298,795	
Carpools	23,100	586,085	
TOTAL	1,286,040	2,011,180	+ 56%
Average Daily Transitway Delay Savings (passenger-hours)	627	670	+ 7%
Average Vehicle Miles Traveled Per Breakdown	26,045	18,898	- 38%
Transitway Accident Rate (Accident/million vehicle-miles)	8.52	0.96 ³	-788%

¹252 Days of operation.

²251 Days of operation.

³Represents 50% decrease in accidents and 400% increase in vehicle-miles due to carpool demand.



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