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16. Abstract

This report presents an evaluation of the Contraflow Lane Project on the I-45 North Freeway in Houston. The purpose of this study is to assess the impacts of the contraflow lane on the operational characteristics of all freeway users.

The Contraflow Lane Project is described and the usage of the priority lane for the first 12 months of operation is summarized. The impacts on the traffic operational characteristics of the non-users of the Contraflow Lane are analyzed, and the total costs and benefits to the public are determined.

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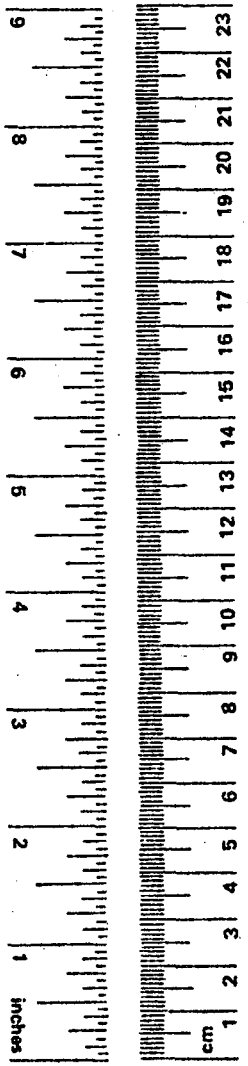
METRIC CONVERSION FACTORS

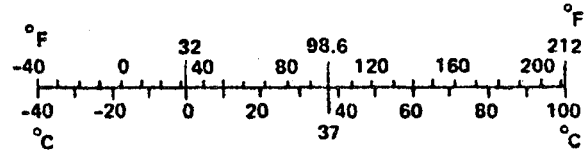
Approximate Conversions to Metric Measures

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.

EVALUATION OF THE FIRST YEAR OF OPERATION, I-45 CONTRAFLOW LANE, HOUSTON

by

William R. McCasland
Research Engineer

Research Report 205-9

Priority Use of Transportation Facilities
Research Study Number 2-10-74-205

Sponsored by

State Department of Highways and Public Transportation
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Texas A&M University System
College Station, Texas

January 1981

ACKNOWLEDGEMENTS

The contraflow lane project involved several organizations in the design, construction, maintenance, operation and enforcement phases. A report on the operations of the project requires the cooperation and assistance of several of these agencies. The following persons made significant contributions to the collection, analysis and presentations of data: Mr. Charles A. Fuhs, Metropolitan Transit Authority of Harris County; Mr. Richard Kabat, Mr. Musa Misleh, and Mr. Larry Galloway, District 12, Department of Highways and Public Transportation; and Mr. Gene Ritch, Texas Transportation Institute.

ABSTRACT

This report presents an evaluation of the Contraflow Lane Project on the I-45 North Freeway in Houston. The purpose of this study is to assess the impacts of the contraflow lane on the operational characteristics of all freeway users.

The Contraflow Lane Project is described and the usage of the priority lane for the first 12 months of operation is summarized. The impacts on the traffic operational characteristics of the non-users of the Contraflow Lane are analyzed, and the total costs and benefits to the public are determined.

SUMMARY

On August 28, 1979 the Texas State Department of Highways and Public Transportation (SDHPT) and the Metropolitan Transit Authority (MTA) reserved the median lane of the off peak direction of flow over a 9.6 mile segment of the I-45 North Freeway in Houston for the exclusive use of buses and authorized van pools. The contraflow lane (CFL) is unique in that:

- it is the longest freeway contraflow project
- it operates during both peak periods
- it has a midpoint crossover
- it permits van pools to operate in mixed flow with buses.

There were other elements that contributed to the CFL project. A ramp metering system was installed by the SDHPT to balance demands on the freeway lanes in both directions. Two park and ride lots, one funded by the MTA, the second by Federal Aid Urban Systems Funds, were constructed near the northern terminus of the CFL. The costs of constructing the improvements to the North Freeway Corridor were:

- Contraflow Lane $ 2,151,000
- Ramp Metering System $ 396,000
- Park and Ride Lots $ 4,260,000

The CFL is established each peak period by the placement of pylons in the pavement and the control of flashing yellow beacons, static and changeable message signs and overhead lane use signals. The cost to operate the CFL is approximately $2,600 per day.

Usage of the Priority Lane

The CFL was designed and constructed to be used by bus transit, but

as a result of a study of all potential users of the CFL, van pools were added to improve the efficiency and safety of the lane. The van pools must have 8 persons registered as riders and pass several other requirements of insurance, driver training and vehicle inspection to receive authorization decals that permit entry into the lane.

After one year of operation, the usage rates have risen to the following levels:

	Vehicle Trips/Day	Person Trips/Day
Bus Transit	125	5140
Van Pool	412	3584
Total	537	8724

The lane is available for operation for 2.5 hours for each peak period. Therefore, the volume of traffic in the lane is very light, and speeds of the CFL vehicles are at free flow conditions of 55 MPH. Van pool vehicles tend to peak during one hour of operation, but the arrival rates are much less than the capacity of the lane.

Traffic in the normal lanes in the peak direction travel at speeds that average 25 - 30 MPH. Therefore, over the 9.6 mile CFL project, the CFL users save 10 to 15 minutes in travel time. During days with capacity reducing incidents in the normal lanes, the savings are much greater.

The CFL is operated by the MTA and enforced by the Houston Police Department. The points of entry are controlled and monitored, and only 10 to 15 unauthorized vehicles each month are remanded by the police for trying to use the lane. There has been no evidence of traffic traveling in the off peak direction using the CFL as a travel or passing lane.

The incident records for the CFL have been excellent. After one year of operation and 970,000 vehicle miles of travel, there has been 3 accidents

involving CFL vehicles and 22 vehicle disabilities.

Impact on Traffic Along the Corridor

The impact of the CFL on travel in the North Freeway Corridor was studied in several ways:

- modal shift to CFL vehicles
- level of service of off peak travel
- level of service on diversion routes
- level of service for users of CFL.

The results of the studies are encouraging.

- Even though over 8700 person trips are now made in the CFL, vehicle volume in the peak direction has not declined. Traffic growth, attracted trips, and latent demand for the corridor fills the void left by the vehicles parked in the park and ride lots. Therefore, the peak direction operational characteristics have not changed.
- The reduced capacity in the off peak direction has caused some reduction in the level of service (LOS), but only in the six-lane section from Airline to Shepherd, a distance of 4.4 miles. For example, in the AM period, the reductions have been from an LOS of C for 2.5 hours, to LOS of D for 1.5 hours and LOS of E for 1.0 hours.
- The diversion of traffic from the off peak direction to the frontage road was the only measurable impact on alternate routes. Average speeds for the estimated 12,500 person-miles that daily diverted the freeway were lowered from 55 MPH to a range of 30 - 35 MPH.
- The LOS of the CFL Users were discussed in the previous section. Total travel time saved by the users was 1200 person hours per day.

Analysis of Benefits

The impact of the CFL on all elements of the travel in the North Freeway Corridor, is determined in the following measures of effectiveness:

- Freeway Travel has been reduced by 844 person hours per day.
- Vehicle operating costs are reduced by $1,575 per day.
- Fuel consumption is reduced by 2,685 gallons per day.
- Air pollutants are reduced.

Conclusion

The Contraflow Lane Project accomplished the goal of improving the mobility for persons using the North Freeway Corridor, and encouraging the use of high occupancy vehicles. The efficiency of the North Freeway, as measured by person miles per vehicle hour, has increased while the number of person-miles was increasing 10.6 percent. This was accomplished, while the total number of accidents was decreasing.

The usage of the CFL continues to increase at a level commensurate with the level of transit service that can be provide to this sector of the Houston urban area.

Implementation Statement

The primary purpose of this research study (Study 2-10-74-205) is to provide data and develop guidelines useful to the State Department of Highways and Public Transportation as well as the various cities in Texas in designing and implementing priority treatment projects on highway facilities.

The Metropolitan Transit Authority of Harris County has a transit improvement program which emphasizes the use of buses on existing facilities. The North Freeway Contraflow Project is the first priority operation of its type to be implemented in Texas, and is one of only four national projects using the contraflow technique on freeways.

The project has several distinctive and unique features, such as the longest contraflow lane at 9.6 miles, the only project to operate in both peak periods and the first project to designate vanpools as eligible users of the Lane.

This report presents and evaluates data on the first year of operation of the Contraflow Project.

DISCLAIMER

The contents of this report reflect the views of the author who is responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

Key Words: Contraflow, Freeway Operations, priority operations.

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EVALUATION OVERVIEW

Introduction

The I-45 North Freeway, which serves the developing communities of the Woodlands and Conroe, Northern Harris County and the Houston Intercontinental Airport, is one of the most heavily-traveled freeways in the State. On August 28, 1979 the Texas State Department of Highways and Public Transportation (SDHPT) and the Metropolitan Transit Authority (MTA) reserved the median lane of the off peak direction of flow over a 9.6-mile segment of the North Freeway for the exclusive use of buses and authorized van pools (Figure 1). The contraflow lanes operate inbound in the morning and outbound in the evening during the peak hours of traffic flow. Pylons placed in the pavement at 40-foot spacings are the only barrier separating these lanes from the opposite direction of flow. In conjunction with the contraflow lanes (CFL), three park and ride lots with a total capacity of 2400 parking spaces were constructed in the North Freeway Corridor (Figure 2).

The North Freeway Contraflow project is the first major preferential operation in Texas dedicated to the exclusive use of high occupancy vehicles. In addition, this project has several unique features:

- This is the longest freeway contraflow project in operation.
- This is the only contraflow project that operates during both peak periods.
- This is the first project to have a midpoint crossover for entry and exit.
- This is the only such project that permits utilization of the lane by vanpools.

The North Freeway was selected as the location for the CFL because the traffic split between peak and off peak traffic volumes was 65 - 35, and

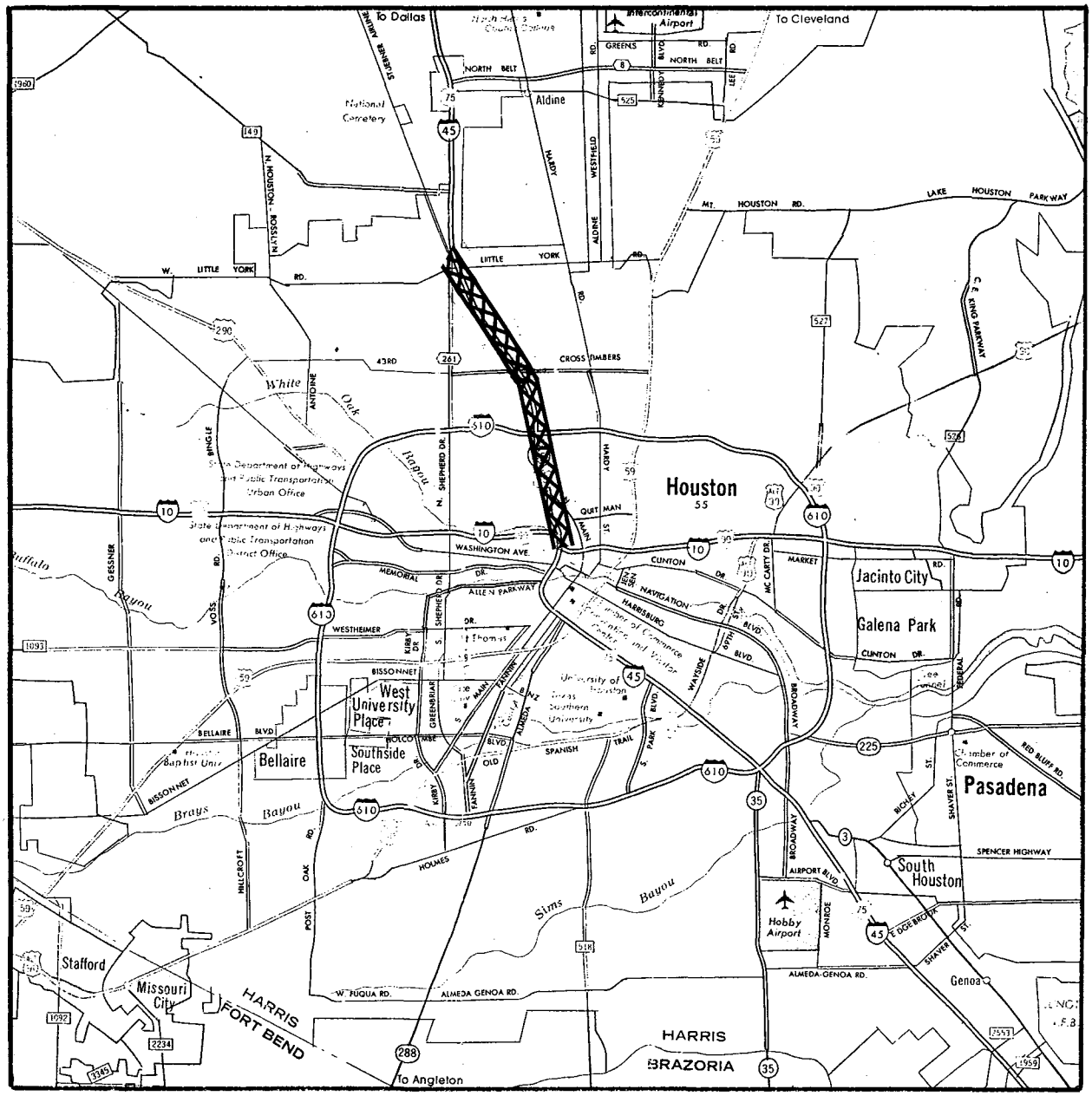
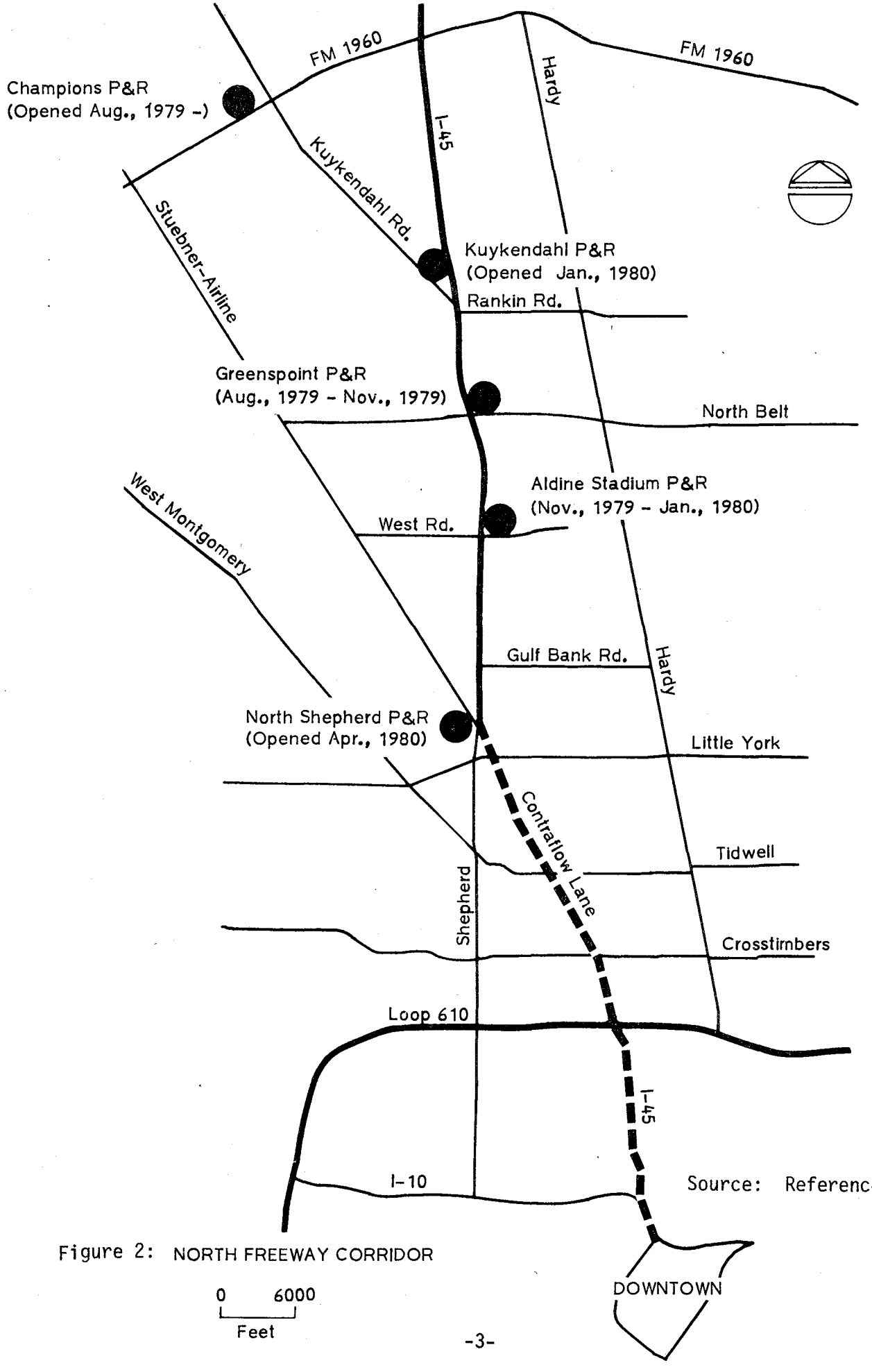


FIGURE 1. LOCATION OF NORTH FREEWAY CONTRAFLOW LANE



Source: Reference (1)

Figure 2: NORTH FREEWAY CORRIDOR

only a few sections were considered critical from a capacity standpoint when one lane was removed from service to the off peak traffic. [2][3] Also, the North Freeway Corridor had sufficient capacity on alternate routes to accommodate traffic diverted from the freeway. Finally, the North Freeway Corridor had a great potential for transit patronage for trips to the central business district (CBD).

A detailed chronology of the development of the project is presented in Appendix A. In summary, the project was initiated in 1974 when the City of Houston (City) requested the SDHPT to assist in the development of a demonstration project to provide priority treatment for buses on Houston's freeways. In 1975 a grant for a Demonstration Project was received from UMTA. A feasibility report and schematics of the project was approved in 1976.[2] Plans and specifications were prepared and a contract was awarded to Brown & Root in November 1977, and the CFL was opened in August 1979.

There were three other elements in the North Freeway Corridor that contributed to the CFL project. A ramp metering system was to be installed by the SDHPT in 1980-81 to relieve traffic congestion. The SDHPT moved the installation forward in order to provide control of traffic demands for both peak and off peak directions while the CFL was in operation. The ramp metering system was completed in March 1979. The two park and ride lots at Sheperd and Kuykendahl were a part of the project. The Kuykendahl lot, funded by MTA, was completed in January 1980, while the Shepherd lot, funded by Federal Aid-Urban System Funds, was completed in April 1980.

The costs of Constructing the improvements to the North Freeway Corridor were:

- Contraflow Lane $ 2,151,000
- Ramp Metering System $ 396,000
- Park and Ride Lots $ 4,260,000

The CFL operation has been successful in attracting an increasing number of transit riders and van pools. Since its opening, ridership in the lane has increased at a six percent rate based on the month to month increase. Public acceptance has been good, although several complaints have been cited. The major complaint of the project during the first year of operations was the apparent underutilization of the lane. This criticism was usually accompanied by proposals to open the lane to car pools.

The complaint of underutilization is understandable in that during the times of set up/take down and the early and later time periods of operation, few vehicles use the lane. However, 200 vehicles now use the lane in the peak hour and carry 3300 persons, the equivalent of 2550 automobiles with an average occupancy of 1.3 persons. The patronage of the CFL is expected to increase as the usage of the park and ride lots grows and the van pool program expands, but the number of vehicles eligible for the CFL will not increase to levels that approach normal lane usage.

Three solutions to this problem are being considered:

- reduce the time required to set up and take down the CFL.
- reduce the time of operation of the CFL, thus reducing the time capacity of the freeway for non-HOV traffic is restricted.
- reduce the size and/or occupancy requirements for van pools.

At this time the option to permit car pools to use the CFL is not being considered. There are several reasons for this decision; safety, enforcement, and capacity of the lane. These factors are discussed in subsequent sections of the report.

The second major criticism of contraflow concerns the impact that the CFL has on traffic operations. The North Freeway varies in width from six lanes at the northern end to ten lanes at the southern end near the CBD. Reducing the roadway by one lane in the three-lane sections resulted in lowering the level of service. Several traffic management and control measures have been employed, such as ramp metering, entrance ramp closure and frontage road signal retiming, to maintain an acceptable level of operation. These have been successful in raising the average speeds to an acceptable level while operating the off peak direction at flow close to the capacity of the reduced sections.

Finally, of major concern to everyone involved with the contraflow lane project is the safety of all users of the freeway. The project was designed with great care to provide sufficient information concerning the operation of the contraflow lane to all motorists. However, the opposing flows of traffic are separated only by the plastic pylons.

The safety record of the CFL was good during the first year of operation with only three accidents involving CFL vehicles. The second accident occurred on April 25, 1980 and resulted in a fatality when a single occupant automobile driver apparently lost control on wet pavement and skidded into the CFL. The automobile was struck broadside by the oncoming van pool and the automobile driver was killed. The occupants of the van pool were injured.

The CFL will continue to be operated for an indefinite time. This report will present the findings of evaluation studies after one year of operation.

Description of Project

The contraflow lane project has three types of priority facilities: a contraflow lane, a reversible flow lane using the roadway shoulder, and a separately constructed reversible busway (Figures 3 and 4). The shoulder lane operation was necessary to avoid the conflict with the lefthand entrance ramp in the interchange with I-10. The separate busway was constructed to transfer the HOV's from the freeway to the CBD street system.

Entry into the CFL is controlled by gates which are manually operated by the field crew. Enforcement of the lane is accomplished at those locations. Static signs with flashing yellow beacons are used to inform oncoming traffic when the CFL is in operation (Figure 5). Lane signals, utilizing the Red X and Green Arrow, are placed over the CFL and adjacent lanes at critical locations (Figure 6). White diamonds designating an HOV reserved lane are painted on the CFL (Figure 7). Plastic pylons are placed in the pavement at 40-foot intervals, except in critical geometric sections where the spacing is reduced to 20-foot intervals (Figures 7 and 8).

Special signing, lane designations, and channelization by pylons are provided at the beginning of the contraflow section (Figure 8). Special crossover ramps are constructed at several locations: the transition from the shoulder lane to contraflow (Figure 4), the midpoint crossover at I-610 for access for egress to the CFL (Figures 9 & 10) and at the northern terminal for access to I-45 northbound lanes or to one of the park and ride lots at the Shepherd interchange (Figure 3). The placement and removal of the pylons and the control of the signal system are accomplished each peak period by a field crew consisting of two police vehicles, 2 trucks for pylon placement, 1 pickup truck and 7 to 9 men (Figure 11). A wrecker is used to sweep the median shoulder clean of disabled vehicles and to stand by for any incidents that would block the CFL. The cost to operate the CFL is approximately $ 2,600 per day.

Figure 3: NORTH SHEPHERD TERMINUS TO CONTRAFLOW

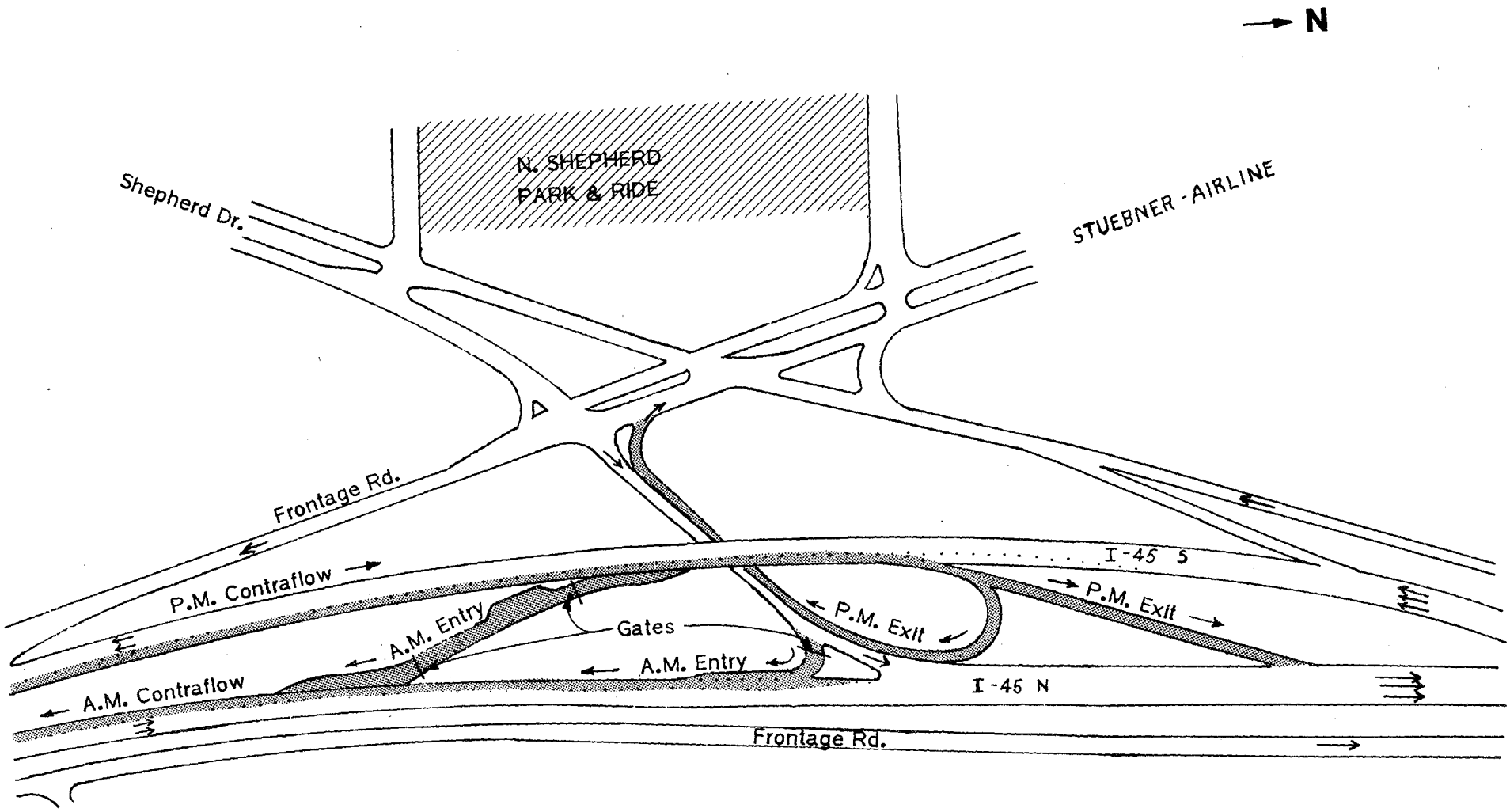


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Figure 4: DOWNTOWN TERMINUS TO CONTRAFLOW

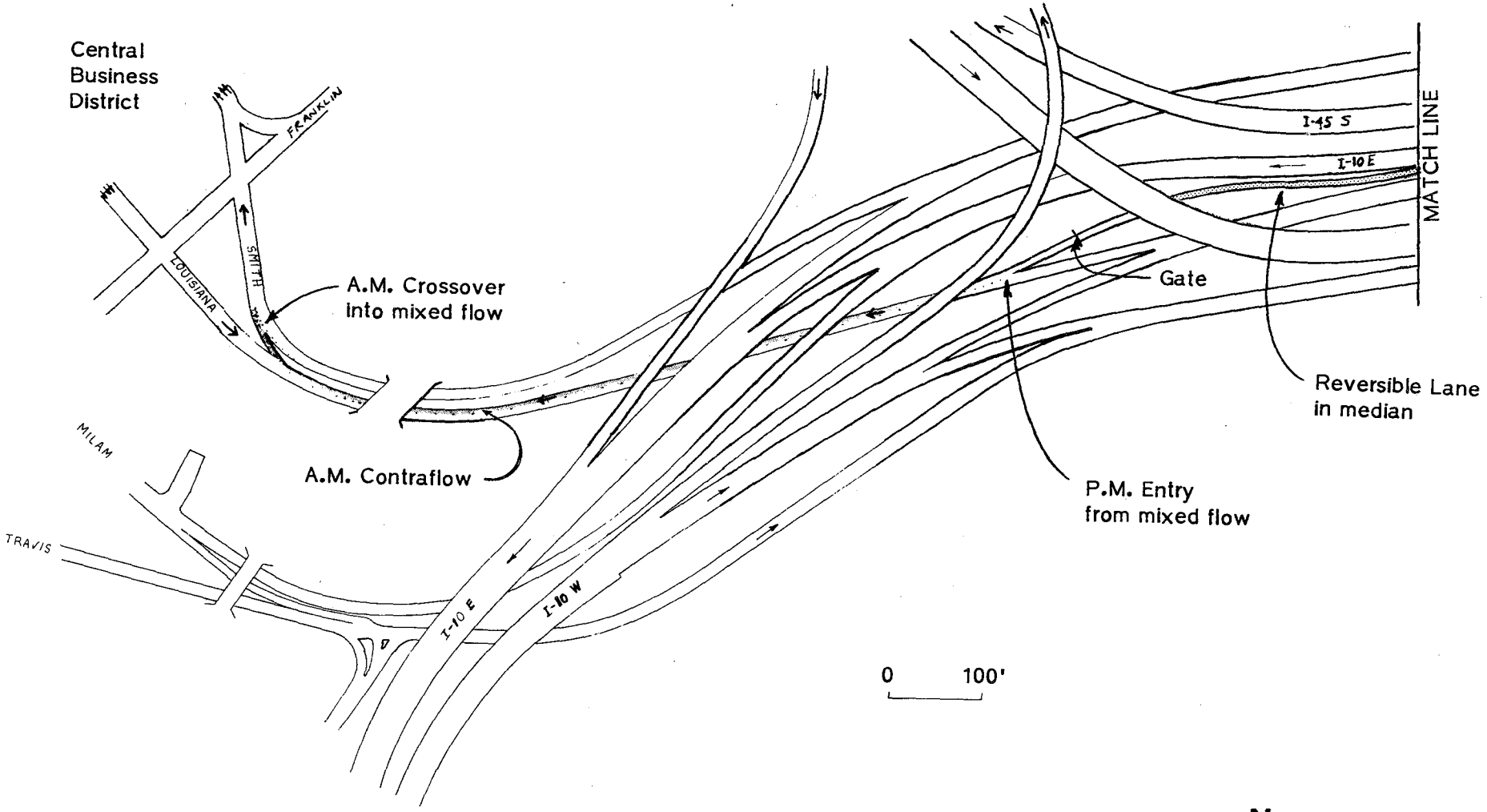

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Figure 4: (Continued)

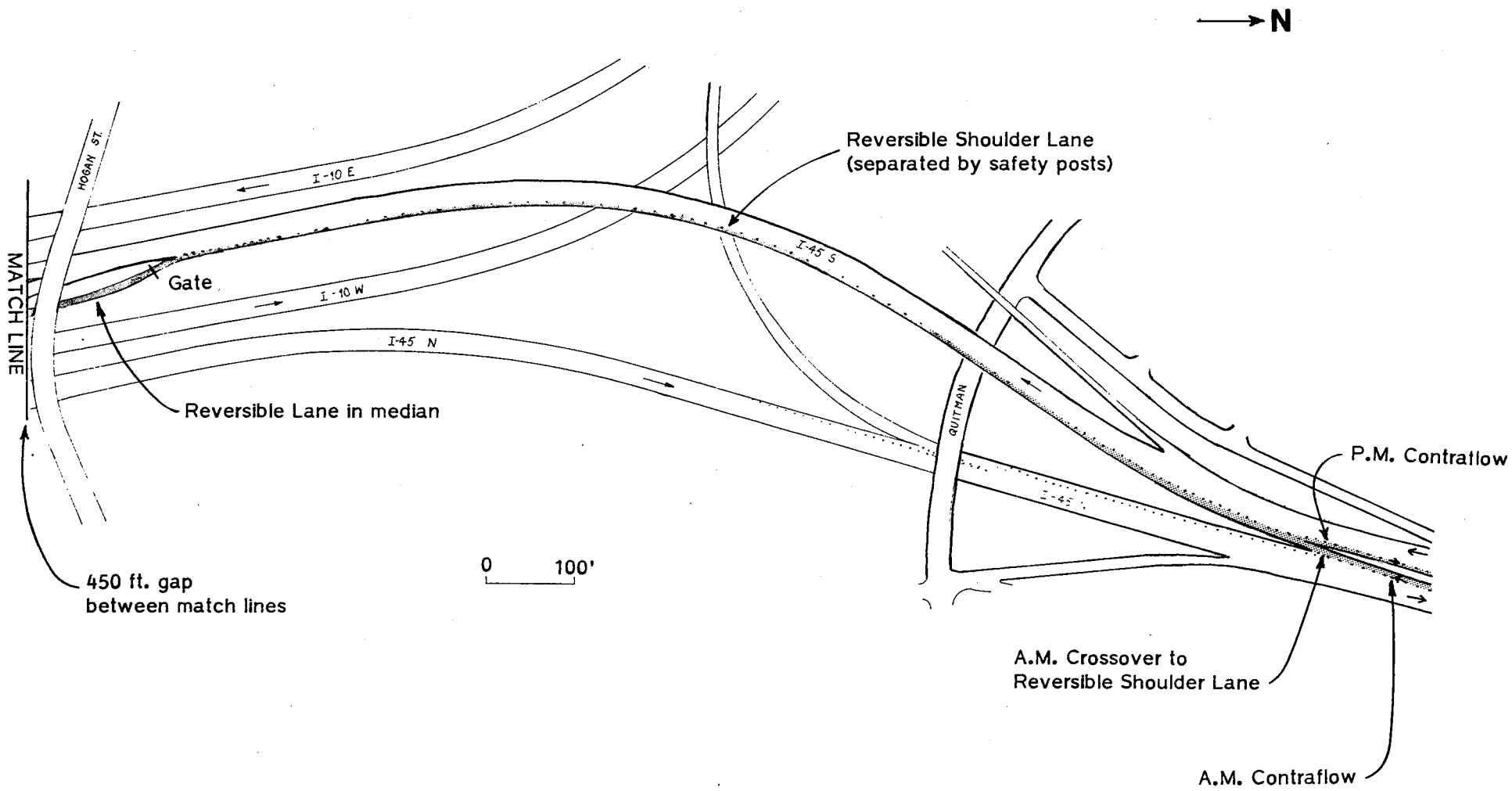

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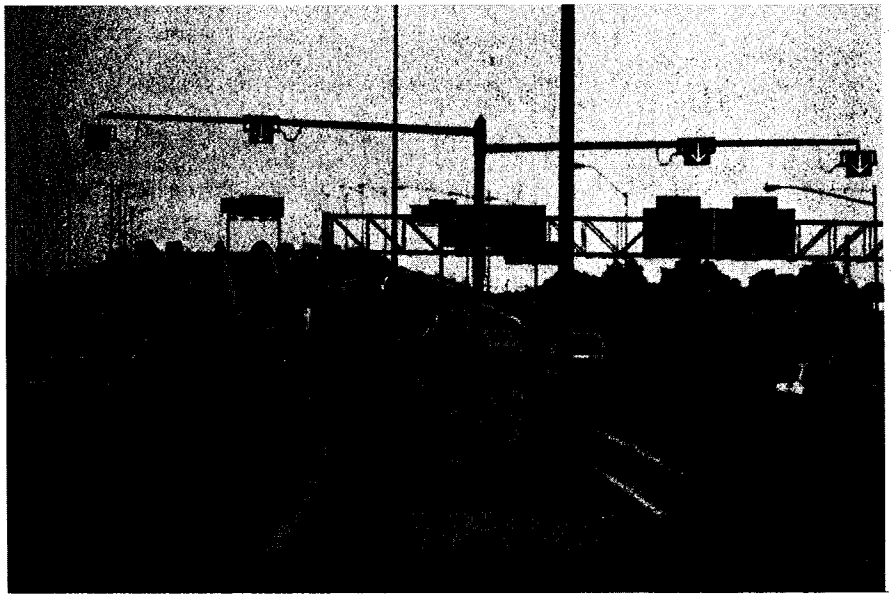
Figure 5: WARNING SIGNS AND FLASHING YELLOW BEACONS



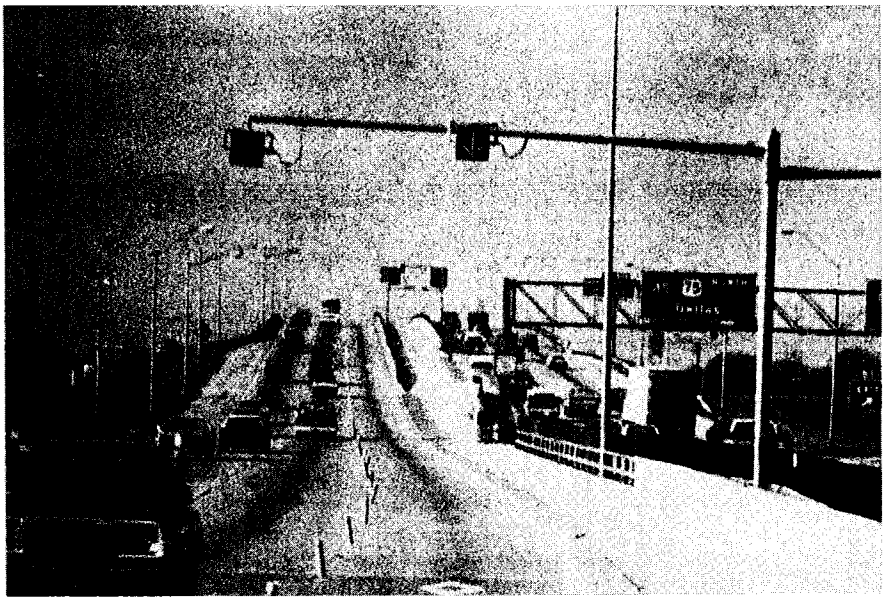


Figure 6: LANE SIGNALS

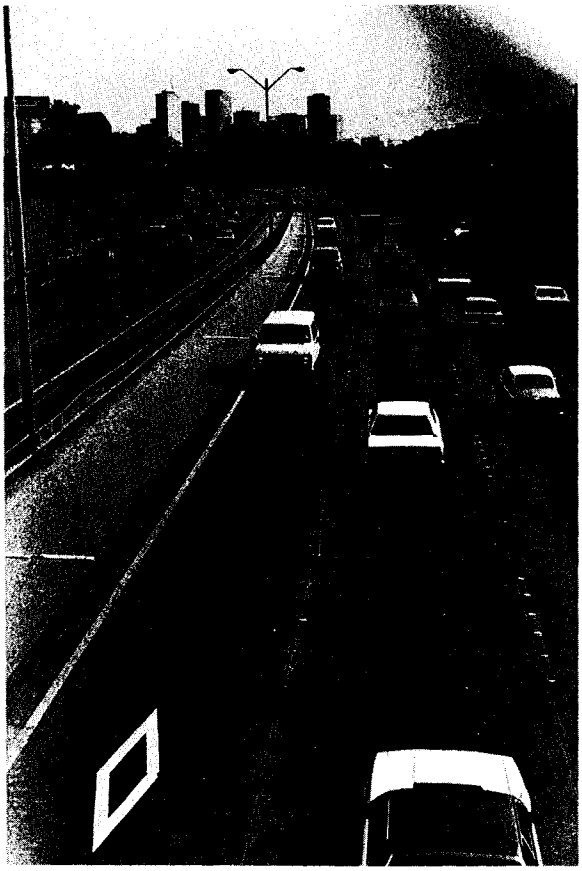


Figure 7: LANE MARKINGS AND PLASTIC PYLONS

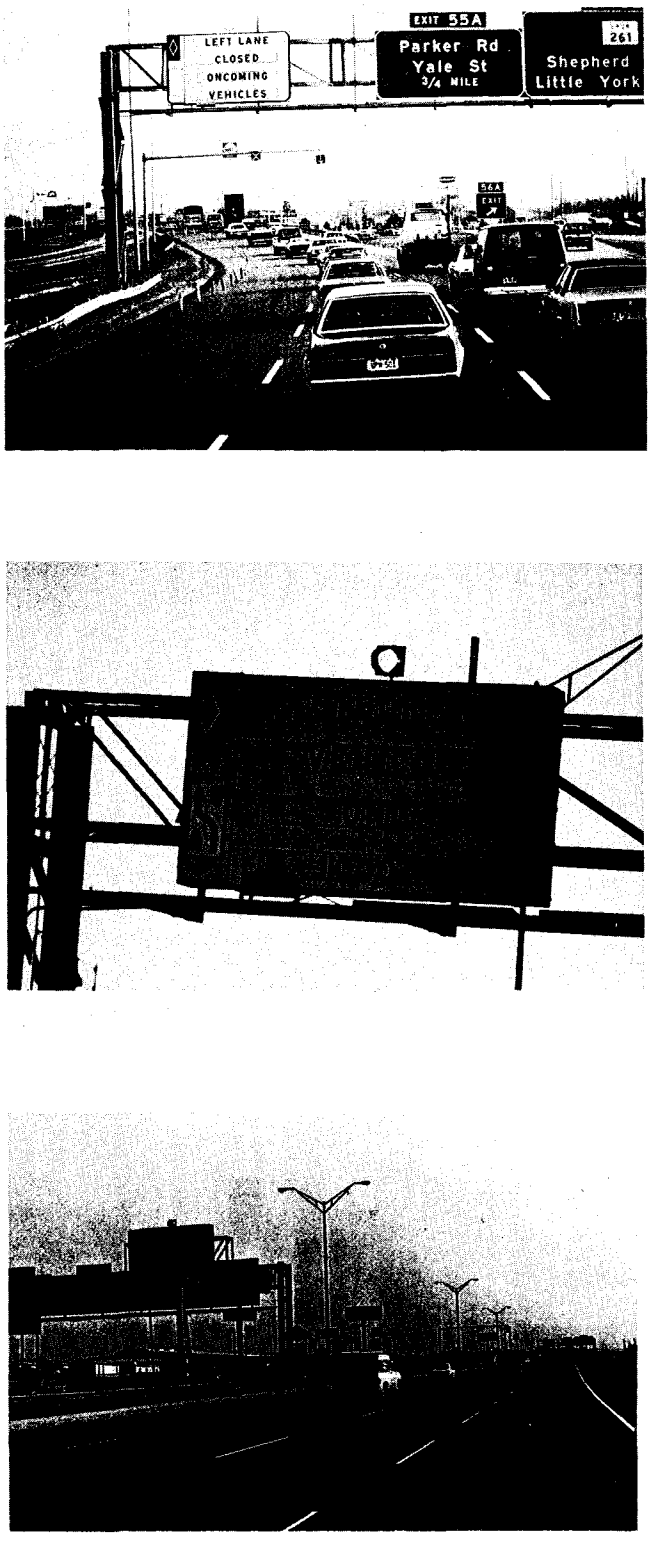


Figure 8: SPECIAL SIGNING AND CHANNELIZATION AT INTRODUCTION TO CFL, NORTHERN TERMINUS

Figure 9: MID-POINT CROSSOVER AT I-610

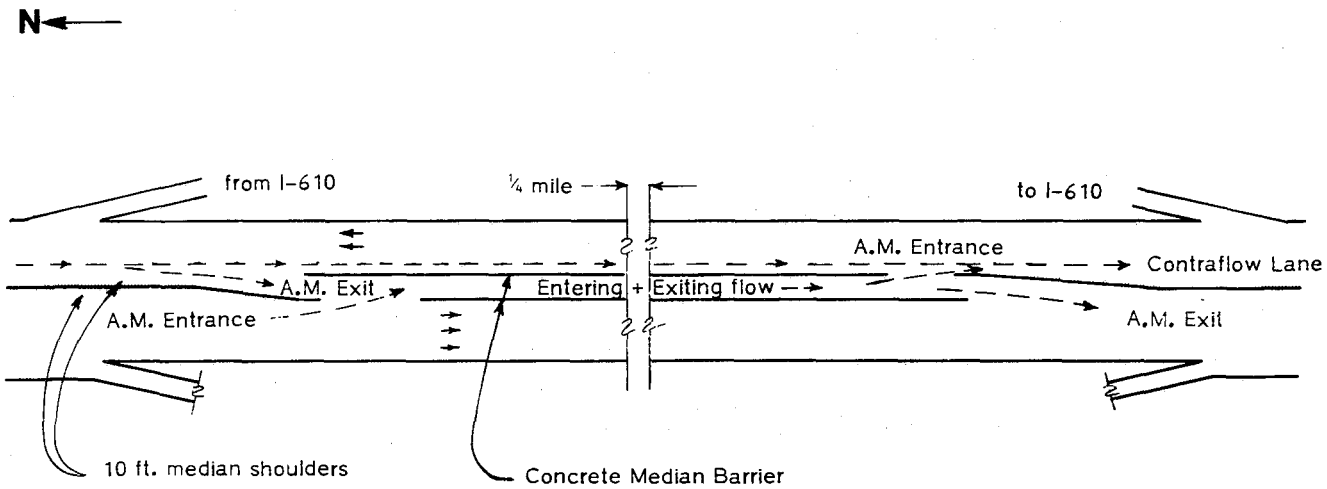
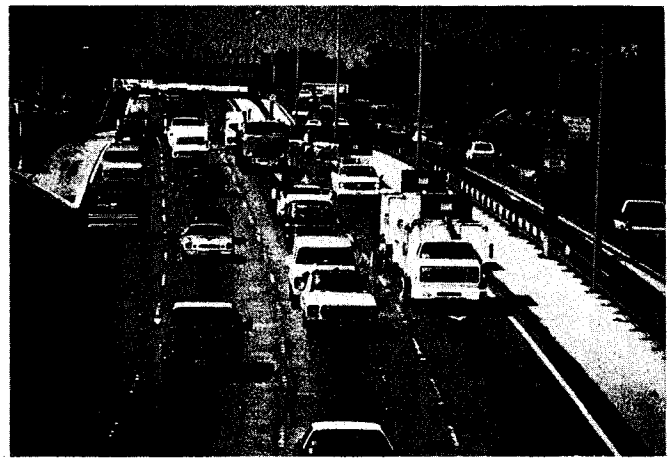


Figure 10: MIDPOINT CROSSOVER AT I-610
Design accommodates a reversal of operation in P.M. period

Source: Reference (1)



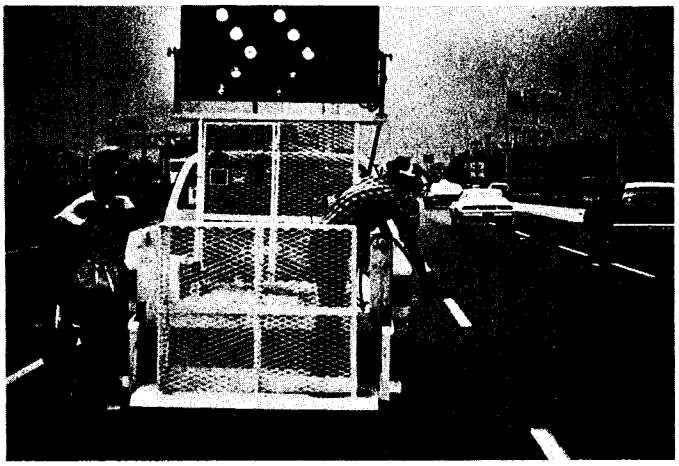


Figure 11: CFL OPERATIONS CREW, LANE TAKEDOWN

USAGE OF THE PRIORITY LANE

Types of Vehicles Using the CFL

The CFL was designed and constructed to be used by bus transit. However, prior to the opening of the lane, a study was undertaken to determine the feasibility and acceptability of other classes of vehicles, (4) such as trucks, taxis, van pools and car pools. The intent was to expand the eligibility for the CFL to improve the efficiency of the lane and to decrease the headways of CFL vehicles to enhance safety. Van pools were determined to be an acceptable group of vehicles that could be regulated and managed by the operators of the CFL (Figure 12). To be eligible the vans must be designed to carry 8 or more persons and have at least 8 persons registered as riders. There are several other requirements concerning insurance, driver training, licensing and vehicle inspection that must be met to receive authorization decals permitting the vehicle entry into the CFL.

Vehicle and Person Volumes in the CFL

Since the first week of operation, the number of vehicular trips for both peak periods have been monitored, and the passenger trips determined from vehicle logs and spot check counts. Average occupancy rates for van pools were measured to be 8.9 persons/van. (5) Table 1 summarizes the utilization of the CFL on the basis of average daily total trips for the specified weeks after the start of the operations in August 1979. The most recent data indicate an increase of 136 percent vehicular usage and 266 percent person usage since the opening of the lane. There is little difference in the usage of the CFL in the AM and PM peak periods.

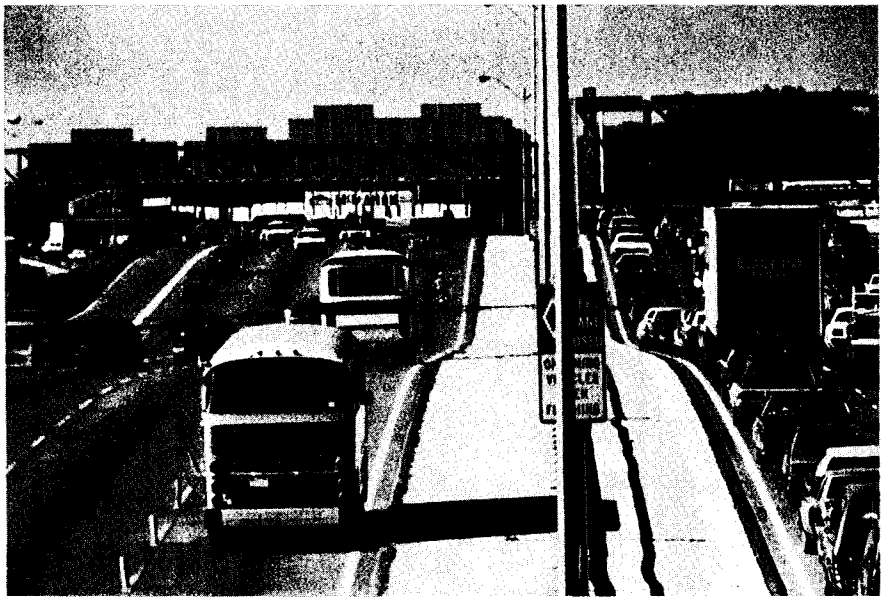


Figure 12: TYPES of VEHICLES USING CFL

Table 1: Average Daily CFL Utilization by Week

Week	Bus		Vanpool		Total	
	Bus Trips	Passenger Trips	Vanpool Trips	Person Trips	Vehicle Trips	Person Trips
1	57	804	164	1539	221	2343
2*	60	1308	170	1596	230	2904
4*	60	1398	214	1819	274	3217
6*	66	U/A	216	1836	282	U/A
8	71	1674	221	1878	292	3552
10	70	1655	236	2005	306	3660
12	70	1831	236	2005	306	3836
14	75	1877	242	2057	317	3934
16	73	2241	268	2278	341	4519
18	75	1725	234	1989	309	3714
20	75	2530	275	2337	350	4867
22	80	2650	283	2405	363	5055
24	85	2908	298	2652	383	5560
26	82	3043	313	2786	395	5829
28	81	3161	315	2803	396	5964
30	83	3330	329	2928	412	6258
32	81	3202	334	2973	415	6175
34	88	3425	336	2990	424	6415
36	120	4140	363	3231	483	7371
38	120	4335	367	3266	487	7601
40	122	4530	376	3347	398	7877
42	127	4710	376	3347	503	8057
44	128	4938	384	3417	512	8355
46	127	5057	388	3453	515	8510
48	124	5036	397	3534	521	8570
50	121	5175	406	3532	527	8707
52	125	5140	412	3584	537	8724

*Estimated from P.M. Surveys

Source: MTA Daily Counts
Reference (5)

On Figures 13 and 14 the average peak period data illustrate graphically the trends in the growth of the CFL usage and the impact of the two park and ride lots on that usage. The Kuykendahl lot, which was the replacement for an existing temporary lot, did not have an immediate impact on transit ridership. However, opening of the Shepherd Lot was accompanied by a new transit service to the area, resulting in a significant jump in transit ridership.

Peaking Characteristics of the CFL

With a vehicular demand of less than 300 vehicles during the 2.5 hour peak period, the capacity of the CFL is seldom a factor in the movement of the HOV's. Thus, van pools can be selective in the times to start the trip. Traffic tends to peak with approximately 60 percent of the van pools traveling during a one hour period (Figure 15). There is some platooning of vehicles during this period, but average speeds are still near the speed limit, which is currently 55 MPH, recently increased from an initial 45 MPH limit.

Consideration has been given to reducing the time of operation for the last 30 minutes of the period since there have been some complaints about underutilization of the lane. However, the growth of the transit usage and the park and ride facilities suggests that the full operational time will be utilized at higher levels in the future.

Speeds in the CFL

The speed limit of the CFL was set at 45 MPH, while all other lanes on the freeway operated at a 55 MPH limit. The lower speed limit was established for reasons of safety. Also, there was concern that some of the transit vehicles might not be able to sustain the higher speeds. Recently, however, the CFL limit has been increased to 55 MPH.

Figure 13:

CONTRAFLOW PEAK PERIOD VEHICLE MOVEMENT

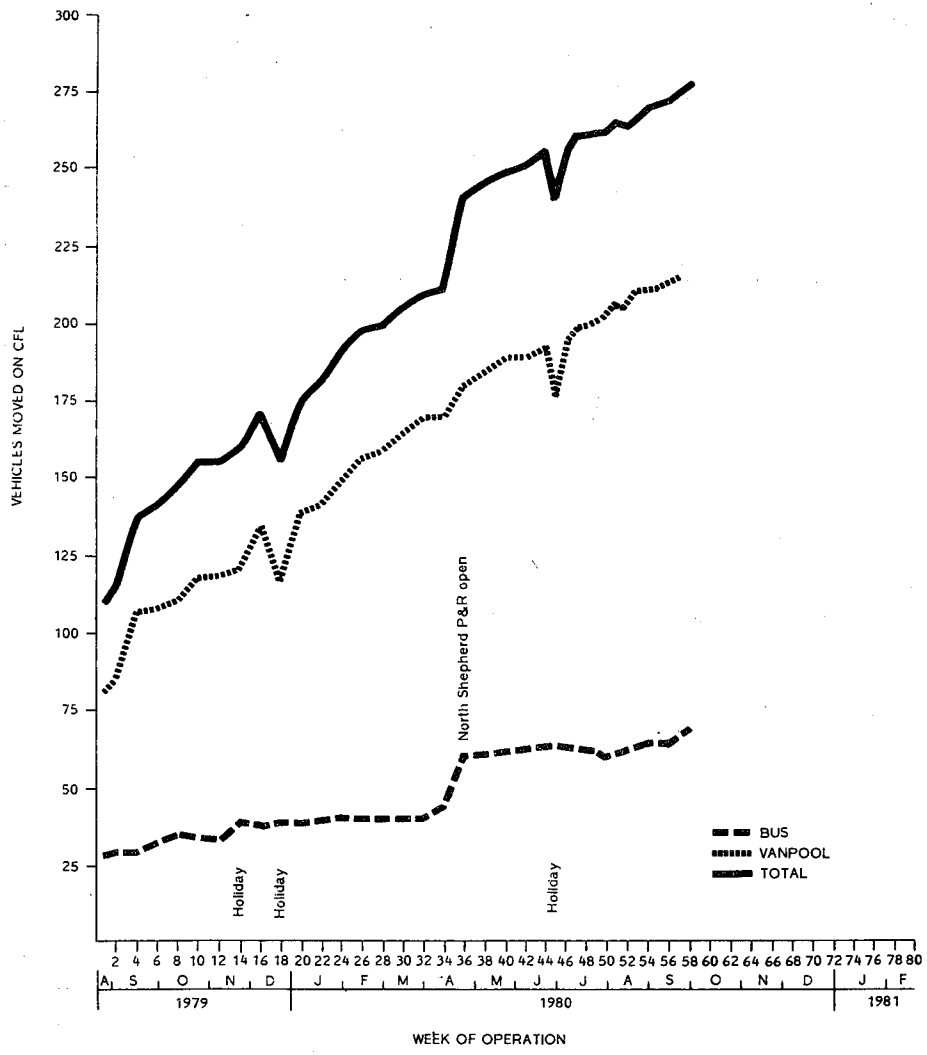
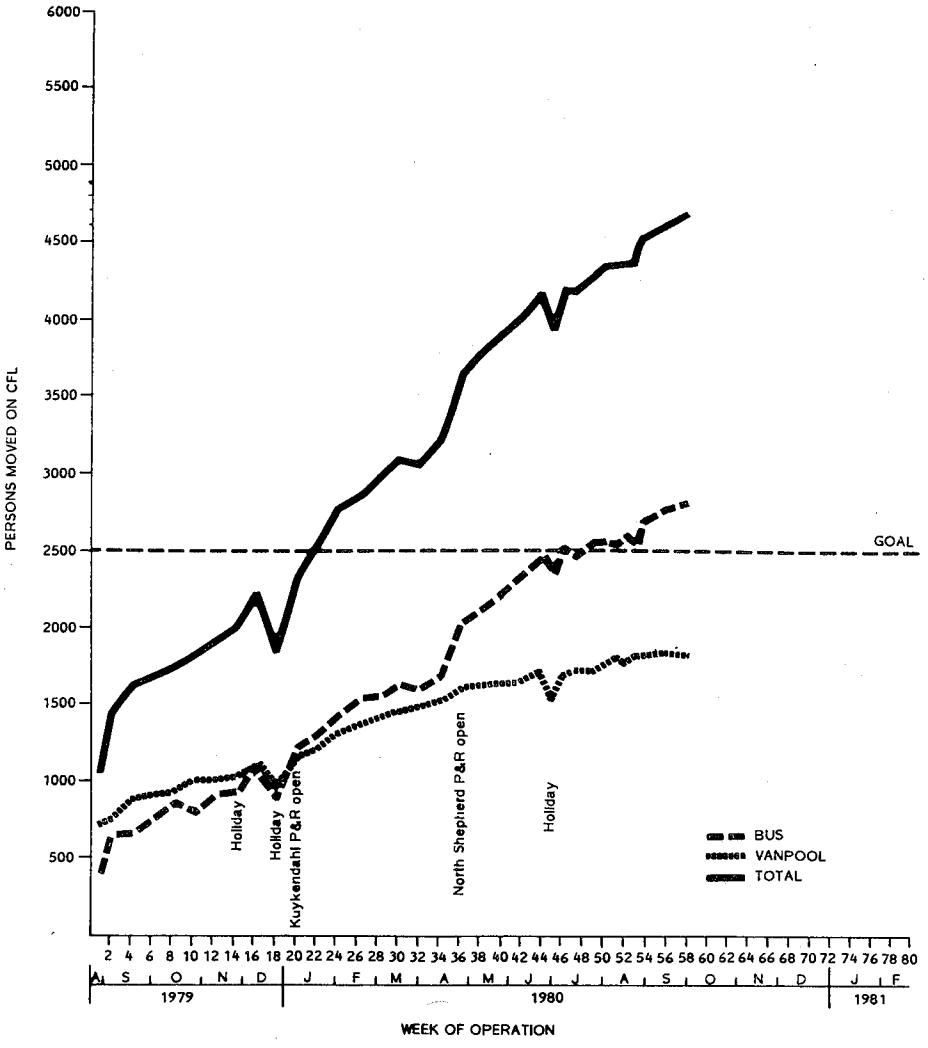


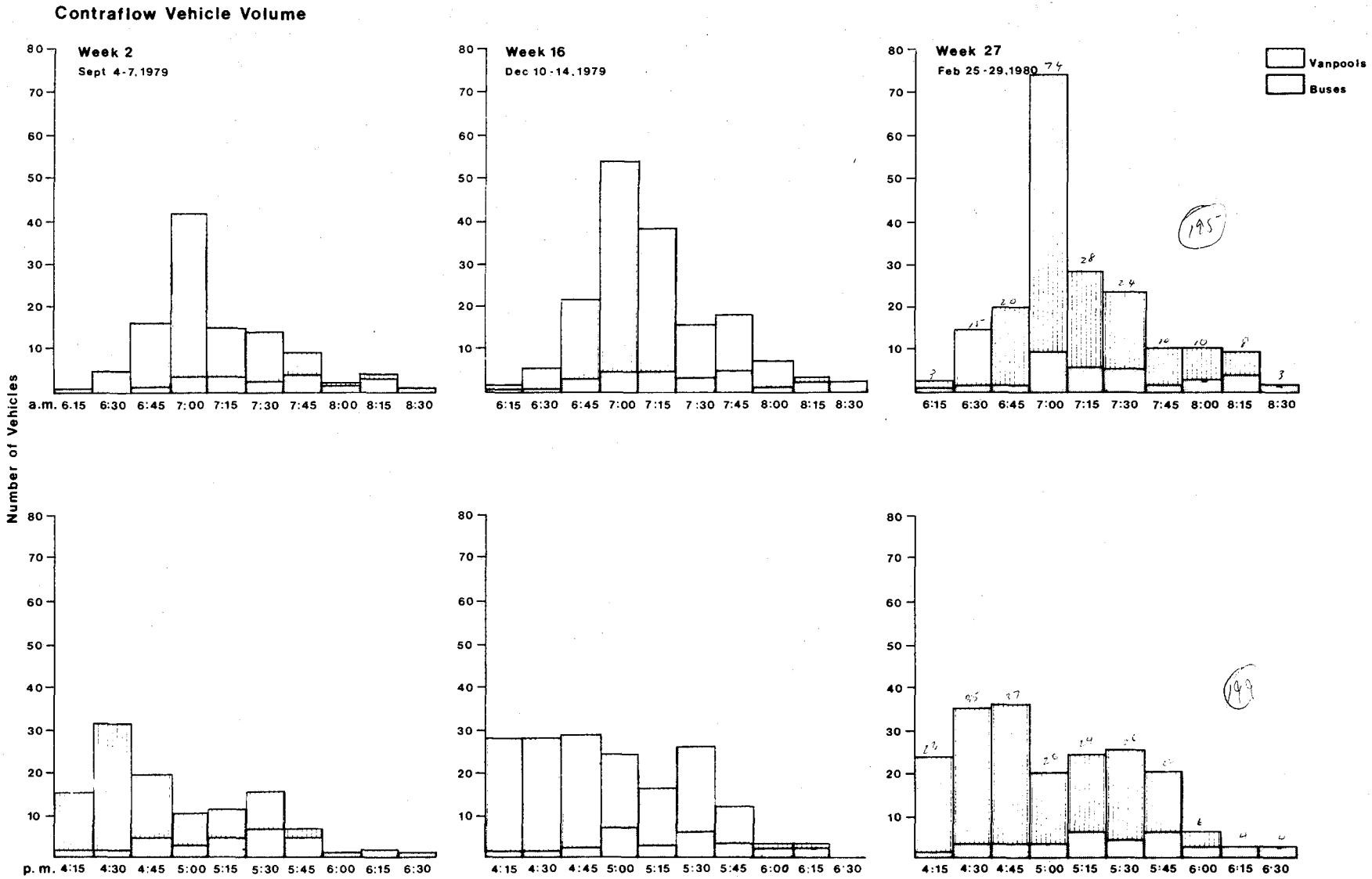
Figure 14:

CONTRAFLOW PEAK PERIOD PERSON MOVEMENT



Source: Reference (5)

MTA August 1980 Monthly Status Report



Source: Reference (1)

Figure 15: CONTRAFLOW VEHICLE VOLUMES

During the first few weeks of operation, the vehicles in the CFL generally complied with the speed limit. As the drivers became more accustomed to the operation, speeds began to increase. With the increase in volumes and tendancy to peak in short time periods, platoons of vehicles were more evident in the CFL. The MTA received complaints from users that speeds in the lane were either too high or too low. That is, the speed range was too great.

A speed survey conducted in June 1980, determined that the 85th percentile speed was between 56 and 60 MPH (Tables 2 and 3). The MTA and SDHPT decided that the speed limit should be changed to 40 Min and 55 Max, effective July 1980.

Travel Times of CFL Users

Travel time for the CFL, calculated over the 9.6 mile length for an average speed of 55 MPH, is 10.6 minutes. Since traffic congestion extends 3 to 4 miles upstream of the northern terminal of the CFL, the Beltway 8 interchange was northern limit of the study area. The HOV's travel in mixed flow in this section and experience travel times of 10 to 15 minutes in the AM peak period. Thus the total trip time to the CBD in the 13.6 mile section would be approximately 23 minutes.

On the outbound trip during the PM peak period, the HOV's have direct access to the CFL from the CBD street system with no delay. The HOV's reenter the main lanes of the freeway at the northern terminal in mixed flow at an average speed of 45 MPH for 3 miles, at which point the freeway speeds increase to 55 MPH to the Beltway interchange. Therefore, the total travel time is 15.5 minutes in the outbound direction.

TABLE: 2

SPEED SURVEY OF
CFL AT TIDWELL

Time Period	50^{th} Percentile	85^{th} Percentile
AM	53 MPH	58 MPH
PM	52 MPH	56 MPH

Source: Speed Survey Conducted by SDHPT, District 12, Houston

TABLE: 3

SPEED SURVEY OF
CFL AT CAVALCADE

Time Period	50^{th} Percentile	85^{th} Percentile
AM	55 MPH	59 MPH
PM	55 MPH	60 MPH

Source: Speed Survey Conducted by SDHPT, District 12, Houston

Perceived Time Savings

In a survey of van pools using the contraflow the question was asked, "How many minutes are you saving by using the contraflow lane?" The responses were generally larger than those calculated from travel time runs made during the first 8 months of CFL operation. (5) Table 4.

Travel time studies indicated that, on incident free days, the average savings were 10 minutes in the morning and 12.5 minutes in the afternoon for CFL speeds of 55 MPH (Table 5). For incident days, which include rain and wet pavement conditions as well as accidents and disabled vehicles, travel times savings in the CFL would be higher. Table 6 presents data on major capacity reductions on the peak direction of flow on the normal lanes of the freeway, recorded at the permanent count station, located 5.5 miles from the northern end of the CFL, for a 12 month period. (7)

This record does not reflect the total number of incidents that occurred on the normal freeway lanes during this time period over the 9.6 mile length of the contraflow project. These data support the higher travel time estimates from the van pools as being realistic and representative of average conditions that exists on the North Freeway.

Description of a "Typical" Incident

On July 28, 1980 one of the four inbound lanes at Main Street was blocked during the peak period by a stalled truck. Travel time from the Beltway to Hogan street was 44 minutes and the average speed was 10 MPH over 11.7 miles. Over this distance the normal travel time for non HOV vehicles is 31 minutes and 23 minutes for the HOV vehicle. Thus, on days with incidents of this magnitude, the CFL users save 21 minutes.

TABLE 4 : VAN POOL SURVEY RESULTS ON PERCEIVED TRAVEL TIME SAVINGS

	Morning		Afternoon	
	Number of Responses	Percent	Number of Responses	Percent
0 - 5 minutes	4	5	2	2
5 - 10 minutes	16	12	2	2
10 - 15 minutes	46	34	27	20
15 - 20 minutes	37	28	53	40
More than 20 minutes	27	20	46	34
No response	1	1	3	2
Total	133	100	133	100
	Average	14.8 Minutes	Average	17.5 Minutes

Source: Reference (4)

TABLE 5:

TRAVEL TIME SAVINGS TO CFL USERS

	Distance Traveled (Miles)	Average Speed (MPH)	Trip Time (Minutes)
AM Peak Period			
Non CFL User	9.6	28	20.6
CFL User	9.6	55	10.6
Time Saved			10.0
PM Peak Period			
Non CFL User	9.6	25	23.1
CFL User	9.6	55	10.6
Time Saved			12.5

TABLE 6: NUMBER OF DAYS HAVING A MAJOR CAPACITY REDUCTION EVENT

	Morning		Afternoon	
	Number of Days	Percent	Number of Days	Percent
Rain	9	4	15	6
Showers	3	1	5	2
Fog	0	0	2	1
Incidents	12	5	29	11
No Incident	231	90	204	80
Total	255	100	255	100

Source: Reference (7)

Enforcement

The Houston Police Department, under the contract with MTA, enforces the use of CFL. Six patrols were assigned to the CFL operations, but after 8 weeks the number of patrols was reduced to two. These patrols also provide protection to the CFL crew during the set up and take down procedures and monitor the CFL during the operations period.

Violations

The number of violations of the CFL are low (Table 7). The primary type of violation is the entry of unauthorized vehicles at the terminals of the CFL. The two police patrols are stationed at the major entry locations at the CFL origin and the midpoint crossover at I-610. Surveillance at the CFL origin is usually supplemented by the CFL crew and CFL Supervisor.

An unauthorized vehicle is usually turned back at the entry point, but, occasionally, the violator will enter the lane, requiring the police at the midpoint crossover to apprehend and remove the vehicle at that point. Eighty percent of the violations occurred during the afternoon period.

- After one year of operation, there has been 3 accidents involving CFL vehicles.
- There have been 970,000 vehicle miles of travel in the CFL lane.
- The breakdown experience for buses and van is:

	Bus	Van	Total
Breakdowns Reported	12	10	22
Veh Miles Traveled	194,000	776,000	970,000
Breakdown Frequency (Vehicle-miles/incident)	16,200	77,600	44,000

Table 7: Summary of Incidents Reported During CFL Operation

	September	October	November	December	January	February	March	April	May	June	July	August	Total
Accidents in CFL -													
No CFL vehicles involved	2	4	2	2	4	1	3	1		1			20
CFL vehicles involved					1			1					2
Stalled vehicles -													
Blocking CFL	2	3		2			2	2					11
Not blocking CFL	3	2		3	6	6	4	4					28
Unauthorized CFL entry -													
Stopped by police at entry	4	6	1		13	7	16	12	25	15	17	11	127
Stopped by police on Lane	1	2	1	2	2	6				1	1		16
Stopped by CFL personnel		1			2	3							6
Not stopped	1	5	2	1	3	2	5	3					22
Other*	6	2	2	3	4	3	6	5				1	32
CFL Authorized Vehicle**													
Breakdowns -													
Bus		1		1	1		1		1	2		5	12
Vanpool		1				1	2	3	1		1	1	10

*Other includes incidents involving high water, CFL vehicles entering Lane prematurely, CFL vehicles speeding, gaps in pylons causing CFL closure, CFL maintenance vehicles involved in accidents, obstructions in CFL, and pedestrians and bicyclists on CFL.

**This is a subcategory of stalled vehicles listed above.

Source: References (1) and (5)

IMPACT ON TRAFFIC ALONG THE CORRIDOR

The impact of the CFL on travel in the North Freeway Corridor was studied in several ways:

- The effect of modal shift on vehicular demand for the freeway in the peak direction.
- The effect of reduced capacity in the off peak direction on the level of service in the remaining lanes and on diversion to alternate routes.
- The effect of the diversion to alternate routes on the level of service for all traffic on these routes.
- The effect on the level of service for users of the CFL.

The measures of effectiveness used in the analysis were volumes, speeds, travel times, and the resultant effects on total travel times, operating costs, fuel consumption and air pollutants. Safety of operation was also examined for the freeway main lanes.

Vehicle Volumes

Peak Direction - Even though the ridership in the CFL has increased to a level of 8724 trips per day, there has been no significant change in the total traffic volume during the peak periods in the peak direction. The record of the permanent count station at Link Road for a two-hour period during the peak directions is shown in Tables 8 and 9.

Special freeway counts were taken at critical locations in the 13 mile study area. There were no significant changes in the peak hour and peak period volumes that could be attributed to modal shift to the CFL (Figure 16). Traffic Growth and latent demand nullified any reduction in demand that might have resulted from the modal shift.

TABLE: 8

7 - 9 AM VOLUMES
PEAK DIRECTION
I-45 Southbound at Link Rd

(Count Station - S-142)

	Before CFL (1978-79)	With CFL (1979-80)	Difference
Sept.	12,128	12,580	+ 452
Oct.	13,076	13,250	+ 174
Nov.	13,479	14,146	+ 667
Dec.	12,913	13,565	+ 652
Jan.	12,724	13,492	+ 768
Feb.	13,083	14,159	+1076
Mar.	13,216	14,246	+1030
Apr.	13,583	14,417	+ 834
May	13,496	14,335	+ 839
June	13,384	14,707	+1323
July	13,645	14,346	+ 701
Aug.	13,610	14,016	+ 406
Monthly Average	13,195	13,938	+ 743
		Percent Change =	+ 5.63%

Source: Reference (7)

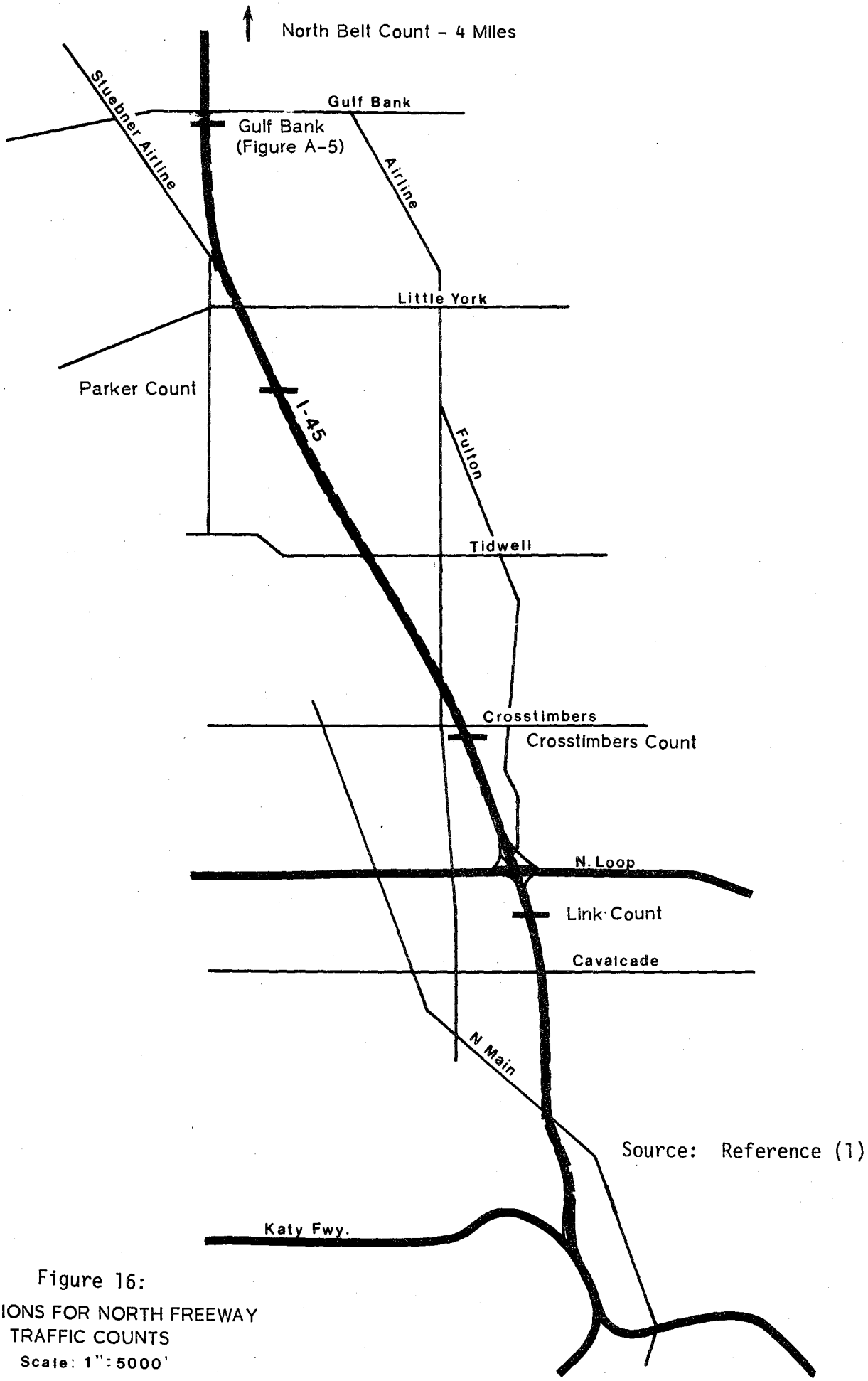
TABLE: 9

4 - 6 PM VOLUMES
PEAK DIRECTION
I-45 Northbound at Link Rd

(Count Station - S-142)

	Before CFL (1978-79)	With CFL (1979-80)	Difference
Sept.	10,856	10,110	- 746
Oct.	10,606	10,948	+ 342
Nov.	10,512	10,098	- 414
Dec.	10,502	10,433	- 69
Jan.	11,300	10,489	- 811
Feb.	11,463	10,871	- 592
Mar.	10,710	10,701	- 9
Apr.	10,080	10,635	+ 555
May	10,930	10,285	- 645
June	10,932	10,798	- 134
July	10,300	10,650	+ 350
Aug.	9,901	10,466	+ 565
Monthly Average	10,674	10,540	- 134
		Percent Change = - 1.26%	

Source: Reference (7)



Source: Reference (1)

Figure 16:
LOCATIONS FOR NORTH FREEWAY
TRAFFIC COUNTS
Scale: 1":5000'

Off Peak Direction - The reduction in capacity in the four- and five-lane sections of the freeway at the Link Road Counter had no significant impact on the volumes in the remaining lanes (Tables 10 and 11). However, in the three-lane section of the freeway from Airline to Shepherd, the capacity was reduced lower than the demand, and the volumes were reduced. At the point of lane reduction, congestion developed to a level that traffic voluntarily diverted to the frontage road. Ramp metering in the three lane section, and the closure of selected ramps, encouraged diversion along the frontage road to downstream entrance ramps outside the critical section. Volumes of 1000 vehicles for the 2.5-hour peak period used the alternate routes for short distances. The remaining lanes in the off peak direction operate at a LOS C-D, with volumes of 1500-1600 vph per lane.

Alternate Routes - The diversion to the frontage road in the off peak direction was the only measurable impact on the arterial streets in the North Freeway Corridor. The increased volumes were accommodated with little additional delay. The capacity of the frontage road at critical intersections was increased to avoid delays of more than one signal cycle. Average speeds between intersections were in the range of 30 to 35 MPH.

CFL - Daily Volumes in the CFL increased from 110 vehicles in the first week to 270 vehicles after 12 months of operation. The volumes were not high enough to adversely affect traffic operations in the Lane, although the HOV's will form platoons during the peak hour. The traffic demand for the CFL peaks during a one hour period, as the van pools exercise their prerogative of selecting their time of trip. Transit volumes remain essentially constant over the peak period to meet trip schedules.

TABLE: 10

7 - 9 AM VOLUMES - Off Peak Direction

I-45 Northbound at Link Rd

(Count Station - S-142)

	Before CFL (1978-79)	With CFL (1979-80)	Difference
Sept.	5559	5356	- 203
Oct.	5592	5487	- 105
Nov.	5501	5490	- 11
Dec.	5734	5354	- 380
Jan.	5520	5439	- 81
Feb.	5636	5591	- 45
Mar.	5877	5698	- 179
Apr.	5707	5730	- 23
May	5844	5847	+ 3
June	5534	5599	+ 65
July	5114	5686	+ 572
Aug.	5370	5728	+ 358
Monthly Average	5582	5584	+ 2
		Percent Change =	0%

Source: Reference (7)

TABLE: 11

4 - 6 PM VOLUMES - Off Peak Direction

I-45 Southbound at Link Rd

(Count Station - S-142)

	Before CFL (1978-79)	With CFL (1979-80)	Difference
Sept.	6836	6155	- 681
Oct.	7122	6625	- 497
Nov.	7297	6906	- 391
Dec.	7081	6880	- 201
Jan.	7152	6977	- 175
Feb.	7224	7030	- 194
Mar.	7060	6787	- 273
Apr.	6968	6752	- 216
May	7038	6750	- 288
June	6633	6870	+ 237
July	6650	6895	+ 245
Aug.	6649	6718	+ 69
Monthly Average	6976	6779	- 197
			Percent Change = - 2.82%

Source: Reference (7)

Vehicle Occupancies

Vehicle occupancy studies were conducted during the last three years at two locations on the North Freeway. The 1978 and 1979 annual vehicle occupancy counts were conducted by the Houston-Galveston Area Council with the cooperation from the State Department of Highways and Public Transportation and the City of Houston. The 1980 vehicle occupancy studies were conducted by the Texas Transportation Institute. The occupancy data are for the average number of people, including the driver, traveling in automobiles. For the purpose of this study, occupants within trucks, transit and intercity buses were excluded from the survey.

The occupancy counts on the North Freeway were established at the existing permanent counter station at Link Road (#S-142) and the Cypress Creek Station. Directional counts were conducted during the morning and afternoon peak periods from 6:30-9:30 a.m. and 3:30-6:30 p.m. respectively, Monday to Friday during the months of June, July, and August for each year. These counts were supplemented by two-hour off-peak sampled counts taken between 11:00 a.m. to 1:00 p.m. Counts were catagorized by occupants of 1, 2, 3, 4, and over. Vehicles were classified by private and commercial types. In addition, a 24-hour machine count was recorded at each station for verification purposes. The field study was conducted by H-GAC staff for 1978 and 1979, and by TTI staff for 1980. The automatic counters for the freeway stations were set up and recorded by the SDHPT.

The data collected during each peak period in both directions have a direct relationship to the CFL project. The results in Table 12 indicate that little change in the occupancy rates was observed as a result of the operation of the CFL. The occupancy rates for the vehicles using the CFL were observed to be 8.7 persons per van pool and 41.1 persons per bus transit.

TABLE: 12

VEHICLE OCCUPANCIES - I-45 NORTH FREEWAY

LINK ROAD STATION

Year	Southbound		Northbound	
	AM	PM	AM	PM
1978	1.28	1.44	1.41	1.36
1979	1.24	1.40	1.33	1.38
1980	1.33	1.38	1.33	1.39

CYPRESS CREEK STATION

Year	Southbound		Northbound	
	AM	PM	AM	PM
1978	1.28	1.68	1.47	1.38
1979	1.25	1.53	1.53	1.34
1980	1.23	1.52	1.43	1.41

COMBINED STATIONS

Year	Southbound		Northbound	
	AM	PM	AM	PM
Before CFL	1.26	1.51	1.44	1.37
After CFL	1.28	1.45	1.38	1.40

Source: 1978 and 1979 Reference (8)

Person Volumes (Table 13)

Peak Direction - The number of persons using the freeway in the peak direction (not including CFL) has increased about 5 percent in the morning and 2 percent in the afternoon. A project to reconstruct a section of I-45 near the CBD has affected the PM flow on the northbound lanes.

Off Peak Direction - There is a reduction in person movement on the main lanes in the 3 lane section which is accountable in the increase in volumes along the frontage road.

Alternate Routes - Over the length of the project, person miles of travel within the freeway right-of-way has not decreased in the off peak direction. Almost all of the diverted traffic uses the freeway frontage road as its alternate route.

CFL - Person movement has increased significantly. Over 4300 persons use the CFL during each peak period.

Speeds

There are three roadways that must be considered in this analysis: the CFL, the peak direction of flow and the off peak direction of flow.

CFL - The CFL initially had a posted speed limit of 45 MPH. Recent speed studies indicate that the average speeds are 52 MPH in the three-lane section and 55 MPH in the four-lane section (Tables 2 and 3). The speed limit for the CFL has been changed to Maximum 55 - Minimum 45 MPH.

Peak Direction of Flow - The CFL has not impacted the average speeds in the peak direction of flow. The terminals of the CFL are adequately

TABLE: 13

PERSON AND PERSON MILES
ON THE NORTH FREEWAY

Traffic Segment	Before CFL		With CFL	
	Persons	Person Miles	Persons	Person Miles
	AM Peak Period			
Offpeak	12,407	119,108	11,540	110,784
Diverted	-	-	1,430	6,292
Peak	19,774	189,830	20,677	198,499
HOV (CFL)	-	-	4,362	41,875
Subtotal	32,181	308,938	38,009	357,450
	PM Peak Period			
Offpeak	14,421	138,442	13,001	124,810
Diverted	-	-	1,430	6,292
Peak	18,473	177,341	18,857	181,027
HOV (CFL)	-	-	4,362	41,875
Subtotal	32,894	315,783	37,650	354,004
Total	65,075	624,721	75,659	711,454
Percent Change			+16.3%	+10.6%

designed so that the deceleration and acceleration of the HOV's do not conflict with the normal flow of traffic (Figures 3 and 4). The reduction in demand for the normal lanes as a result of modal shift has been replaced by traffic growth. During the peak hour the average speeds in the peak direction were 28 MPH during the AM peak and 25 MPH during the PM peak. The speeds were slightly higher for the total 2.5-hour peak period. An average speed of 30 MPH is used in the analysis of benefits.

Off-Peak Direction of Flow - Before the CFL was installed, traffic in the off peak direction traveled at free flow conditions at speeds averaging between 50 and 55 MPH. The reduction in capacity did not affect speeds in the eight-lane section south of Airline Drive.

However, speeds in the six-lane section were severely reduced at the beginning of the CFL operation. During the first week of operation, average speeds were 20 to 30 MPH for both AM and PM peak periods. By the third week of operation, speeds had increased to 35 to 40 MPH outbound in the AM and 30 to 35 MPH in the PM.

The outbound section continued to improve as traffic sought and found adequate alternate routes to the freeway. Most traffic used the continuous frontage road from Airline Drive, where the freeway cross-section was reduced from 8 to 6 lanes, to the Little York entrance ramp downstream of the CFL. After 1 year of operation, the average speeds were 45 to 50 MPH even though some congestion developed infrequently. The ramp control system helped maintain good operations by balancing the demands and minimizing accidents by allowing singled vehicle entry into the critical section of the freeway.

The inbound section had congestion problems on the approach to the

Shepherd interchange where the CFL begins, and in the restricted three-lane section down to the Airline entrance ramp where the roadway widens to 8 lanes. The demand on the three lanes approaching the CFL was greater than the capacity of two lanes. A ramp closure control plan was implemented to reduce this demand (Figures 17 and 18). The two entrance ramps closest to the Shepherd interchange were closed during the PM peak period, reducing the demand for the freeway main lanes by 1000 vehicles. This control reduced the queueing effect at the lane reduction and increased the average speeds on the approach to 50 MPH and within the section adjacent to the CFL to 40 - 45 MPH. Traffic, diverted by the ramp closures, used the frontage road as an alternate route. Half of the diverted traffic entered the freeway at downstream ramps, while the other traffic remains on the frontage roads.

The two non-CFL lanes operated at or near capacity at the downstream section near Airline Drive. To reduce the probability that congestion would develop in this section because of minor fluctuations in traffic flow, a third ramp, upstream of Airline Drive, was closed. The traffic was diverted along the frontage road through one intersection to the expanded freeway section. The use of the frontage road as an alternate route added some delay to the diverted traffic, but reduced the travel time for the freeway traffic. The added delay is insignificant for several reasons: 1) the frontage road average speeds are high, approximately 35 MPH; 2) there is little or no delay at the signalized intersection; 3) the delay at downstream ramps is less than the diverted traffic would experience at the normal entry point; 4) diverted traffic benefits from the improved operations on the freeway; and 5) the number of vehicles diverted is small, compared to the freeway volumes that benefit from the control.

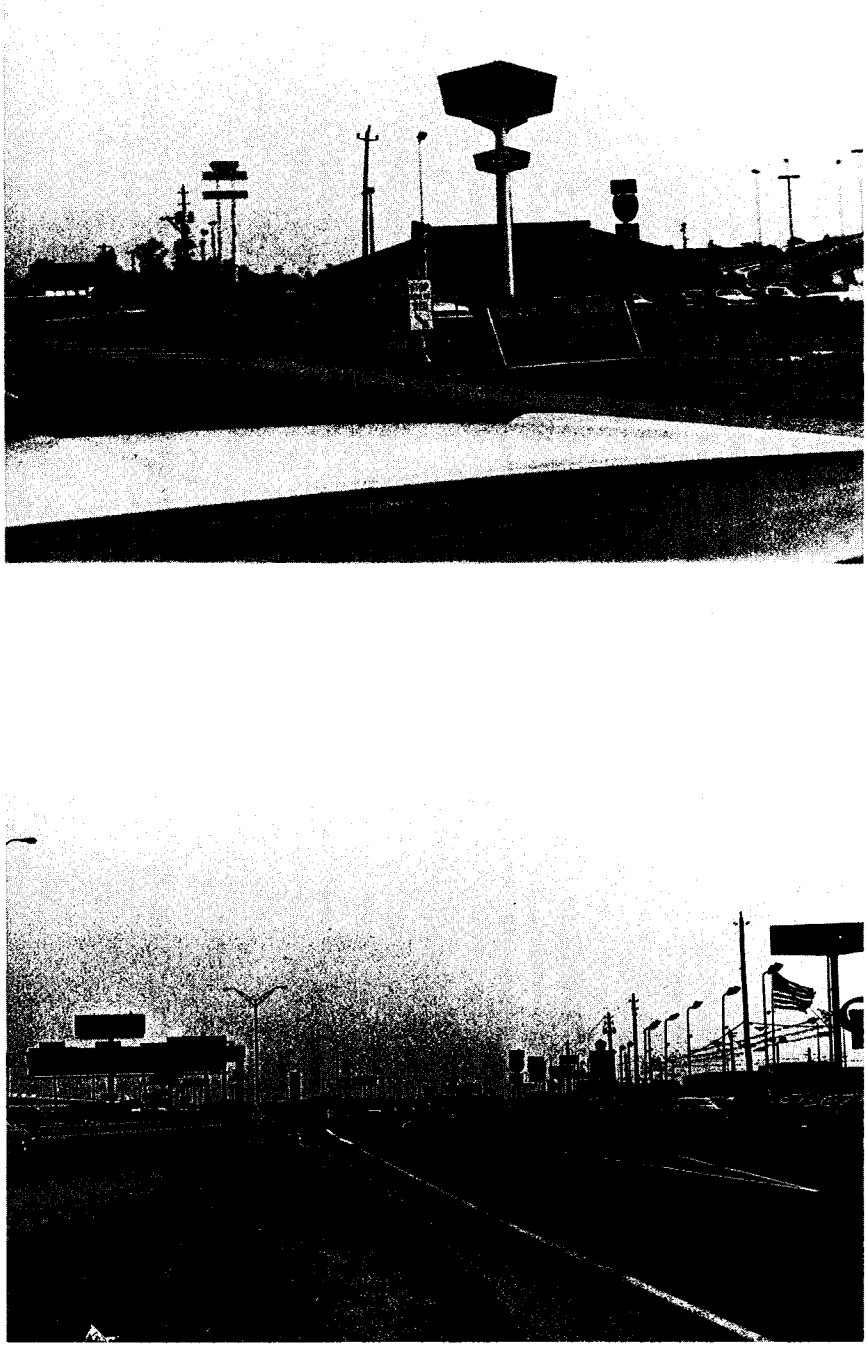
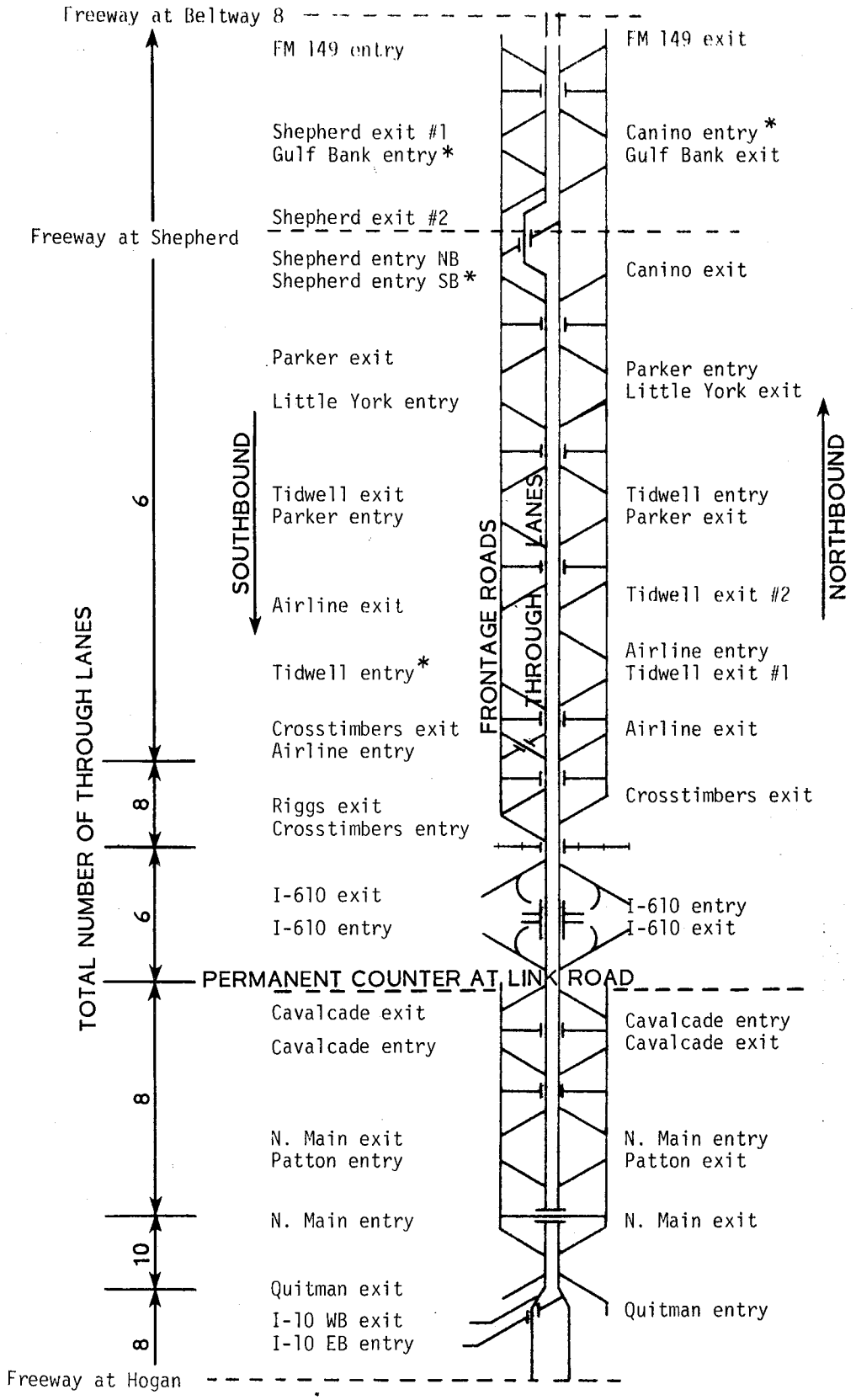


Figure 17: ENTRANCE RAMP CLOSURES AT SHEPHERD AND GULFBANK TO SOUTHBOUND I-45

Figure 18: Schematic of Ramp Locations on North Freeway



*LOCATIONS OF TEMPORARY RAMP CLOSURES

+LOCATIONS OF RAMP METERS

Source: Reference (1)

Travel Times

CFL Traffic - Travel times for the CFL were discussed in the section of usage of CFL, page 24. For the inbound direction, the average trip time was 23 minutes. For the outbound trip, 15.5 minutes.

Non-CFL Traffic - Both directions of travel and both peak periods are examined in the following sections.

Inbound (AM) - The non-CFL traffic has a travel time of 10 to 15 minutes from North Beltway 8 to the Shepherd interchange. From Shepherd to the southern end of the CFL section, the average speed was 28 MPH during the peak hour for a travel time of 20.6 minutes. Thus, the total trip time to the CBD distribution system as approximately 33 minutes.

These times represent the average travel times when there were no capacity reducing events to cause additional delay. With more than 80,000 vehicle-miles per hour being driven during the peak period on the inbound direction, it is probable that one or more incident will occur each day. For example, the vans in the CFL have a disability rate of one per 62,000 VMT and a study on the Gulf Freeway in 1970 determined a rate of one per 36,000 VMT for all traffic. The extent to which the incident will cause delay to the traffic will depend on the time, location and severity of the capacity reduction.

Inbound (PM) - Traffic operations on the non-CFL lanes have improved as a result of the ramp closure strategies and the average speeds for the full 13.6-mile trip is 50 MPH. The total trip time is 16 minutes. Therefore, a driver will have one to two minutes delay traveling through the CFL section on an incident free day.

There were exceptions which should be noted. It is still possible for a queue to form on the three-lane approach to the beginning of the CFL. Usually, the queue will not be long and will dissipate in 20 or 30 minutes, but the congestion will add one minute to the travel time during this period.

The two non-CFL lanes from Shepherd to Airline drive will operate at or near capacity for short time periods. Any traffic incident that blocks one or more lanes, or causes a distraction to drivers in the open lanes, will reduce the flow and increase the travel time.

Inbound (Diverted Traffic) - Some traffic is required to use the frontage road as an alternate route. The average speed along this route, including the delays at signalized intersections, is 25 MPH. Thus, the travel time for the diverted traffic is 10 minutes, as compared to 6 minutes on the main lanes of the freeway. This is the maximum delay to motorists. Often, the diverted trip will not be over the full length of the section but will only be to an adjacent downstream entrance ramp.

Outbound (AM) - Average speeds over the 13.6-mile section of freeway have increased to 50 MPH. This is below free speed because the average speed in the three lane section is 45 MPH. The total trip time is 16 minutes.

The two non-CFL lanes in the three lane section are operating at capacity and are susceptible to breakdowns when fluctuation in demand exceed the capacity. The frontage roads offer a good alternate route to bypass the congestion with little added delay.

Outbound (PM) - The average speed on the outbound direction to Shepherd during the PM peak period is 25 MPH. Some improvement in the

speeds downstream of Shepherd has been made as a result of the ramp closure strategy. Total trip time is calculated to be 28 minutes.

Outbound (Diverted Traffic) - Some traffic has diverted to the frontage road as an alternate route to the freeway lanes in the six-lane section. From the Airline exit ramp, where the freeway cross section is reduced one lane, to the Gulfbank entrance ramp, which is north of the CFL terminal, the travel time on the frontage road varies from 8 to 9 minutes. The freeway travel time through the same section is 6 to 7 minutes. Therefore, the additional delay to each vehicle is 2 minutes. It is estimated that 750 to 1000 vehicles have diverted the freeway, resulting in added total travel time of 25 to 33 vehicle hours or 33 to 44 person hours of delay.

Summary of CFL Impact on Traffic Operations

The users of the CFL saved a minimum of 9 minutes in the morning and 11.5 minutes in the afternoon. For days with incidents in the normal lanes, the time savings are greater.

The peak direction was not adversely affected by the deployment of the CFL. Nor was there a sufficient change in demand as a result of modal shift to the CFL to cause a measurable improvement in traffic operations.

The off peak direction of flow was severely affected in the six-lane section. Travel conditions changed from free flow to forced flow. But drivers sought and found alternate routes, and the operating agencies applied stringent controls to critical entrance ramps to achieve a balance in capacity and demand. Operating speeds have increased and the non-CFL lanes operate at levels of service C and D.

ANALYSIS OF BENEFITS

In the peak direction of flow, the operating characteristics have not changed significantly with the installation of the CFL. Vehicle miles of travel have not changed, even though a daily usage of the CFL represents the equivalent of almost 57,000 passenger car miles. The amount of travel that switched from passenger cars to HOV's is estimated to be 40,000 vehicle miles. For a freeway that carries in excess of 300,000 vehicle miles of travel during the peak period, the reduction of 13 percent is significant, but since the growth of the CFL usage has taken place over a period of 12 months, travel in the normal lanes has increased to a level equal to or greater than the period before the opening of CFL. However, the ability of the freeway to accommodate travel equivalent to the 57,000 vehicle miles at a high level of service is significant in measurable and calculable terms of travel time, vehicle operating costs, gasoline consumption, air pollutants, and roadway efficiency. Factors, used to calculate costs, fuel consumption and air pollutants, are found in Reference 9.

Total Travel Time

The Contraflow Lane saves an average of 10 minutes in the A.M. and 12.5 minutes in the P.M. to each passenger (Table 5). However, reduced levels of service on the main lanes in the off peak direction, coupled with delays created by ramp meters and ramp closures, reduced overall travel time improvements. This section of the report collectively sums the various travel time changes resulting from the implementation of CFL.

In Table 14, changes in "before" travel times are shown for CFL users and off peak traffic in terms of the number of person-hours

TABLE 14: NET TIME CHANGES FOR CFL AND OFF-PEAK DIRECTION USERS BY PEAK PERIOD

	Change in "Before" Person-Hours[1]		
	CFL	Off-Peak Direction	Net Change
A.M. (6:00 - 8:30 a.m.)			
Initially (Week 12)	-384	+558	+174
After 6 Months (Week 31)	-451	+360	- 91
After 12 Months (Week 52)	-532	+284	-248
P.M. (4:00 - 6:30 p.m.)			
Initially (Week 12)	-290	+506	+216
After 6 Months (Week 31)	-468	+ 69	-399
After 12 Months (Week 52)	-665	+ 69	-596
	Net Effect Both Peak Periods		-844
	Person-Hours saved annually = 211,000		

[1]Based on 1979 Data for Before Conditions

gained or lost. No significant travel time changes for the peak direction mixed flow were observed.

The net effects shown in Table 14 indicate that CFL operation initially casued some increase in net travel time in the morning period, but growth on the CFL pushed time savings to a net of about 91 person-hours after six months. Loss in travel speeds in the off peak direction represented slightly more than half of the total time savings gained on Contraflow.

In the afternoon, CFL operation initially impacted the off peak direction severely, with almost twice the amount of person-hours lost in mixed flow against that gained on the CFL. After ramp closures were added in January and February, levels-of-service improved and the time lost to freeway traffic was eliminated. Some delay had increased significantly and by Week 52 the net effect represented a reversal of initial findings, with 596 person-hours saved daily.

Daily net effects after 52 weeks of project operation represented an estimated 844 person-hours of time saved among all freeway users for both 2.5-hour time periods for each day of operation.

Vehicle Operating Costs

Changes in vehicle operating costs result from the changes in average speeds and level of service on freeway, and the different operating characteristics encountered on an alternate route by the diverted traffic. The measure of benefits uses the conditions before the CFL was implemented as a base, compared to volume and speed data collected one year later.

There is a change in vehicle operating costs that result from the shift from a passenger vehicle to a HOV. An assumption is made that the growth in transit ridership and van pools is attributed to the implementation of CFL. Of course, other factors, such as Park and Ride Lots and van pool programs, also influenced the growth in HOV usage in the North Freeway Corridor.

The increase in transit and car pool usage during the year of CFL operation is calculated in Table 15. Assuming an average vehicle occupancy from Table 12 of 1.4 persons/vehicle for passenger cars, 39,633 vehicle miles of travel per day have been eliminated. The reduction in cost of vehicle operations is estimated to be $4,919.64 per day.

From the point of view of the CFL user, this cost must be adjusted by the costs to the persons to ride transit or join a van pool. Using the bus fare of $0.90 for the Shepherd Park and Ride as an average cost to all HOV passengers over the length of the CFL, the change in out-of-pocket vehicle operating costs as a result of modal shift is estimated to be a reduction of $ 1,204.05.

TABLE 15:

CHANGES IN VEHICLE OPERATING COSTS
DUE TO MODAL SHIFT

Bus Passengers	Bus Trips
5140 @ 52nd week	125
-800 @ 1st week	-29
-180 from bus shuttle	-12
4160 persons	84 trips

$$\left(\frac{4160 \text{ persons}}{1.4 \text{ persons/vehicle}} - 84 \text{ vehicles}\right) \times 9.6 \text{ miles} = \frac{27{,}719 \text{ Veh. Miles}}{\text{Day}}$$

Van Pools-Persons	Van Pool Trips
3584 @ 52nd week	412
-1539 @ 1st week	-164
2045 persons trips	248

$$\left(\frac{2045 \text{ persons}}{1.4 \text{ persons/vehicle}} - 220 \text{ vehicles}\right) \times 9.6 \text{ miles} = \frac{11{,}914 \text{ Veh. Miles}}{\text{Day}}$$

$$\frac{39{,}633 \text{ Veh. Miles}}{\text{Day}} \times \frac{0.12413}{\text{Veh. Mile}} = \frac{\$ - 4{,}919.64}{\text{Day}}$$

$$\frac{39{,}633 \text{ Veh. Miles}}{9.6 \text{ Miles/Trip}} \times \frac{\$ 0.90}{\text{Trip}} = \frac{\$ + 3{,}715.59}{\text{Day}}$$

$$\text{Change in Costs} = \frac{\$ - 1{,}204.05}{\text{Day}}$$

The CFL has not changed operating characteristics of the peak direction of travel and, thus, has not affected the vehicle operating costs.

In the off peak direction, average speeds and conditions have been reduced from 55 MPH and free flow. In the AM period, speeds in the 4.4-mile section from I-610 to Shepherd have been lowered to 45 MPH and 40 MPH with Levels of Service D and E. In the PM period, speeds were lowered to 40 MPH and 35 MPH at levels of Service D and E. For an average volume of 1600 vph per lane, the changes in operating costs are calculated in Table 16. Conditions in the remaining sections of the study section from Hogan to I-610 and Shepherd to Beltway 8 were unchanged.

In Table 16, the net operating costs for vehicles using the freeway lanes were calculated to be a savings of $758.13 per day. The slower speeds resulted in improved fuel efficiency and thus reduced operating costs.

The diverted traffic to the alternate routes had an increase in costs, primarily due to the stops and stop time at the intersections (Table 17).

The savings in operating costs for CFL vehicles were calculated on the basis of the same volume of buses and van pools using the freeway in the peak direction at speeds of 30 MPH at LOS F if the CFL were not available (Table 18).

Table 19 summarizes the changes in costs to the motorists to operate their vehicles on the North Freeway Corridor as a result of the CFL operation. Other than vanpool vehicles and buses, only Type I vehicles were included in the analysis. The percent of trucks is too small to have an impact on the results.

TABLE: 16

CHANGES IN OFF PEAK VEHICLE
OPERATING COSTS
DUE TO SPEED AND LOS CHANGES

	Volume	Time	Distance	Speed	LOS	Running Costs For Type 1 Vehicle*	Daily Vehicle Operating Costs
	vph	Hours	Miles	MPH		Cents Per Vehicle Mile	Dollars
AM Period							
Before	3200	2.5	4.4	55	C	11.077	$ 3,899.10
After	3200	1.5	4.4	45	D	10.200	$ 2,154.24
After	3200	1.0	4.4	40	E	9.977	$ 1,404.76
	Savings in Operating Costs						$ 340.10
PM Period							
Before	3200	2.5	4.4	55	C	11.077	$ 3,899.10
After	3200	1.5	4.4	40	E	9.977	$ 2,107.14
After	3200	1.0	4.4	35	F	9.958	$ 1,373.93
	Savings in Operating Costs						$ 418.03
Total Change in Vehicle Operating Costs = -$758.13/day or -$189,532.50/year							

* Unit costs account for speed changes and stops that are normally experienced by vehicles on freeways. Reference 10.

TABLE: 17

CHANGES IN VEHICLE OPERATING
COSTS FOR DIVERTED TRAFFIC
AM & PM Periods

Volume in Vehicles	Distance in Miles	Speed MPH	Running Costs Rates For Type I Vehicles in Cents Per Mile	Daily Vehicle Operating Costs in Dollars
		Before CFL		
2000	4.4	55	11.077/veh. mile	$ 974.78
		After CFL		
2000	4.4	35	11.276/veh. mile	$ 992.29
2000	6 changes	35 to 0	3.580/change	$ 429.60
2000	3 min/veh Idling Time		37.540/hour	$ 37.54
			Subtotal	$1459.43
Change in Operating Costs to Diverted Traffic = + $484.65/day or + $121,162.50/year				

TABLE: 18

CHANGES IN CFL VEHICLE OPERATING COSTS

AM & PM Periods

Volume in Vehicles	Distance in Miles	Speed MPH	Level of Service	Running Costs Cents Per Vehicle Mile	Daily Vehicle Operating Costs in Dollars
Before CFL					
125 Buses	9.6	30	F	28.945	$ 347.34
412 Vans	9.6	30	F	12.413	$ 490.96
				Subtotal	$ 838.30
After CFL					
125 Buses	9.6	55	B	27.067	$ 324.80
412 Vans	9.6	55	B	10.504	$ 415.45
				Subtotal	$ 740.25
Total Change in Vehicle Operating Costs = - $98.05/day or - $24,512.50/year					

TABLE 19:

SUMMARY OF DAILY VEHICLE OPERATING COSTS

AS A RESULT OF THE CFL

Modal Shift	- $ 1,204.05
Peak Direction	No Change
Off Peak Direction	- $ 758.13
Alternate Route	+ $ 484.65
CFL	- $ 98.05
Total	- $ 1,575.58 per day
	-$393,895.00 per year

Fuel Consumption

The contraflow lane impacts energy consumption in several ways. The most direct and measurable considerations are vehicle miles of travel and vehicle operation characteristics. Other indirect effects could be the reduction in automobile parking facilities and additional transportation facilities. For this analysis, only the direct impacts are considered.

Vehicle Miles of Travel - The CFL carries 8724 persons over a distance of 9.6 miles in 537 vehicles each day. If we assume that without CFL all persons would ride in passenger cars with an average vehicle occupancy ratio of 1.4 persons per vehicle, the savings in vehicle miles attributed to the CFL would be:

$$\left(\frac{8724 \text{ persons}}{1.4 \text{ persons/vehicle}} - 537 \text{ vehicles}\right) \times 9.6 \text{ miles} = 54{,}667 \frac{\text{Veh.Mile}}{\text{Day}}$$

A conservative estimate of fuel consumption is 17 MPG for vehicles operating on a freeway at 30 MPH at Level of Service F. Assuming the same rate of consumption for travel in the CFL, the fuel savings is 3216 gallons per day, or 803,919 gallons of gasoline per year.

However, to be realistic, not all persons now using the CFL were in passenger cars before its installation. For example, those persons in HOV's at the beginning of the CFL operation and in 12 bus trips serving the Houston Intercontinental Airport did not make a mode choice because of the CFL. Certainly, other van pools formed since the CFL was started would have done so regardless of the CFL; but, for this analysis, the benefits of fuel conservation for new van pools will be assigned to the priority lane.

Growth in transit ridership, however, is a direct result of the availability of new facilities and services; park and ride lots, new transit service and the CFL. Fuel conservation can not be assigned to one or the other of these transit improvements, but should be credited to the total program for improving HOV operations. Table 20 presents the fuel savings that are achieved by the reduction in vehicle miles of travel as a result of these improvements.

Vehicle Operational Characteristics - Fuel consumption rates vary with average speed and level of service. The average fuel rate of 12 MPG for the CFL is used because the lower rates for buses offset the higher rates for vans traveling at 50 MPH.

The CFL has not changed the operating characteristics of the peak direction of travel and thus has not affected the fuel consumption.

In the off peak direction, average speeds and conditions have been reduced from 55 MPH and free-flow. In the AM period, speeds in the 4.4-mile section from I-610 to Shepherd have been lowered to 45 MPH and 40 MPH with a Level of Services D and E. In the PM period, speeds were lowered to 40 MPH and 35 MPH at Levels of Service D and E. For an average volume of 1600 VOH per lane, the changes in fuel consumption are shown in Table 21.

Some traffic was diverted from the freeway in this section. For each peak period, it is estimated that 1000 vehicles now use the frontage road or similar type arterial street during the time CFL is in operation. The average running speed on the alternate routes is 35 MPH. There is an average delay of 3 minutes at traffic signals, and six stops per trip. The change in fuel consumption for the diverted traffic can be calculated as shown in Table 22.

TABLE: 20

FUEL CONSUMPTION REDUCTIONS DUE TO MODAL SHIFT

Bus Passengers	Bus Trips
5140 @ 52nd week	125
-800 @ 1st week	-29
-180 from bus shuttle	-12
4160 persons	84 trips

$$\left(\frac{4160 \text{ persons}}{1.4 \text{ persons/vehicle}} - 84 \text{ vehicles}\right) \times 9.6 \text{ miles} = \frac{27{,}719 \text{ Veh. Miles}}{\text{Day}}$$

$$\frac{27{,}719 \text{ Veh Miles/Day}}{17 \text{ MPG}} = \frac{1629 \text{ Gallons of Fuel}}{\text{Day}}$$

Van Pools-Persons	Van Pool Trips
3584 @ 52nd week	412
- 1539 @ 1st week	- 164
2045 persons trips	248

$$\left(\frac{2045 \text{ persons}}{1.4 \text{ persons/vehicle}} - 220 \text{ vehicles}\right) \times 9.6 \text{ miles} = \frac{11{,}914 \text{ Veh. Miles}}{\text{Day}}$$

$$\frac{11{,}914 \text{ Veh Miles/Day}}{17 \text{ MPG}} = \frac{701 \text{ Gallons of Fuel}}{\text{Day}}$$

Total Fuel Saving = 2330 Gallons of Fuel/Day

2330 x 250 Days = 582,500 Gallons per Year

TABLE: 21

CHANGES IN OFF PEAK
FUEL CONSUMPTION DUE TO
SPEED AND LOS CHANGES

	Volume	Time	Distance	Speed	LOS	Fuel Consumption Rate (1)	Fuel Consumed
	VPH	Hours	Miles	MPH		Gallons/Veh.Miles	Gallons
AM Period							
Before	3200	2.5	4.4	55	C	0.0613	2158
After	3200	1.5	4.4	45	D	0.0538	1136
After	3200	1.0	4.4	40	E	0.0531	748
						Fuel Saved Per Day	274
PM Period							
Before	3200	2.5	4.4	55	C	0.0613	2158
After	3200	1.5	4.4	40	E	0.0531	1121
After	3200	1.0	4.4	35	F	0.0516	727
						Fuel Saved Per Day	310
Total Fuel Saved = 584 gallons/day or 146,000 gallons/year							

(1) Type 1 Vehicle

TABLE: 22

CHANGES IN

FUEL CONSUMPTION FOR DIVERTED TRAFFIC

AM & PM PERIODS

Volume in Vehicles	Distance in Miles	Speed MPH	Fuel Consumption Rate[1] Gallons Per Unit	Fuel Consumed Gallons
		Before CFL		
2000	4.4 miles	55	@ 0.0613/veh.mile	539
		After CFL		
2000	4.4 miles	35	@ 0.0434/veh.mile	382
2000	6 changes	35 to 0	@ 0.00980/change	118
2000	3 min/veh Idling Time		@ 0.370/hour	37
			Subtotal	537
Total Fuel Saved to Diverted Traffic = 2 gallons/hour or 500 gallons/year.				

[1] Type 1 Vehicle

The buses and van pools have a decrease in fuel consumption as a result of the smoother flow at LOS B in the contraflow lane (Table 23).

In summary, the reduction in speed on the main lanes of the freeway and the alternate routes as a result of the reduction in capacity in the off peak direction produces a positive benefit in fuel conservation.

One factor that was not included in this analysis was the impact that incidents have on the speeds and level of service in the reduced section. For example, if an incident occurs such that half of the traffic experiences delay, the freeway fuel consumption as calculated in Table 21 for the After Period would change in the following way:

3200 vph	1.25 hrs	4.4 miles	40 mph	E	0.0531	935 gal.
3200 vph	1.25 hrs	4.4 miles	20 mph	F	0.0772	1359 gal.
						2294 gal.

This would be an additional 428 gallons consumed per incident day. If we assumed an incident of this magnitude occurred 20 percent of the time, the annual fuel consumption would increase by 42,800 gallons.

Similiar events could occur on the frontage road or alternate streets, but their impact would be considerably less than the freeway incidents.

Fuel Consumption to Operate CFL - The operations field crew requires 1 wrecker, 2 trucks, 1 pickup truck, 2 police vehicles, and 1 supervisor vehicle. During one day of operation each of these vehicles will travel the length of the CFL several times. The following table estimates gallons of fuel consumed on a normal day of operation (Table 24).

A summary of all the events that affect fuel consumption indicates that the CFL could have generated a saving of 671,300 gallons of fuel per year (Table 25).

TABLE: 23

CHANGES IN FUEL CONSUMPTION
FOR USERS OF CFL - AM & PM PERIODS

Daily Volume of Vehicles	Distance in Miles	Speed in MPH	Level of Service	Fuel Consumption Rate Gal/Veh Mile	Fuel Consumed in Gallons
Before CFL					
125 Buses	9.6	30	F	0.1577	189
412 Van Pools	9.6	30	F	0.0574	227
				Subtotal	416
Before CFL					
125 Buses	10 changes	35-20		0.1170	14
412 Van Pools	10 changes	35-20		0.00524	22
				Subtotal	36
After CFL					
125 Buses	9.6	55	B	0.1687	202
412 Van Pools	9.6	55	B	0.0585	231
				Subtotal	433
Total Change in Fuel Consumed = - 19 gallons/day or - 4750 gallons/year					

TABLE: 24

FUEL CONSUMPTION FOR CFL OPERATORS

Types of Vehicles	Vehicle Miles of Travel (Veh-Miles)	Fuel Consumption Rate (GPVM)	Fuel Consumed (Gal.)
Operations Crew			
MTA-Vehicles	380	.2249	85
Police	160	.1649	26
Subtotal	540		101
Annual Fuel Consumed = 25,250 gallons			

TABLE: 25

SUMMARY OF CHANGE IN ANNUAL FUEL CONSUMPTION
AS A RESULT OF THE CFL

	Gallons
Modal Shift	- 582,500
Peak Direction	No Change
Off Peak Direction	- 146,000
Alternate Route	- 500
CFL Vehicles	- 4,750
Incidents	+ 42,800
CFL Operating Crew	+ 25,250
Total	- 671,300

Air Pollution

The environmental impacts of the CFL can be estimated in a similar manner to fuel consumption. Changes in air pollutants due to modal shifts would be determined for the 27,686 Veh-Miles of passenger vehicle travel transferred to buses and the 11,914 Veh-Miles of passenger vehicle travel transferred to vans (Table 20). These vehicles would have operated in the peak direction of flow under condition of 30 MPH and LOS F (Table 26).

The provision of the CFL for all buses and van pools results in a further change in air pollutants because the CFL vehicles will be operating at an average speed of 55 MPH (Table 27).

For off peak travel, the changes in travel conditions and the resultant changes in air pollutants are shown in Table 28. For diverted traffic, the changes in air pollutants at a freeway speed of 55 MPH to the alternate route speed of 35 MPH is calculated in Table 29.

Based on actual fuel consumption records, the average speeds for vehicles used in the operation of the CFL were 15 MPH for MTA vehicles and 10 MPH for police vehicles. The air pollution, added to the freeway corridor as a result of the operators, is calculated in Table 30.

The potential for incidents is increased with the CFL operation. It was estimated that 42,800 gallons of fuel would be burned due to the additional delay caused by these incidents. If we assume an average speed of 20 MPH during this period, the air pollutants can be estimated as follows:

$$\frac{42{,}800 \text{ gallons}}{.0772 \text{ gallons/veh. mile}} = 554{,}404 \text{ Veh. Miles traveled at 20 MPH}$$

The pollutants calculated in Metric Tons:

CO	HC	NO
26	2	2

A summary of the total change to the air pollutants as a result of the CFL is presented in Table 31.

TABLE 26:

AIR POLLUTION CHANGES DUE TO MODAL SHIFT

Mode	Daily Vehicle Miles of Travel	Pollutants at 30 MPH CO Kgms	HC Kgm	NO Kgm
Passenger Vehicles	-39,600	-1202	-127	-168
Buses	806	110	11	9
Van Pools	2,381	72	8	10
Total	-36,413	-1164	-108	-149

TABLE 27:

AIR POLLUTION CHANGES FOR
USERS OF CFL - AM & PM PERIODS

Daily Volume of Vehicle	Distance in Miles	Speed in MPH	Pollutants at Specified Speed		
			CO Kgms	HC Kgms	NO Kgms
Before CFL					
125 Buses	9.6	30	164	17	14
419 Van Pools	9.6	30	122	13	17
Subtotal			286	30	31
After CFL					
125 Buses	9.6	55	135	12	16
419 Van Pools	9.6	55	77	10	19
Subtotal			202	22	35
Change in Pollutants			- 84	- 8	+ 4

TABLE 28:

CHANGES IN AIR POLLUTANTS
DUE TO SPEED AND LOS CHANGES
IN THE OFF PEAK DIRECTION

	Volume	Time	Distance	Speed	Pollutants at Specified Speeds		
	VPH	Hours	Miles	MPH	CO Kgms	HC Kgms	NO Kgms
AM Period							
Before	3200	2.5	4.4	55	648	85	177
After	3200	1.5	4.4	45	432	52	100
After	3200	1.0	4.4	40	318	37	64
Change in Pollutants					102	4	- 13
PM Period							
Before	3200	2.5	4.4	55	648	85	177
After	3200	1.5	4.4	40	478	56	97
After	3200	1.0	4.4	35	363	40	62
Change in Pollutants					193	11	- 18
Total					295	15	- 31

TABLE 29:

CHANGES IN AIR POLLUTANTS

FOR DIVERTED TRAFFIC

Volume in Vehicles	Distance in Miles	Speed MPH	Pollutants at Specified Speeds		
			CO Kgms	HC Kgms	NO Kgms
Before CFL					
2000	4.4 miles	55	162	21	44
After CFL					
2000	4.4 miles	35	227	25	39
2000	3 min/veh Idling Time		88	5	1
Change in Pollutants			153	9	- 4

TABLE 30:

AIR POLLUTION CHANGES DUE TO
OPERATORS OF CFL - AM & PM PERIODS

Type of Vehicles	Distance Traveled (Veh-Miles)	Speed in MPH	Pollutants at Specified Speeds		
			CO (Kgms)	HC (Kgms)	NO (Kgms)
MTA Vehicles	380	15	90	9	4
Police	160	10	15	1	1
Total	540		105	10	5

TABLE 31:

SUMMARY OF CHANGES IN ANNUAL
QUANTITIES OF AIR POLLUTANTS
AS A RESULT OF THE CFL

	POLLUTANTS		
	CO (MT)	HC (MT)	NO (MT)
Modal Shift	-291	-27	-37
Peak Direction		No Change	
Off Peak Direction	74	4	- 8
Alternate Route	38	2	- 1
CFL Vehicles	- 21	- 2	1
Incidents	26	2	2
CFL Operating Crew	26	3	1
TOTAL	-148	-18	-42

Roadway Efficiency

One objective of the North Freeway Contraflow Lane Project is to raise the level of efficiency for moving people. This level of efficiency would be measured by moving more people at higher speeds. The CFL presents a trade off situation between off peak movement and the HOV movement. Based on the average volumes, vehicle occupancies, speeds, and travel times, the CFL has been successful in increasing the productivity. The freeway carries 16 percent more persons in the same 2.5-hour peak period, and the efficiency, as measured by passenger miles per vehicle hour, has increased by 6.0 percent (Table 32). This measure reflects the change in vehicle occupancies and speeds of vehicles. The table indicates the relative effectiveness of the CFL lane to move people.

Safety

The CFL Project is divided into three sections for the accident analysis:

Section 1 - Hogan Street to HB&T	3.2 miles
Section 2 - HB&T to Shepherd	4.4 miles
Section 3 - Shepherd to Beltway	4.2 miles

(See Figure 18)

Accidents for a 12 month period before CFL was opened are compared to a 12 month period with CFL in operation. Peak periods were defined to include the CFL operation and the setup and take down operations and were set at 5 - 9 AM and 3 - 7 PM.

AM Peak Period - During the AM Peak Period in the peak direction of flow, the accident frequency was reduced by 34 percent (Table 33). Most of the reduction came after January 1980 when the ramp closure controls were

TABLE 32:

SUMMARY OF CFL PRODUCTIVITY
FOR AM AND PM PEAK PERIODS

Traffic Segment	Before CFL			With CFL		
	Passenger Miles (2)	Vehicle Hours (3)	Ratio $\frac{(2)}{(3)}$	Passenger Miles (2)	Vehicle Hours (3)	Ratio $\frac{(2)}{(3)}$
AM Peak Period						
Off Peak	119,108	1,504	79.2	110,784	1,672	66.3
Diverted	-	-	-	6,292	126	49.9
Peak	189,830	5,022	37.8	198,499	5,169	38.4
HOV (CFL)	-	-	-	41,875	52	805.4
Subtotal	308,938	6,526	47.4	357,450	7,019	50.9
PM Peak Period						
Off Peak	138,442	1,667	83.0	124,810	1,913	65.2
Diverted	-	-	-	6,292	126	49.9
Peak	177,341	4,315	41.1	181,027	4,310	42.0
HOV (CFL)	-	-	-	41,875	52	805.3
Subtotal	315,783	5,982	52.8	354,004	6,401	55.3
Total	624,721	12,508	50.0	711,454	13,420	53.0
Percent Change				+ 10.6%	+ 7.3%	+ 6.0%

TABLE 33:

NUMBER OF ACCIDENTS ON NORTH FREEWAY
DURING THE MORNING PEAK PERIOD

	Section 1	Section 2	Section 3	Total
		Peak Direction		
Before	41	50	36	127
After	22	35	27	84
		Off Peak Direction		
Before	24	27	11	62
After	14	36	6	56

placed in effect.

In the off peak direction of flow, there was a small reduction in total number of accidents. However, Section 2, which was critically affected by the reduced capacity, experienced a 33 percent increase in accident frequency.

PM Peak Period - The accident experience in the peak direction of flow was unaffected by the CFL operation (Table 34).

The off peak direction experienced a significant increase in accidents in Sections 2 and 3 where traffic congestion was most severe. For example, the approach to CFL from the north in Section 3 had an increase of 25 accidents which represents a 250 percent change. The application of control management in the form of ramp closures in these sections has greatly reduced congestion and is expected to reduce the accident experience.

Conclusions on Safety - The CFL has no impact on the accident experience in the peak direction of flow. In the off peak direction, the accident experience increased significantly in those sections that had significant fluctuation in level-of-service caused by the reduced capacity.

Cost of Operation

The cost to operate the CFL during the first year of operations was $645,400 (Table 35). After one year of operation, the annual rate of cost, based on reduced enforcement and wrecker services, is $536,400.

TABLE 34:

NUMBER OF ACCIDENTS ON NORTH FREEWAY
DURING THE AFTERNOON PEAK PERIOD

	Section 1	Section 2	Section 3	Total
		Peak Direction		
Before	43	62	22	127
After	47	59	24	130
		Off Peak Direction		
Before	37	45	17	99
After	20	66	42	128

TABLE 35:

AVERAGE MONTHLY CFL OPERATING COSTS

		Setup/Take-Down Procedures		Enforcement	Wrecker	Facility Maintenance and Repair	Total
		Labor	Supplies				
1979	Sept	$30,000	$2,600	$14,200[1]	$15,000	$3,000	$64,800
	Oct	30,000	2,600	13,100[1]	15,000	3,000	63,700
	Nov	30,000	2,600	7,600[2]	15,000	3,000	58,200
	Dec	30,000	2,600	5,200	15,000	3,000	55,800
1980	Jan	33,000	2,600	6,400[3]	15,000	3,000	60,000
	Feb	33,000	2,600	6,100	15,000	3,000	59,700
	Mar	33,000	2,600	6,100	15,000	3,000	59,700
	Apr	33,000	2,600	6,100	0	3,000	44,700
	May	33,000	2,600	6,100	0	3,000	44,700
	June	33,000	2,600	6,100	0	3,000	44,700
	July	33,000	2,600	6,100	0	3,000	44,700
	Aug	33,000	2,600	6,100	0	3,000	44,700
Total		384,000	31,200	89,200	105,000	36,000	645,400

[1] 4-6 Police Patrols during first month of Project.

[2] 2-4 Police Patrols during third month of Project.

[3] 2 Police Patrols.

[4] Wrecker service privately contracted just seven months.

Source: Reference 1

CONCLUSIONS

The Contraflow Lane Project was implemented to improve the mobility for persons using the North Freeway Corridor. The Project was designed to encourage the use of high occupancy vehicles. Control measures were taken to maintain or improve traffic operations for all vehicles using the North Freeway. Based on the experience of 12 months of operation and the level of traffic operations at the end of the year of operation, the following conclusions are made:

1. The CFL usage has continued to increase. The CFL, Park and Ride Facilities and increase transit service have a significant combined effect on encouraging persons to use high occupancy vehicles.
2. Total Travel Time for users of the North Freeway has been reduced by 844 person hours per day. CFL users save 1197 person hours, non-CFL users expend 353 additional person hours of travel.
3. Peak period-peak direction travel has not been affected by the CFL. The reduced demand caused by a shift to the CFL is offset by traffic growth.
4. Traffic in the off-peak direction of travel has suffered additional travel time and displacement to alternate routes. The Level of Service has reduced from levels of B-C to D-E.
5. Alternate routes are capable of providing an acceptable level of service to the diverted traffic. The reduced service is acceptable because it applies to only 4.4 miles of the 9.6-mile Project.
6. Vehicle occupancies for non-CFL users has not changed.
7. The vehicle operating costs for North Freeway Users has been reduced by $394,000 per year.

8. Fuel consumption for North Freeway Users has been reduced by 671,000 gallons per year.
9. The CFL results in a reduction of Air Pollutants of CO, HC, and NO of 150, 18 and 42 metric tons, respectively.
10. The efficiency of the North Freeway to carry persons has been increased. As measured in terms of person miles per vehicle hour, the efficiency has increase 6%, while the number of person miles has increased 10.6%.
11. The CFL has a good safety record. Only three accidents involved the CFL vehicles during the first year of operation. In each case, the accident would probably have occured under normal operations. Two accidents resulted in a fatalities; a motorist lost control and slid into the lane and a pedestrian ran across the freeway.
12. The CFL vehicles experienced one breakdown for every 44,000 vehicles miles of travel. This is above the normal average of disability that ranges from 30,000 to 40,000 VMT.
13. Although some sections of the freeway have experienced high percentage increases in accidents, the total number of accidents for the North Freeway in both directions in both peak periods has decreased 4 percent.

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APPENDIX A

I-45 NORTH-CONTRAFLOW PROJECT (CFL)

1974	November 27	Mayor Hofheinz requests District 12 to evaluate feasibility of contraflow as result of a previous meeting with the Texas Highway Department (THD), Chamber Transportation Committee, and City Traffic and Transportation Department. Mayor commits police, vehicles and other control equipment needed for operation and enforcement.
	December 2	District 12 completes a rather limited and subjective analysis concerning CFL and concludes that CFL might be possible on I-45 North.
	December 12	Get acquainted meeting with THD, Houston Traffic Department, Office of Mayor, and Texas Transportation Institute (TTI).
1975	January 9	Meeting of City of Houston. (Mayor, Transit Consultant, Traffic and Transportation), THD (District 12 and D-10) and TTI in which City proposed obtaining Federal Demonstration Funds.
	January 17	Meeting of City of Houston and THD in which District 12 provided City with <u>preliminary</u> report entitled

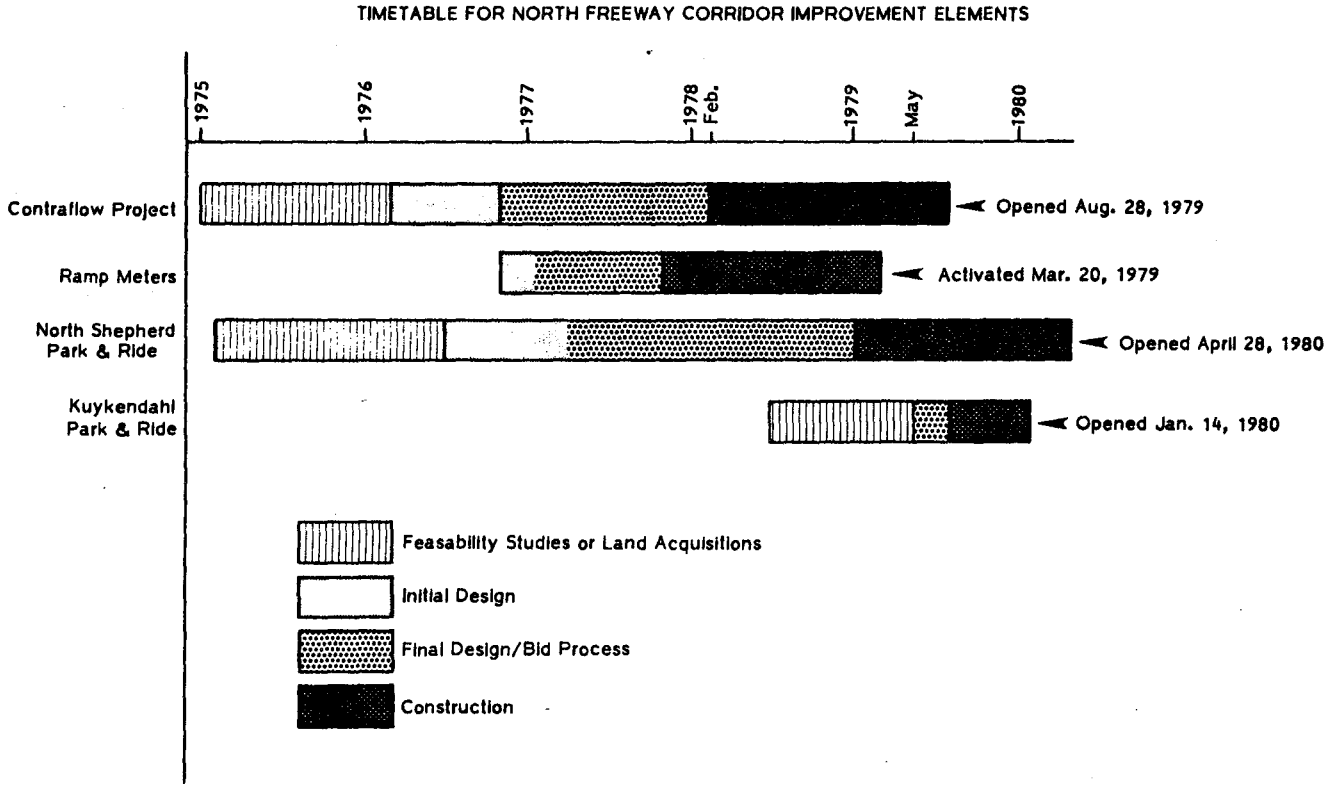
	"Utilization of Contraflow Techniques on Freeways in Houston" as part of material to be taken to UMTA in Washington.
April 9	City of Houston submits Service and Methods Demonstration Program (SMDP) to UMTA. $1,240,015 total project cost for I-45 (North and Gulf Freeways), I-10 (West) and U.S. 59 (Southwest Freeway).
May 19	District 12 receives a copy of SMDP and transmits a copy to Austin (File B. L. DeBerry (BLD)).
June 9	THD Austin (BLD) concurs in District 12's recommendation to approve general concept of the proposed SMDP. Concern expressed relative to legal aspects, safety, and not jeopardizing possiblity of future federal funds for operational improvements.
June 13	SMDP grant approved by UMTA.
August 18	Tender Minute Order (70388) authorizing THD to participate in SMDP with City paying for design, power and operation. City accepted on September 3, 1975.
August 20	SDPHT Austin requested conceptual approval of SMDP. Approved by FHWA Division on September 22, 1975.

	August 22	Initial draft agreement submitted to District 12 by City.
	November 17	District 12 submitted draft agreement to Austin (BLD).
	December 15	Agreement signed by City and State.
1976	March 4	District 12 sends feasibility of I-45 contraflow report to Austin (D-18T) for review and forwarding to FHWA.
	March 16	Letter from City to District 12, concerned with delay.
	March 22	District 12 transmits preliminary copies of feasibility studies without administrative review.
	May 7	City of Houston proposes to District 12 a reallocation of resources due to increased cost estimates in feasibility report. Requested consideration of FHWA and/or State cost participation.
	May 12	District 12 transmits City's May 7 request to Austin (D-18T).
	June 7	FHWA (Division) approves feasibility study.

	June 21	Austin (D-19) denies City's May 7 request. District 12 notifies City August 6.
	June 30	FHWA makes June 7 approval conditional on 13 points.
	August 6	Revised feasibility report given to City by District 12. Approved by City, August 20.
	October 8	District 12 transmits draft construction agreement to D-18.
	November 16	District 12 transmits proposed construction and operation agreement to City.
	November 18	Schematics approved by FHWA.
	December 3	District 12 request D-8 to consider lighting. Approved December 27.
1977	January 14-17	District 12 notifies City of need for lighting, revised cost estimate ($1,184,500) and a need for $50,000 for additional engineering work.
	February 16	City notifies District 12 that UMTA has agreed to new cost and schedule.

	June	State Department of Highways and Public Transportation (SDHPT) submitted final plans to City after approval from Austin SDHPT and FHWA.
		City submitted application for Section 5 Capital Grant Assistance from UMTA.
	September	City holds public hearing in support of Section 5 Application.
	November	City awarded Section 5 Capital Grant.
		SDHPT receives Bids for construction of CFL.
1978	February	Construction begins on CFL and Ramp Control System under the supervision of SDHPT.
1979	March 20	Ramp Control System becomes operational.
	August 28	Official opening of Contraflow Lane.
	October 5	First CFL closure due to a vehicle breakdown.
1980	January 3	SDHPT - MTA initiate Ramp Closures to improve operations in off peak direction - 1 ramp in the AM, 3 ramps in the PM.

January 14	Kuykendahl Park & Ride Lot opens for operation.
January	First accident involving an authorized vehicle in the CFL.
	Achieve goal of 2,500 persons using CFL each day.
February	SDHPT - MTA expand ramp closures to 2 ramps in the AM and 4 ramps in the PM.
April 25	First fatal accident involving an authorized vehicle in the CFL.
April 28	North Shepherd Park & Ride Lot opens for operation.



Source: Reference 1