TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/TX-80/4+205-10		

4. Title and Subtitle	5. Report Date
Priority Treatment for High-Occupancy Vehicles on the Katy Freeway, Houston	January, 1980
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Dennis L. Christiansen and Timothy J. Lomax	Research Report 205-10

9. Performing Organization Name and Address	10. Work Unit No.
Texas Transportation Institute Texas A&M University College Station, Texas 77843	11. Contract or Grant No. Research Study 2-10-74-205
	13. Type of Report and Period Covered Interim - September, 1973 January, 1980
12. Sponsoring Agency Name and Address Texas State Department of Highways and Public Transportation; Transportation Planning Division P.O. Box 5051 Austin, Texas 78763	14. Sponsoring Agency Code

15. Supplementary Notes

Research performed in cooperation with DOT, FHWA.
Research Study Title: Priority Use of Freeway Facilities

16. Abstract

This report presents an evaluation of the need for "intermediate" range priority treatments for high-occupancy vehicles on the Katy Freeway (I-10) in Houston, Texas. Short range HOV treatments are evaluated in other reports. This study evaluates priority treatment needs from the central business district to State Highway 6.

17. Key Words	18. Distribution Statement
Priority Treatment, High-Occupancy Vehicles, Exclusive Busways	No Restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

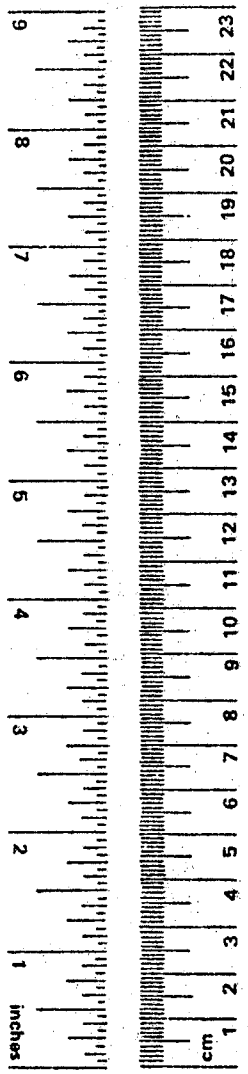
19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	83	

Form DOT F 1700.7 (8-69)

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

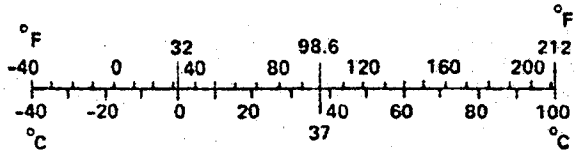
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2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



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

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



PRIORITY TREATMENT FOR HIGH-OCCUPANCY VEHICLES ON THE KATY FREEWAY, HOUSTON

A Feasibility Study

by

Dennis L. Christiansen
Study Supervisor

and

Timothy J. Lomax
Engineering Research Associate

Edited by

A. V. Fitzgerald
Assistant Research Specialist

Research Report 205-10

Priority Use of Transportation Facilities

Research Study Number 2-10-74-205

Sponsored by

State Department of Highways and Public Transportation
in cooperation with the
U.S. Department of Transportation
Federal Highway Administration

Texas Transportation Institute
Texas A&M University
College Station, Texas 77843

January 1980

ABSTRACT

This report presents an evaluation of the need for "intermediate" range priority treatments for high-occupancy vehicles on the Katy Freeway (I-10) in Houston, Texas. Short range HOV treatments are evaluated in other reports. This study evaluates priority treatment needs from the central business district to State Highway 6.

Key Words: Priority Treatment, High-Occupancy Vehicles, Exclusive Busways

EXECUTIVE SUMMARY

The Katy Freeway, I-10W in Houston, is a major interstate facility serving travel demands between western Harris County and various parts of Houston along and within the circumscribed area of Loop 610. In recent years extensive residential and commercial development have occurred along the freeway as far west as Brookshire, a distance of 35 miles from the Houston central business district.

The freeway presently has a 10-lane cross section from the CBD to Loop 610, an 8-lane cross section from Loop 610 to Wirt, and a 6-lane cross section from Wirt to Katy. In the near future the State Department of Highways and Public Transportation plans to expand the cross section between Loop 610 and Beltway 8 to 8 lanes. It is that proposed project that makes significant improvements for high-occupancy vehicles feasible.

This study evaluates the feasibility and desirability of implementing various alternative HOV improvements along the Katy Freeway. Studies already conducted for the Metropolitan Transit Authority have identified those limited actions that can be undertaken immediately to expedite HOV flow. Long-range, optimal HOV improvements will need to be developed in conjunction with plans the Department will be developing for possible "double-decking" of the freeway, and the possibility of purchasing all or part of the M-K-T Railroad right-of-way will also influence long-range plans. Also the long-range plan has yet to be identified through the alternatives analysis process. The primary focus of this study, thus, is to identify any "intermediate range" HOV improvements, improvements that might be implemented at the same time the freeway is widened and would be operational for 5 to 20 years, that appear desirable. Implementation of such an improvement would probably allow a priority HOV facility to be operational at least 10 years sooner than what would result if no actions were taken until the long-range solution was implemented.

The Katy Freeway is one of the most congested freeways in the nation. It serves more CBD work trips than any other Houston Freeway, and, with the exception of the Southwest Freeway, serves more trips to the Galleria/Post Oak and Greenway Plaza complexes than any other freeway. It is those types of trips that are most amenable to service by transit.

Average daily traffic volumes in the range of 175,000 are recorded along the Katy Freeway, and volumes have recently been increasing at nearly 5% per year. Peak period travel distances have decreased by 10% per year. This suggests that, even if a latent travel demand did not exist, the entire additional capacity provided by the freeway widening would be fully utilized within about 5 years. However, Department projections call for traffic volumes to increase at rates of between 4% and 11% per year at least until 1990. As a result, it is appropriate to evaluate the feasibility of also providing HOV improvements as one additional means of increasing the effective freeway capacity.

The HOV improvement would need to be capable of serving both peak periods, and initially would extend from an eastern terminus near Washington to a western terminus near SH 6, a distance of 13.1 miles. Trips to the CBD, Galleria/Post Oak, and Greenway Plaza could utilize the HOV facility. Midpoint entries would be necessary. Utilization estimates suggest that approximately 3000

persons per 2-hour peak period would initially use the facility (buses, vanpools, and carpools) and that this usage would increase to nearly 13,000 by 1995 (buses only).

This study, as well as several others ("Houston Corridor Study," "Cost-Effectiveness Analysis for Gulf Freeway Busway," Research Reports 205-1 and 205-8), evaluated factors relative to the implementation of priority HOV improvements. These analyses, as applied to the Katy Freeway, considered the alternative actions listed below and arrived at the following conclusions concerning those actions.

Exclusive Busway. Insufficient width is available to develop a two-lane median busway at-grade. A one-lane median facility appears feasible. At this time, the one-lane busway is viewed as superior to a two-lane, elevated busway because: it can be implemented in 3 to 5 years rather than 10 to 20 years; the one-lane busway improvement is compatible with the Department's plans to widen the Katy Freeway and can be implemented simultaneously as a complementary improvement; the one-lane HOV lane is a low cost, low risk option that can readily be converted to other uses when, and if, necessary; MTA has not yet developed the long-range plan that would be needed to justify an expensive, elevated busway; the one-lane facility provides an excellent means of testing demand prior to committing large sums of money; there is strong reason to suspect that the one-lane facility is the most cost-effective action to take, even though the one-lane median facility compromises, it does not destroy the functionality of the freeway main lanes.

Contraflow Lane. Given the Department's widening plans, at least between Beltway 8 and Loop 610, a contraflow lane appears feasible, though not necessarily desirable. Given a choice between contraflow and an exclusive median HOV lane, the median lane is superior because: it does not incur the very high daily operational cost ($2,000 to $3,000) required to set up, take down, and enforce contraflow; the contraflow eliminates the positive separation of opposing traffic flows; contraflow penalizes off-peak direction traffic by reducing the number of lanes serving that traffic; less control and concern need to be given to the types of vehicles allowed to utilize an exclusive median facility; and, since the HOV facility must be elevated to provide mid-point access/egress, it is more feasible to provide that access/egress with an exclusive median lane.

Freeway Control With Priority Entry. This concept can be expected to have a relatively low benefit/cost ratio. This concept does not provide the same degree of schedule reliability nor line haul travel speeds that an exclusive lane can provide. Furthermore, this concept does not increase total freeway capacity; if anything, that capacity is reduced in order to maintain acceptable operating speeds. Inability to meter freeway-to-freeway traffic causes this concept to not be applicable to the Katy Freeway, at least during the afternoon peak.

Frontage Roads With Signal Preemption. Some short-term gains can be achieved through this approach, and those improvements are currently being pursued. The effectiveness of those improvements is limited and will decrease as traffic volume increases. Sufficient bus capacity cannot be generated using this approach to be able to serve projected travel volumes.

Based on these analyses, as an interim improvement that is compatible with the Department's current plans to add one additional traffic lane in each direction from Loop 610 to Beltway 8, a one-lane, reversible, median HOV lane appears to be feasible and justifiable on the Katy Freeway. Of the priority treatments available, the one-lane HOV lane represents the preferred action at this time if it is decided to pursue intermediate-range improvements. Such an improvement is not the optimal, long-range improvement, but is an improvement that should be useful over a 5 to 20 year time period, at which time its flexibility will permit it to easily be converted to other uses, if necessary.

An initial implementation cost of approximately $20 to $30 million will be required. All data presented in this report indicate that the one-lane median HOV lane would have a highly favorable benefit/cost ratio; indeed, there is reason to suspect that 7.6 would be a conservation estimate of that ratio.

IMPLEMENTATION STATEMENT

The intent of Project 205 has been to assist the Department in planning and implementing priority treatment on roadways in Texas. District 12 currently has plans to undertake a major reconstruction of the Katy Freeway, and the issue of what actions to take in that regard needed to be addressed. This report is intended to assist District 12 in addressing those issues.

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. This report does not constitute a standard, specification, or regulation.

TABLE OF CONTENTS

INTRODUCTION

Since the inception of this project in 1974, the primary intent has been to assist the State Department of Highways and Public Transportation in planning for and implementing priority treatments for high-occupancy vehicles on roadways in Texas. As part of this assistance, the Institute has begun to perform feasibility studies concerning high-occupancy vehicle treatments for specific urban freeways in Texas.

The Project 205 Committee, comprised of 6 District Engineers and 3 Division Heads, has assisted the Institute in selecting the specific facilities to be evaluated. This feasibility study, which addresses the Katy Freeway (Interstate 10) in Houston, is the first of a series of studies to be undertaken by Texas Transportation Institute. Figures 1 and 2 identify the Katy corridor study area. From Loop 610 to downtown, a 10-lane freeway currently exists. Between Loop 610 and Wirt, an 8-lane cross section exists. From Wirt to Katy, the freeway is presently a 6-lane facility.

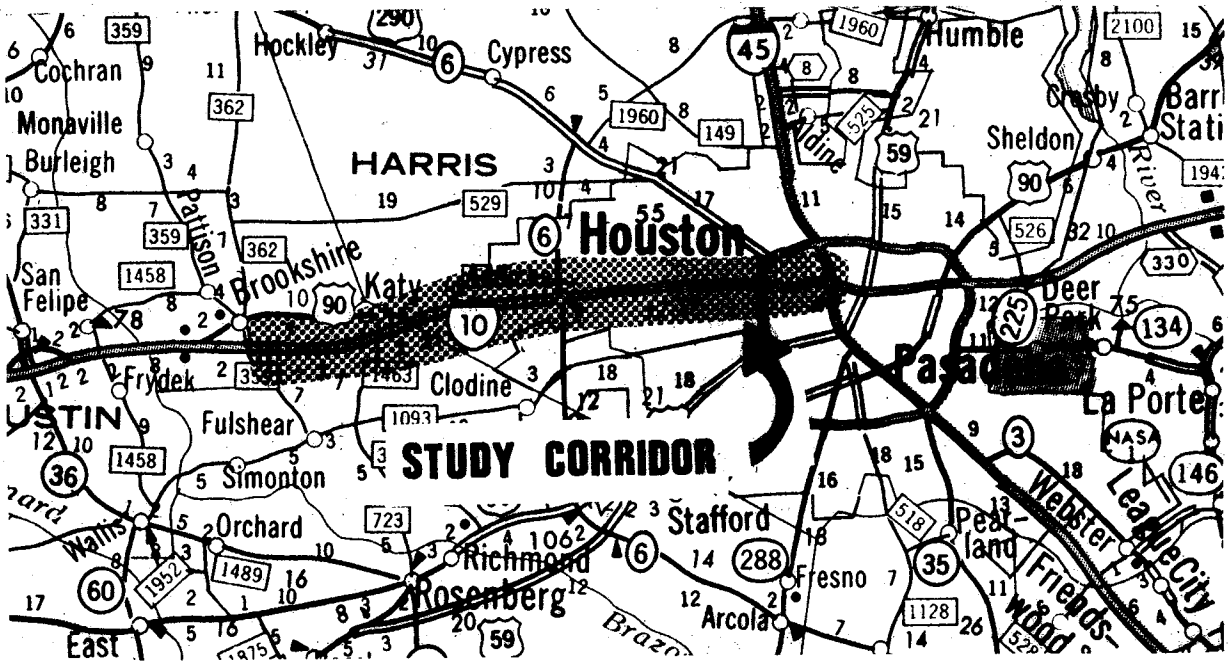


Figure 1: General Location of Katy Freeway Study Corridor

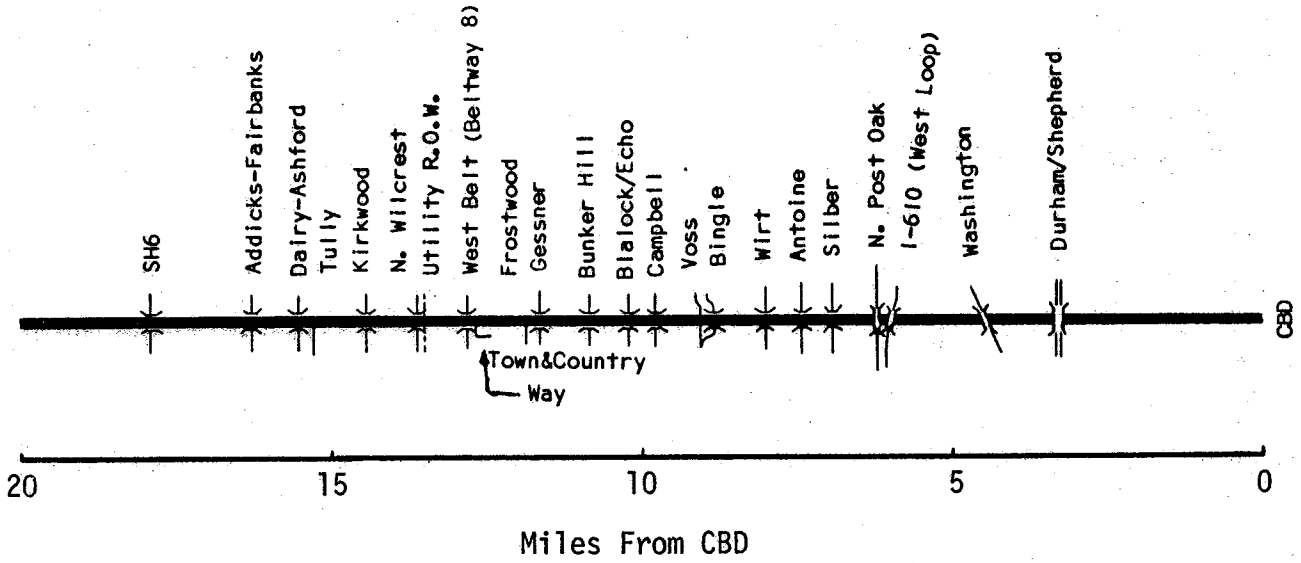


Figure 2: Katy Study Corridor and Major Intersecting Roadways

The intent of the feasibility studies is to evaluate what priority treatments, if any, should be considered for the time and funding levels listed below.

- Immediate implementation, low cost
- Moderate implementation time, moderate cost
- Desirable long-range improvement

At this point in time, it does not appear appropriate to evaluate all 3 of these levels for the Katy Freeway. A project report, entitled "Houston Corrodor Study," recently prepared by the Texas Transportation Institute for the Metropolitan Transit Authority (MTA), evaluated immediate implementation possibilities in the I-10 corridor. The recommended actions, which are already being considered for implementation by MTA and SDHPT, primarily involve bus use of frontage roads and surface streets with various improvements in traffic signalization. Even those actions will provide only minimal improvements to bus travel times, however. Those actions are further reviewed in the "Overview of Applicable Priority Treatments" section of this report. The desired long-range (20+ years) improvement is difficult to identify at this time. Such an

improvement will need to be an integral part of the Department's plans for possible double-decking of the Katy Freeway; once those plans are more clearly defined, it will be possible to identify manners in which desirable priority treatments can be incorporated into that design. Also, long-range improvements in the corridor depend upon the feasibility of obtaining all or part of the right-of-way presently owned by the M-K-T Railroad. The feasibility of obtaining that right-of-way is yet to be assessed. This study does, however, comment on the apparent compatibility of intermediate-range and long-range actions.

As a consequence, this report primarily focuses on mid-range (5-15 year) improvements. It is recognized that the improvements considered are not optimal; however, it appears feasible to develop functional priority treatments in conjunction with major improvements planned by the Department in the Katy corridor. The Department currently has plans to add one additional travel lane in each direction between Loop 610 and Beltway 8 (West Belt). It is assumed in this study that most of the improvements being planned by the Department will be implemented in the near future. Without implementation of those improvements, the potential for implementing priority treatment improvements is greatly restricted.

In addition to this introductory section, this report is presented in 5 sections. The initial section defines the extent and characteristics of traffic congestion in the Interstate 10 corridor, and the implications this traffic congestion has concerning priority treatment. The second section reviews available priority treatments and identifies those that appear applicable, based on physical design and traffic operating patterns, for implementation in the study corridor. The third section identifies the number of high-occupancy vehicles that can be expected to use the priority treatment and presents some preliminary cost-benefit relationships. The fourth section presents conceptual

designs for the improvements; cross-sections and renderings of both existing and possible future conditions are presented. The final section presents the major study findings and recommendations.

TRAFFIC CONSIDERATIONS

The Katy Freeway (I-10) is a major interstate highway serving travel demands from western Harris County to various parts of Houston along and within the circumscribed area of Loop 610. Extensive residential and commercial development have occurred along this freeway as far west as Brookshire, a distance of 35 miles from downtown Houston.

The Katy Freeway is also one of the most congested roadways in the state. In 1978, Average Daily Traffic (ADT) values over 175,000 were recorded along a six-lane section of the Katy Freeway. A recent study (Research Report 205-7) evaluated the relative traffic congestion along 19 major urban freeways in Texas. Two different congestion indices were developed in that study; one of those congestion indices showed the Katy to be the fifth most congested roadway in the state, the other index showed the Katy Freeway to be the second most congested roadway in the state.

In terms of trips served to major Houston activity centers, 1985 estimates indicate that the Katy Freeway will be serving more central business district (CBD) work trips than any other freeway in Houston (Houston Corridor Study). With the exception of the Southwest Freeway, the Katy Freeway serves more trips to Galleria/Post Oak and Greenway Plaza than any other Houston freeway.

In essence, existing travel demands along the Katy Freeway are high. That freeway is presently serving, and is projected to continue to serve, a high percentage of the trips destined to the rapidly growing activity centers in Houston.

Traffic Volumes

Existing and projected traffic volumes in the Katy Freeway corridor are of particular concern for two reasons. First, it is the intense existing congestion that created interest in the potential need for high-occupancy vehicle

(HOV) improvements. Second, the State Department of Highways and Public Transportation (SDHPT) has near term plans to add one additional traffic lane in each direction between Loop 610 and Beltway 8. The extent to which this improvement will alleviate congestion needs to be assessed to more clearly evaluate the need for supplementary HOV improvements.

One permanent traffic count station (Station S-141) is located on the Katy Freeway. The count station is located 0.8 miles west of Loop 610 on an 8-lane section of the Katy Freeway. However, this 8-lane section is relatively short, existing only between Loop 610 and Antoine; farther west a 6-lane cross section exists, while inside Loop 610 a 10-lane cross section exists. As a consequence, during the morning peak insufficient upstream capacity exists to fully utilize the roadway capacity at the count station; effectively, in determining traffic volume per lane, a 7-lane cross section exists in the vicinity of the count station.

Trends in average daily traffic on Katy Freeway are depicted in Figure 3.

Travel on Katy, even during the years with significant gasoline shortages (i.e., 1974 and 1979), has continued to increase; indeed, from 1974 to 1978, travel increased at a compound rate of 4.6% per year. Also, there is little doubt that the intense congestion that exists on Katy suppresses this growth rate. This is suggested by the fact that, in the Houston-Galveston Study area, travel increased at an annual rate in excess of 7% during this period (H-GRTS, Highway Travel Facts, 1968-1978). Thus, it is highly probable that significant latent travel demand has, and continues to, develop. All elements necessary to create latent travel demand exist in the Katy corridor (Research Report 167-5).

Daily traffic per lane approaches 25,000, a condition that can be expected to occur only if traffic flow is directionally balanced during the peak periods and the freeway is heavily utilized throughout the day. Recent count data

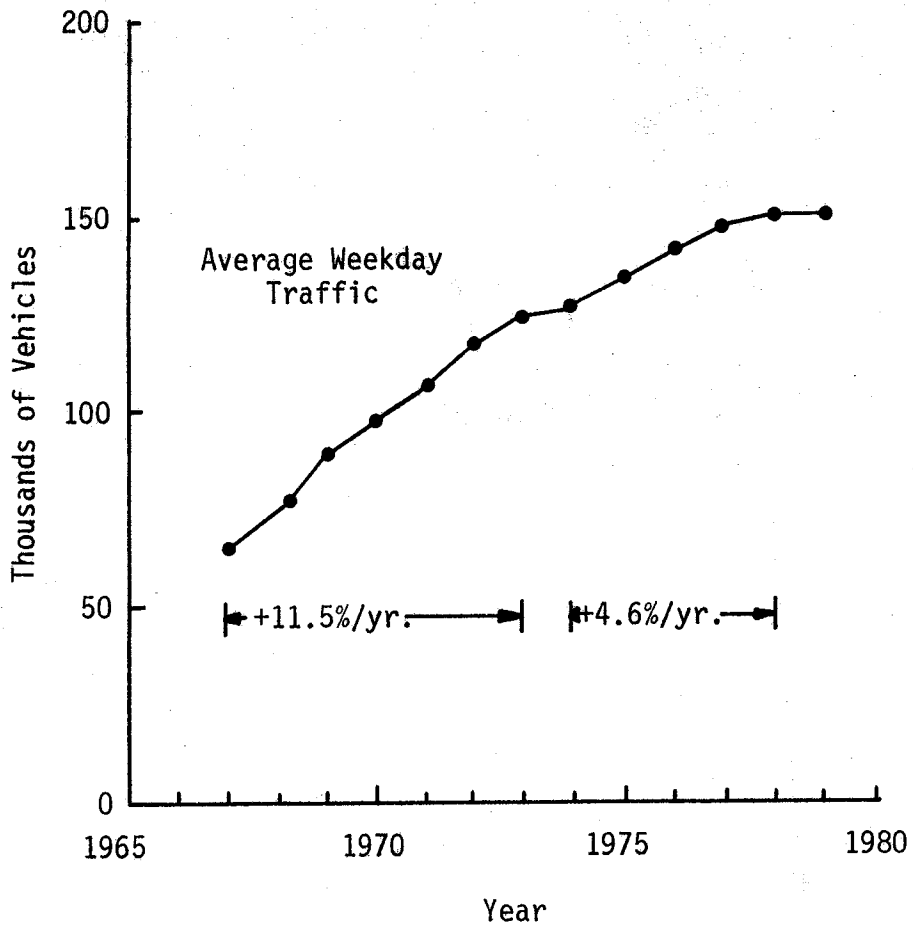


Figure 3: Trends in Average Daily Traffic on the Katy Freeway, Count Station S-141

(Houston-Galveston Area Council Transportation Newsletter, November 1978) indicate that peak period directional splits are as balanced as 55/45. Permanent count data suggest that travel remains high throughout the daytime hours (Figure 4); hourly counts (both directions) exceed 7,000 for 14 consecutive hours. For 4 hours per day, peak direction flow rates approach or exceed 1900 vehicles per hour per lane. Peak hour travel represents only 7% of ADT.

The planned expansion of the freeway will increase the number of through lanes by 20% to 33%. Even if a latent travel demand did not exist, continuation of the 4.6% annual growth rate would result in the expanded facility experiencing the same intense level of congestion the existing facility experiences within

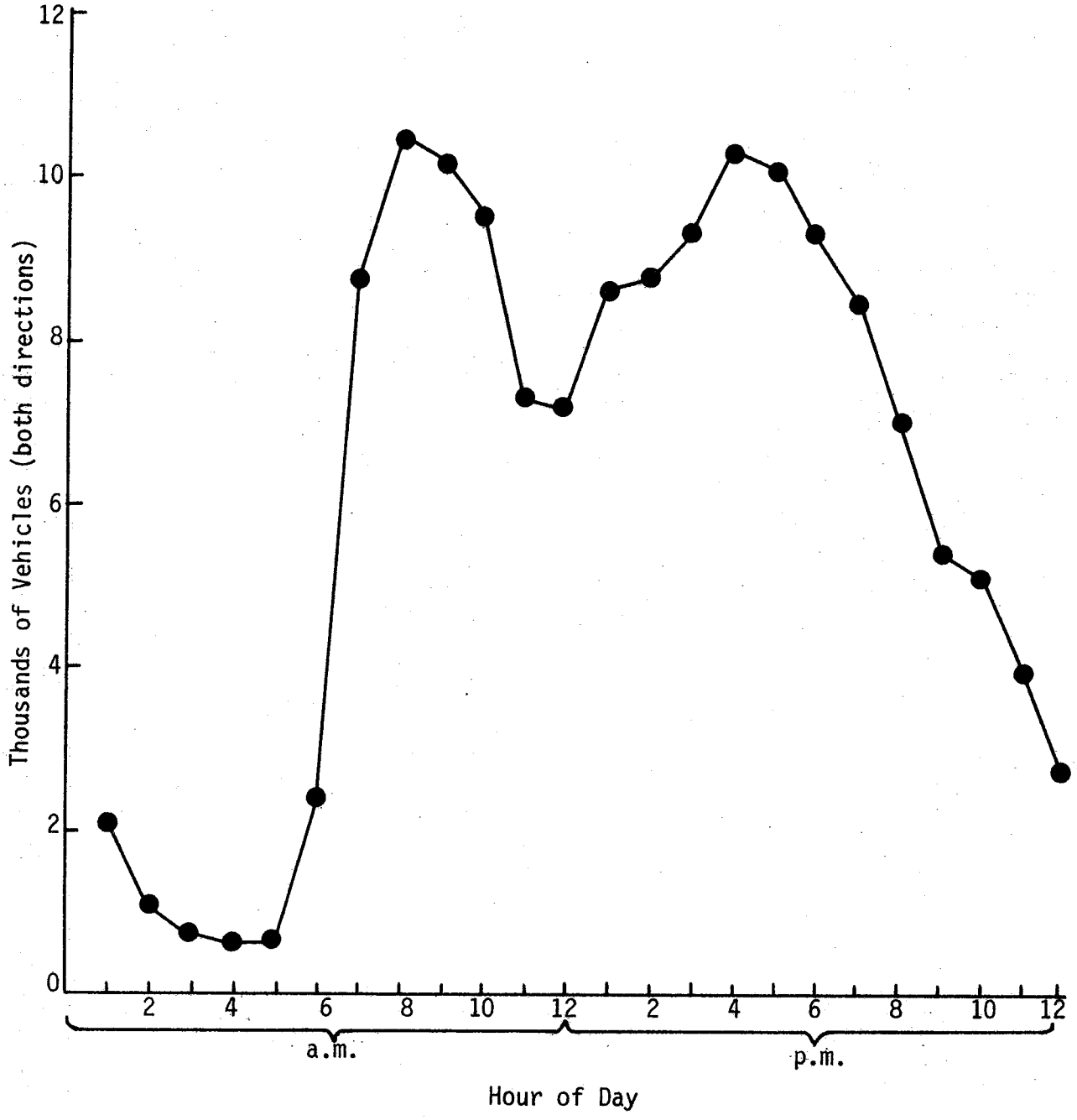
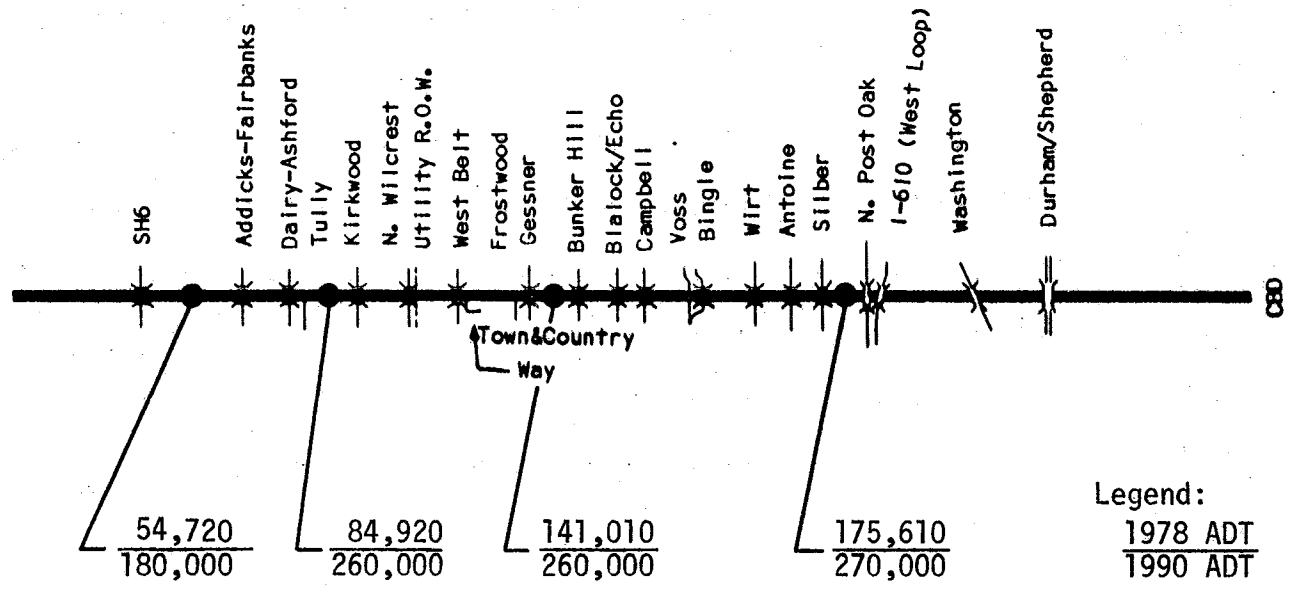


Figure 4: Hourly Variations in Traffic Volumes on the Katy Freeway (From count station S-141, July 1978)

4 to 7 years; in all probability, at least 6 to 10 years will pass before the improvement becomes operational. In essence, expansion of the main lanes is a badly needed improvement but will not, by itself, provide all the additional capacity needed to serve projected travel increases on the freeway. Current

Department projections (Figure 5) indicate that traffic volumes on the Katy Freeway can be expected to increase by approximately 54% to 233% between 1978 and 1990, representing annual increases of 4% to 11%. It appears that ADT volumes in the corridor can be expected to increase by approximately 100,000 vehicles throughout the study section in that 12-year period. Within 5 years of their opening, the additional lanes will be serving 25,000 vehicles/lane/day, or about 34,000 persons per day. All of the expanded capacity will be fully utilized.



Source: Houston-Galveston Regional Transportation Study

Figure 5: Existing and Projected Daily Traffic Volumes in the Katy Freeway Corridor

Travel Time and Delay

Travel time surveys have been taken in 1973 and 1976 (Houston-Galveston Regional Transportation Study). In 1973, homeward-bound CBD commuters could drive on Katy Freeway to beyond Addicks Road (SH 6) in 30 minutes; by 1976 they

could get only as far as Gessner. Over a 3-year period, a 30% reduction in peak hour travel distance on the Katy Freeway took place.

Pertinent 1976 morning and afternoon travel speeds along the Katy Freeway are shown in Figures 6 and 7 (pages 12, 13, 14 and 15). The a.m. peak (Figure 6 pages 12 and 13) indicates that the most depressed speeds (less than 20 mph) occur along the 3-lane inbound roadway between Gessner and Wirt. Depressed speeds exist along the entire section from Loop 610 to nearly Wilcrest.

Afternoon travel time data are shown in Figure 7 (pages 14 and 15). Speed reductions are most evident from Washington to Wirt, where the number of outbound lanes reduces to 3. Outbound speed reductions are apparent as far west as Blalock.

As noted previously, travel time delay increased noticeably from 1973 to 1976. Texas Transportation Institute performed a very limited travel time analysis along Katy in 1978. Speed reductions in both peaks, as identified in that limited study, appeared to have become depressed as far west as Kirkwood. Since total traffic volume increased by over 7% from 1976 to 1978, this increase in the extent of the congested portions of the roadway does not seem unreasonable.

As part of previous research (Research Report 205-7) estimates were made of the peak period delay experienced per vehicle along 19 Texas freeways. This delay was computed by comparing peak period travel times to off-peak period travel times. The 1976 Katy Freeway data indicate a 15-minute delay per vehicle in the peak direction during the peak period (Houston-Galveston Regional Transportation Study data); of the 19 freeways studied, this was the second highest delay time recorded.

Implications of Traffic Data

Texas freeways are some of the most congested in the nation (Research Report 205-7), and the Katy Freeway is one of the most congested facilities in Texas. Indeed, congestion indices (Table 1) developed by Texas Transportation Institute suggest that Katy Freeway is considerably more congested than the San Bernardino Freeway (Los Angeles), the Southeast Freeway (Boston), and the Banfield Freeway (Portland). All those freeways have at some point in time had priority treatment incorporated into their operation.

Table 1: A Comparison of the Congestion Index on the Katy Freeway with Congestion Indices for Other Selected Major Urban Freeways.

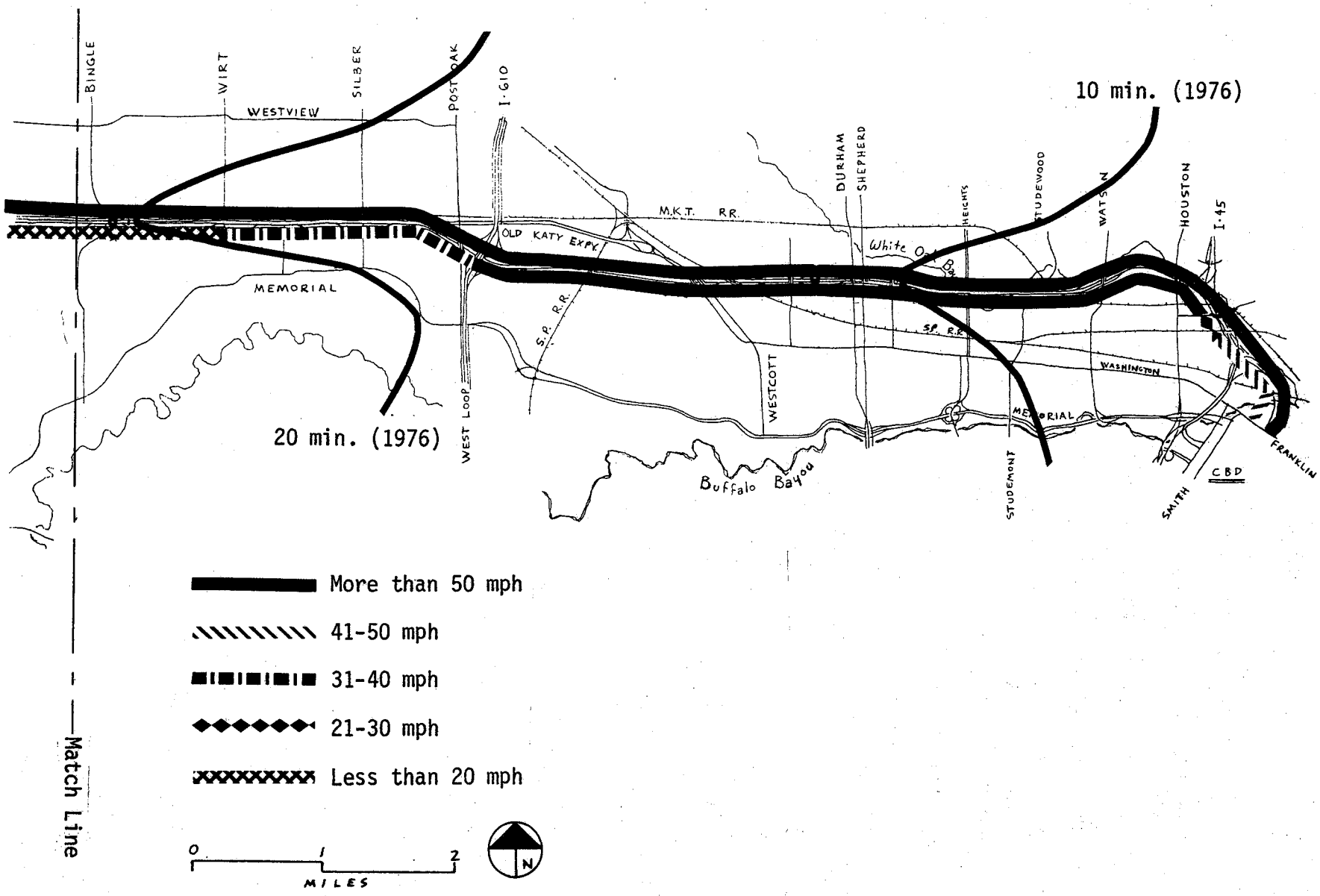
Freeway/City	Societal Congestion Index[1]
Santa Monica/Los Angeles	4.7
Katy/Houston	*4.4*
San Bernardino/Los Angeles	3.3
Southeast/Boston	2.2
Banfield/Portland	1.8

[1]Societal Congestion Index = $\left[\frac{\text{Delay Time}}{10} + \frac{\text{AADT/Lane}}{20{,}000}\right] \times \frac{\text{AADT}}{100{,}000}$

Source: Research Report 205-7

Traffic congestion is already intense along Katy Freeway, and it appears that volumes in the near future will increase by at least 4% to 5% per year. Planned expansion of Katy Freeway, adding one lane in each direction from Loop 610 to Beltway 8, is a badly needed, critical traffic improvement. However, given the existing congestion, the latent demand that would appear to have developed, and the historical growth rate in traffic volumes, adding one

Figure 6: 1976 A.M. Peak Travel Speeds on Katy Freeway



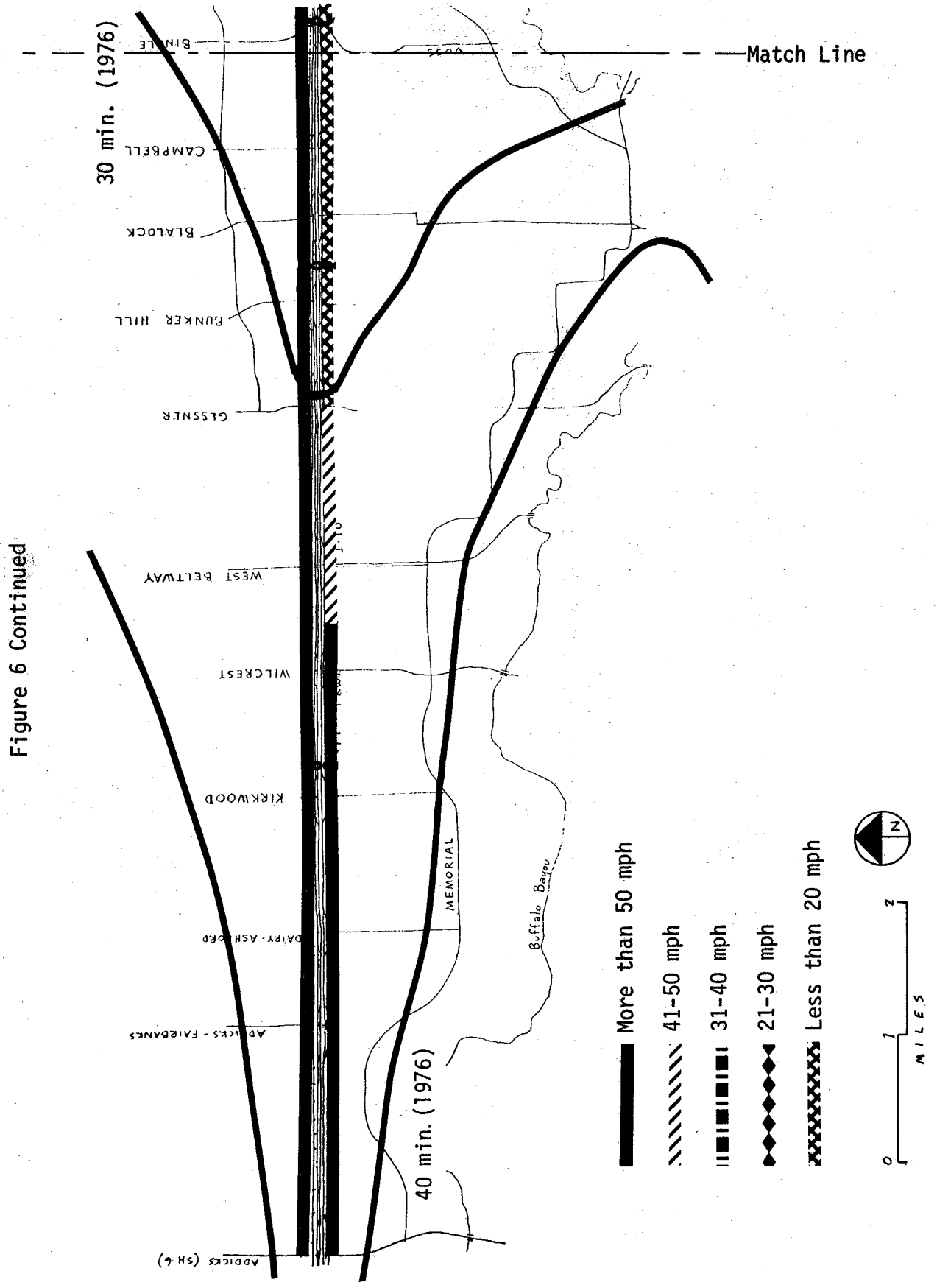
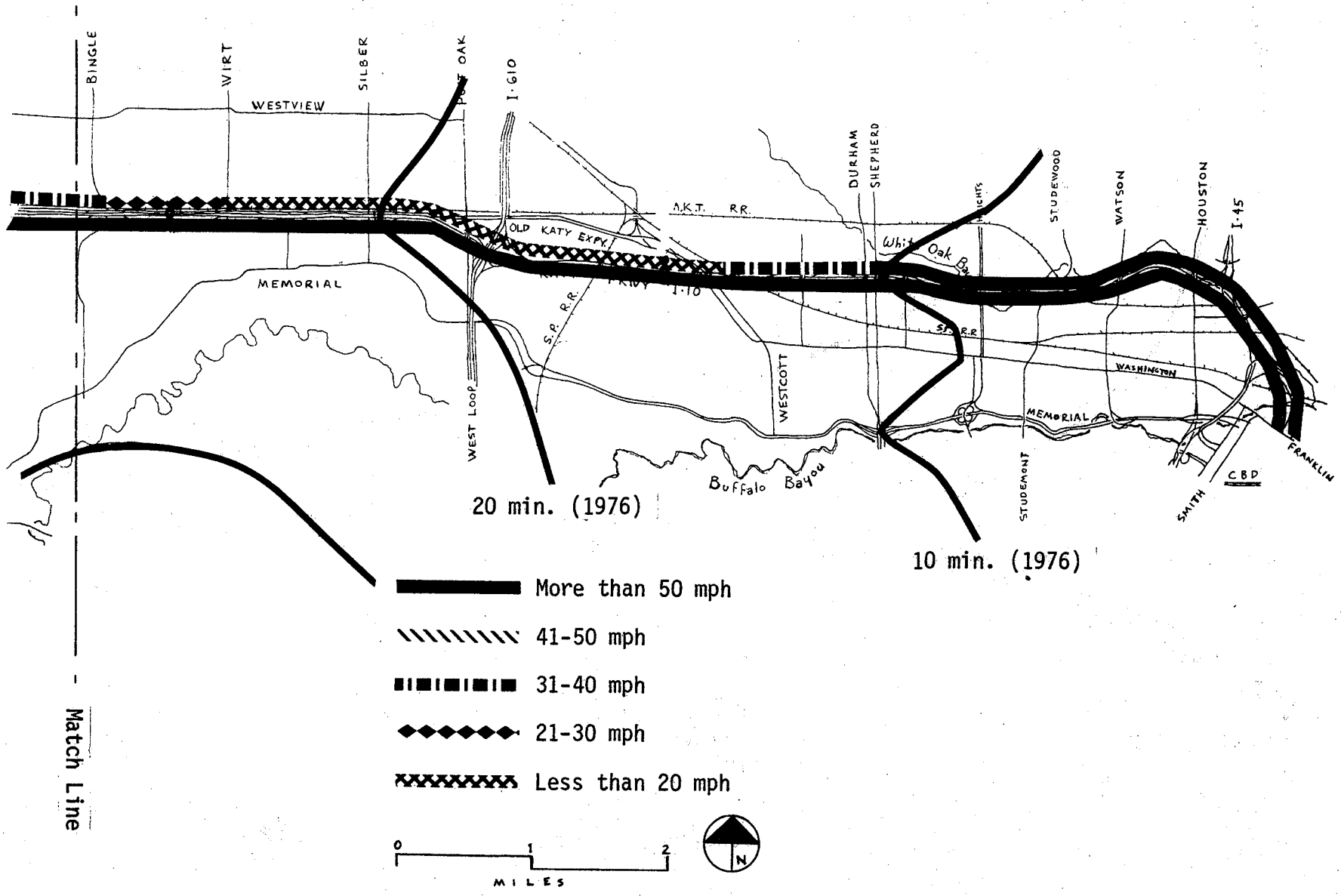


Figure 6 Continued

Figure 7: 1976 P.M. Peak Travel Speeds on Katy Freeway



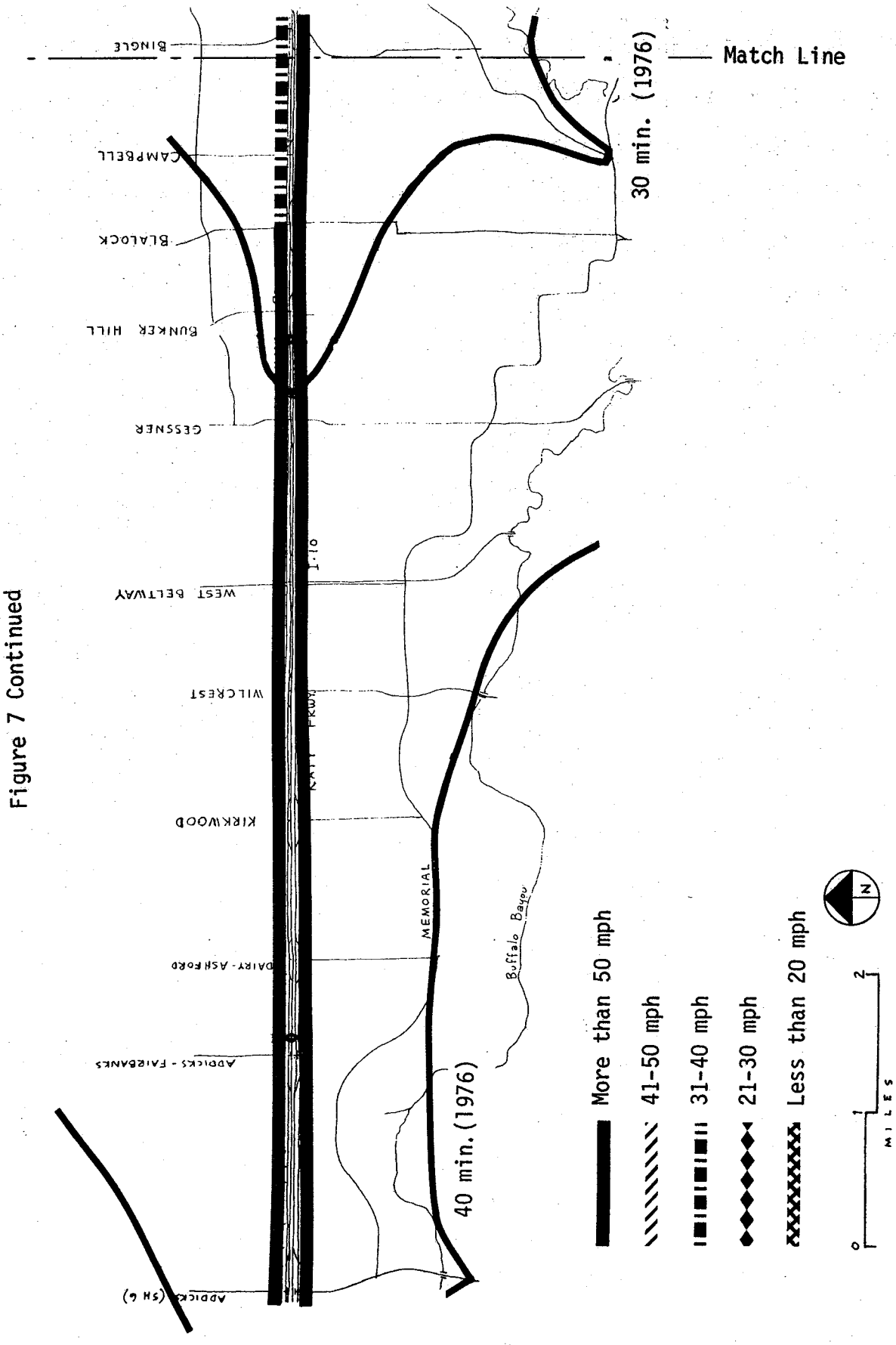


Figure 7 Continued

additional lane in each direction, while representing a very necessary improvement, in no way adds sufficient roadway capacity to serve the travel demands anticipated to occur along the Katy Freeway.

As a result, it is necessary to evaluate the feasibility and desirability of incorporating improvements for high-occupancy vehicles into the Katy corridor. Due to the critical need to expand roadway capacity, these improvements should not preclude the feasibility of adding travel lanes to the existing facility. Rather, if HOV improvements are appropriate, those improvements should complement the planned freeway expansion and, to the extent possible, be implemented at the same time the major freeway reconstruction is taking place. Since considerable construction would be required simply to build an HOV lane, the attitude of the general public could be negative unless additional traffic lanes were provided at the same time.

Traffic data suggest that intense congestion occurs during both the morning and evening peaks; thus, priority treatment should be able to serve travel demands in both peaks. Morning traffic indicates that improvements are needed from Kirkwood to Loop 610. Evening travel demands suggest that improvements are necessary at least from Washington to Blalock.

OVERVIEW OF APPLICABLE PRIORITY TREATMENTS

In evaluating the potential for priority treatment on the Katy Freeway, a number of alternative improvements justify consideration. The need to expand the number of lanes on the freeway was discussed in the previous section of this report. The next issue to address is, given that the Department will be making major improvements to the Katy Freeway in the near future, what priority treatments, if any, should be considered for incorporation into the expanded facility.

The intent of this section of the report is to screen the available priority treatment techniques. This section of the report identifies those priority treatments that appear to be technically feasible. The cost-effectiveness of the more feasible alternative is considered in the subsequent section of this report.

Previous research reports (205-1 and 205-8) have identified and reviewed alternative priority techniques as those techniques relate to specific Texas freeways. Those preliminary evaluations have identified the general types of improvements that appear to be applicable in the Katy Freeway Study Corridor.

The applicability of the following 5 priority treatments to Texas Freeways was considered in previous reports.

1. Exclusive Busway - lanes that are physically separated from other traffic;
2. Contraflow lane - a lane reserved for buses on the left-hand side of the median barrier;
3. Reserved Lane-Concurrent Flow - a lane reserved for high-occupancy vehicles in the normal direction of flow that is not physically separated from other lanes;
4. Freeway Control with Priority Entry - a situation where total freeway traffic volumes are controlled by traffic signals at entry ramps, with high-occupancy vehicles provided special entry ramps; and

5. Use of Frontage Roads - the use of signal preemption, reserved lanes, or other devices to expedite the movement of buses along freeway frontage roads or other surface streets.

Each of these techniques requires a different set of design and operational characteristics in order to be applicable to a specific freeway. A set of design and operational characteristics considered critical to the implementation of each of the 5 techniques was developed as part of previous research. In developing those characteristics, the underlying assumptions set forth below were utilized. If different underlying assumptions are considered, different guidelines will result.

1. Negative effects on existing traffic capacity available to the general public should be minimized.

   a. To be effective and enforceable, all of the techniques implemented must have the support of the general public. An episode similar to the Los Angeles "Diamond Lane" controversy would be highly undesirable.

   b. Removal of emergency parking shoulders would probably be acceptable as would narrowing of lane widths along short sections of roadway. Removal of an existing lane of travel in a congested portion of the freeway probably would not be acceptable.

2. The application of priority treatment to any segment of freeway should result either in improved HOV travel speeds or in improved bus schedule reliability.

   a. Priority treatment along portions of freeways that are operating at 45 mph or better in mixed flow would yield little if any benefit. Such projects could not be justified unless there is strong evidence that the "free-flow" conditions will be short-lived and that early implementation of priority treatment would be beneficial.

   b. No consideration is given to trying to force a reduction in Vehicle-Miles-of-Travel (VMT) through the implementation of priority treatment. The primary objective of priority treatment techniques is to increase the effective capacity of the existing facilities.

Design and Operational Characteristics

For each type of priority improvement, the design and operational characteristics of a freeway which are critical to implementation of that technique are presented in this section. It should be noted that these characteristics are divided into two sets: those considered to be "Required Attributes," and those considered to be "Desired Attributes." If a specific freeway does not meet all of the "Required Attributes" for a certain priority treatment technique, then that particular technique is considered technically infeasible for application to the freeway being evaluated. The "Desired Attributes" are to be considered only if all "Required Attributes" are satisfied. If all desired characteristics are not met, the improvement may be undesirable but not necessarily infeasible.

Exclusive Busway

Different types of exclusive busways might be considered. One type might consist of an elevated guidway with adequate lane and shoulder widths to assure optimal operation. The other type might be considered more of a "intermediate" range improvement; a busway that might be implemented primarily at-grade in the median. Such an improvement could also be implemented in the near future. It is recognized that several design and operational aspects of this latter design, although "workable," may not be optimal.

Numerous justifications, listed below, strongly suggest that, at this time, the one-lane, intermediate range facility is a preferred alternative when compared to an elevated, two-lane exclusive busway.

- Implementation Time. The intermediate range improvement, since it does not require large-scale construction activity, could be implemented in 6 to 10 years. In all likelihood, 10 to 20 years would be required to develop an elevated exclusive busway facility.

- Compatibility with Existing Plans. The Department has plans to add one lane in each direction to Katy Freeway in the near future. A one-lane, basically at-grade busway could be relatively easily incorporated into those plans and implemented simultaneously as a complementary improvement.

- Limited Risk. Given the Department's existing plans, provision of a median busway is a low-cost alternative. Also, even if it proves to be unsuccessful or not totally compatible with long-range plans, the median busway can easily be converted to many other uses (e.g., inside shoulder to enhance freeway operations) at a minimal cost.

- Lack of Long-Range Plan. The Metropolitan Transit Authority is presently pursuing a lengthy alternatives analysis designed to develop a long-range transit plan. Until that plan is completed and adopted, it would not be appropriate to assume that an exclusive, elevated busway, which represents a long-range improvement, is a desired improvement in the Katy Freeway. A flexible, intermediate range improvement would result in minimal loss even if it is not compatible with long-range transit plans.

- A Test of Demand. Houston does not have a history of high-level transit service. Thus, even though estimates of potential usage are presented in subsequent sections of this report, those estimates must be viewed as being only approximations. A one-lane busway would provide a means of testing demand to assess whether possible justifications for more elaborate facilities exist.

- Cost-Benefit. This particular study does not develop detailed cost-benefit values for the two alternatives. However, as part of a similar study undertaken for the Gulf Freeway in Houston (Cost Effectiveness Analysis of Alternatives for Gulf Freeway Busway, prepared by Houston Urban Office), the one-lane, at-grade busway had a benefit/cost ratio of 7.6 while the two-lane, elevated busway had a benefit/cost ratio of 2.4. In terms of traffic patterns, lane widths, and corridor development, the Katy and Gulf Freeway corridors are similar in many respects, and it would be reasonable to expect that a detailed cost-benefit study for the Katy Freeway would yield results similar to those found in the Gulf Freeway study (Table 4, pg. 39).

As a consequence, the following exclusive busway guidelines pertain to the construction of busways that are primarily at-grade and only one-lane wide (busways that can be built in existing freeway medians). A two-lane, at-grade busway cannot be built in the space available without severe impacts on other freeway traffic. As a result, this study primarily pertains to priority treatment techniques that can be implemented in the intermediate time range. Totally grade-separated busways, although possibly a desired long-range solution, will need to be designed in conjunction with any double-decking plans for the Katy

Freeway, and their feasibility also depends on whether right-of-way currently owned by the M-K-T Railroad can be obtained. It might be noted that a median busway was shown to be undesirable for the Katy Freeway in Research Report 205-8. That report did not consider the reconstruction of the Katy Freeway.

Required Attributes. The following attributes are considered essential for application of an exclusive busway to an existing freeway.

- Continuous wide median section (~20 feet wide) available along most of the critical segment.

  Note: Some occasional discontinuities can be accommodated at reasonable costs. For example, a short stretch of narrow median might be spanned by an elevated section or an extremely narrow cross-section. Also, discontinuities at overpass structures can sometimes be handled by decking between the two roadway structures or by the elimination of shoulders on the main travel lanes.

- Buses are able to reach the exclusive lane expeditiously.

  Note: This can probably be accomplished at-grade if the desired entry point for buses is upstream of the congested section. If the improvement is several miles in length, opportunities for midpoint entry should exist. For a variety of reasons (listed in subsequent sections), midpoint entry is an essential feature of the Katy busway.

- No left-hand entrances or exits that cannot be grade-separated within available right-of-way.

- No existing underpasses with center columns that cannot be negotiated by restriping lanes or some device other than eliminating the columns.

Desirable Attributes. The following attributes are considered desirable for application of an exclusive busway to an existing freeway.

- Minimum median clutter requiring relocation (Luminaire posts, sign structures, drainage inlets, etc.).

- Minimum grade differentials between roadways on each side of the median.

- Continuous median shoulders across existing overpass structures.

Contraflow Lane

Required Attributes. The following attributes are considered absolute requirements for applicability of a contraflow lane.

- Minimum of three through lanes in the off-peak direction.

  At least two remaining travel lanes must be available to the general public in the off-peak direction for the roadway to continue to function as a freeway.

- A directional split high enough that the resulting flow rates in the off-peak direction will not exceed 1700 vehicles per hour per lane after the lane is removed.

  Flow rates as high as 1700 vehicles per hour per lane result in level-of-service E (speeds of 30-40 mph) and can easily deteriorate into level-of-service F (Stop-and-Go).

- No left-hand entrance and exit ramps without bypass opportunities.

  Obviously, these ramps would cause traffic conflict problems.

- An opportunity to design a safe entrance to, and exit from, the contraflow lane on each end of the congested portion.

  Safety considerations include sufficient sight distance, adequate weaving opportunity, and opportunity for police to enforce the restrictions.

Desired Attributes. The following attributes are considered desirable for a contraflow lane.

- A directional split such that the resulting flow rates in the off-peak direction would be less than 1500 vehicles per hour per lane after the lane is removed.
- An available median shoulder over most of the route for stalled vehicles.
- Acceptable sight distances along the freeway for safe operation during periods of infrequent bus traffic.
- Continuous freeway lighting over the entire contraflow segment.
- Opportunities for designing intermediate entries to, and exits from, the contraflow lane, thereby increasing the flexibility of operations.

Note: This attribute probably requires a wide median (at least 20 feet wide) in those locations where entry and exit points are desired.

Reserved Lane-Concurrent Flow

Evaluation of the problems encountered in all projects using concurrent flow reserved lanes on freeways have led to a recommendation against further implementation of this technique. *Thus, the reserved lane-concurrent flow technique will not be considered as applicable to any Texas radial freeway.*

Freeway Control and Priority Entry

Required Attributes. The following attributes are considered to be absolute requirements for implementing this priority technique.

- Capability to control the total volume of traffic on the freeway sufficiently to assure no worse than level-of-service D in the critical segment.

  Note: It is considered highly undesirable if freeway-to-freeway traffic must be reduced sufficiently to back the queue onto the other freeway in order to meet this requirement.

- Adequate queueing space available at each control location.

  Note: If isolated ramps fail to meet this criteria, they should either be closed completely or dedicated totally to high-occupancy vehicles (HOV's).

- Available HOV entry ramp locations to permit HOV's to bypass queued vehicles to enter the freeway.

Desired Attributes. The following attributes are considered desirable for implementation of freeway control with priority entry.

- Continuous frontage roads--at least to an intersection with a suitable arterial street that could be used as a diversionary route.

  Note: This feature would permit cars to enter the ramp queue and remain long enough for the drivers to estimate how long it would require to enter the freeway and then divert to the frontage road if they so desire.

- The ability to control the traffic without obviously placing more severe restrictions on traffic entering at certain ramps.

  Note: Such cases of obvious discrimination result in intense protests from those neighborhoods affected.

Use of Frontage Roads

Required Attributes. The following attributes are considered to be absolute requirements for implementing this priority technique.

- Continuous frontage roads over the length of the critical segment (or a combination of frontage roads and suitable parallel surface arterial streets).
- The ability to clear the queue ahead of the bus whenever signal preemption is used.

Desired Attributes. The following attribute is considered desirable for implementation of priority treatment on frontage roads.

- At least three approach lanes to each high volume intersection so that the buses will not be impeded by turning movements.

Applicability to Katy Freeway

Research Report 205-8 compared the guidelines presented previously in this section to the design and operational features of the Katy Freeway. The conclusions, as set forth in Research Report 205-8, are documented in this section. These conclusions are based on the existing design of the Katy Freeway. The impact the Department's planned improvements have on the applicability of these improvements is also presented in this section. The applicability of these improvements is considered over the critical sections of roadway identified previously; in the a.m., the critical distance is Kirkwood to Loop 610, while in the p.m., the critical section is Washington to Blalock.

Exclusive Busway. The following analysis summarizes the applicability of an exclusive busway to the existing design of the Katy Freeway.

Attributes	Peak Period	
	A.M.	P.M.
Required:		
Wide Median	∿ 1.4 miles of 4-ft. wide median[1]	
Entry Locations	Yes, except where median is narrow[2]	
Left-Hand Ramps	None	None
Center Columns	2 locations[3]	3 locations[4]
Desired:		
Median Clutter	Some luminaires and sign bridges	
Grade Differentials	None	
Median Shoulders	Yes, generally	

[1]From Blalock to Bingle a narrow median exists. Otherwise the median is typically 20 ft. wide.

[2]This pertains only to the freeway, not to constraints that might be imposed by development adjacent to the freeway. This constraint is based on inadequate median width in which to locate columns that would be necessary to elevate the transitway.

[3]Post Oak Road and Loop 610.

[4]Post Oak Road, Loop 610, and the Southern Pacific Railroad.

Conclusions Concerning Exclusive, Median Busway. Based on existing design, it might be feasible to provide a busway, but it would be quite expensive. That is the conclusion presented in Research Report 205-8. However, the Department's plans greatly enhance the feasibility of this concept.

The opportunity to widen the basic cross section makes a median busway a feasible improvement. Certain operational difficulties, which will detract

from the quality of main lane operation, will be encountered through implementation of such an improvement. These difficulties, which are discussed in detail in subsequent sections of this report, are not considered to be sufficiently critical to make the median HOV lane infeasible. While it may be necessary to, at least initially, allow carpools to use the lane to develop sufficient vehicular flow, such usage would result in some operational difficulties.

Contraflow Lane. The following analysis summarizes the applicability of a contraflow lane to the existing design of the Katy Freeway.

Attributes	Peak Period	
	A.M.	P.M.
Required:		
Minimum of 3 Lanes	Yes	Yes
Flow Rates per Lane in Off-Peak Direction	1800	2335

Conclusions Concerning Contraflow. Based on existing design, per lane flow rates in the off-peak direction are too high to permit successful implementation of this concept. Addition of one lane in each direction would reduce the per lane off-peak direction flow rates shown above to 1200 (a.m.) and 1500 (p.m.). Based on these values, the concept can be considered feasible, although not necessarily desirable.

Freeway Control With Priority Entry. The following analysis summarizes the applicability of freeway control with priority entry to the existing design of the Katy Freeway.

Attributes	Peak Period	
	A.M.	P.M.
Required:		
Total Control	Yes	Requires on-freeway control
Queueing Space	Yes	Yes
HOV Ramps	Difficult at Campbell	Yes
Desired:		
Continuous Frontage Roads	Yes	Not inside Loop 610
Nondiscriminating Metering	Yes, if Ramps controlled far enough to the west	Not unless Loop 610 is metered

Conclusions Concerning Freeway Control With Priority Entry. Due to the need to meter on-freeway traffic, this concept does not appear applicable to serving evening peak period traffic. If freeway metering is set up sufficiently far to the west, this concept appears feasible in the morning. However, in that development is occurring as far west as Brookshire (35 miles from downtown Houston), it may be difficult to implement such a system without favoring long-distance commuters. For this reason and the fact that the technique is not applicable to the p.m. peak, this alternative is not given further consideration. Planned improvements will not alter this conclusion. Also, this concept will not provide the same level of schedule reliability as an exclusive HOV facility will, and it also will probably not result in as high of travel speeds for the HOV vehicles over the line-haul section of the improvement. It does not increase total vehicular capacity.

Use of Frontage Roads. The following analysis summarizes the applicability of using frontage roads as a priority treatment technique on the Katy Freeway.

Attributes	Peak Period	
	A.M.	P.M.
Required:		
Continuous Frontage Roads	Yes, if using Post Oak & Old Katy Highway	
Clear Queue	Probably	Unknown
Desired:		
3 Lanes at Intersection	Yes	Except at Bingle

Conclusions Concerning Frontage Roads. Improvements are feasible for both peak periods. This alternative was evaluated extensively by TTI as part of work performed for the Metropolitan Transit Authority and documented in the "Houston Corridor Study."

Improvements suggested in that study are currently being considered for implementation. Relatively minor reductions in bus travel time appear feasible through such actions. However, as traffic volumes increase, the effectiveness of these improvements will be reduced, and it does not represent a means of significantly increasing person movement in the corridor. As a result, while it may represent a desirable immediate improvement, its effectiveness over a 5 to 20 year time period will be minimal due to increased traffic volumes.

This concept does not provide preferential treatment for carpools. Nor does it result in high travel speeds or high schedule reliability for HOV vehicles. Capacity to serve large volumes of HOV vehicles is not generated.

Findings Concerning Applicable Priority Treatments

The need for priority treatment on the Katy Freeway during both peak periods detracts from the attractiveness of freeway control with priority entry. The potential of using frontage roads was evaluated in the "Houston Corridor Study." Rather minimal improvements can be expected to result from those actions, and they represent, at best, short term improvements. Insufficient roadway width precludes developing a two-lane median HOV facility and expanding total traffic lanes. To gain public acceptance due to the lengthy construction disruptions, a project that both expands general traffic lanes and provides an HOV lane appears attractive. A median busway appears feasible, however.

Previous portions of this section have discussed numerous technical features that impact the applicability of the various priority treatments to the Katy Freeway. Some additional considerations are summarized in Table 2.

The improvements to the Katy Freeway to be undertaken by the Department appear to make an exclusive one-lane median busway, a contraflow lane, or some combination of the two, feasible. Given a choice between operating on an exclusive HOV lane or a contraflow lane, the exclusive lane represents a prefenable alternative for the reasons listed below.

- Operational Cost. It is costing the Metropolitan Transit Authority $2000 to $3000 per day to set up, take down, and enforce the contraflow lane on I-45N. Costs of operating a busway would be a small fraction of that cost.
- Positive Separation of Flow. An exclusive HOV lane would allow median barriers to continue to provide a positive separation of traffic flow during all times of day.
- Penalty to Off-Peak Traffic. The exclusive lane will not penalize traffic moving in the off-peak direction through removal of a travel lane.
- Eligible Vehicles. The exclusive HOV lane would permit less concern to occur over the types of vehicles and drivers eligible to use the lane.

Table 2: Comparison of Alternative Priority HOV Improvements[1]

Parameter	Alternative HOV Improvement			
	1-lane Median Busway	2-lane Elevated Busway[2]	Use of Frontage Roads	Freeway Control w/Priority Entry
Quality of bus Service				
Avg. Speed, mph	50	50	30	40[3]
Schedule Reliability	Excellent	Excellent	Poor	Good-Fair
Carpools Included	No/Yes[4]	Yes	No	Yes
Impact on Other Traffic	Minor	Minor	Major	Moderate-Major
Cost, Thousands/Mile[5]	$2,000	$9,000	$130	$400
Maximum Capacity				
Buses, Veh./Hr.	400[6]	400[6]	60[8]	200[9]
Carpools, Veh./Hr.	0	800[7]	0	400[9]
Total, Persons/Hr.	20,000	24,000	3,000	12,000

[1]Based on a similar table presented in "Cost-Effectiveness Analysis of Alternatives for Gulf Freeway Busway," Prepared by Houston Urban Office, June 11, 1979

[2]For numerous reasons listed previously in this section, this does not appear to represent a desirable improvement at this time. As considered in this matrix, this facility would operate with one-lane in each direction

[3]Attainable only with sufficient enforcement to control ramp violation rates

[4]Operationally, it may be undesirable to allow carpools onto a facility one-lane wide without continuous shoulders. Realistically, during the early years of operation, it may be necessary to allow some carpool utilization to generate an "acceptable" level of total vehicular utilization

[5]Does not include costs required to provide "support" facilities such as park-and-ride lots

[6]This value based on flow volume that could return in mixed flow in off-peak direction. At this flow level, carpools would be undesirable on the one-lane busway

[7]Sufficient carpools added to obtain level-of-service D

[8]At 60 buses per hour, every cycle would be preempted by buses, destroying the capability of cross streets to serve traffic demands

[9]It is assumed that no more than 50% of the additional capacity provided by adding one-lane can be used by HOV vehicles

- Midpoint Entry. Due to the length of the improvement contemplated along Katy, it is essential that midpoint access to the HOV lane exist. This is much easier to accomplish if an exclusive median lane is devoted to use by HOVs.

However, the key to the exclusive HOV lane concept is to be able to implement such an improvement without destroying the functionality of the freeway to serve vehicular travel. As shown in a subsequent section of this report, although implementation of a median lane does detract from the ability of the freeway to serve vehicular traffic, such an improvement does not severely restrict freeway design so as to create an unacceptable condition.

As a result, the subsequent sections of this report primarily concentrate on the feasibility of incorporating a one-way, reversible HOV lane into the median of Katy Freeway in conjunction with freeway expansion plans currently being considered by the Department.

UTILIZATION AND BENEFIT/COST

The previous sections of this report strongly indicated that a reversible, one-lane HOV median lane represents the preferred interim transit improvement in the Katy corridor. If interim improvements are to be undertaken, this appears to be the appropriate action.

This section of the report evaluates utilization and benefit/cost, expanding on some of the information documented in the previous section. Estimates of priority lane usage in 1980 and 1995 are set forth, and the implications these have on the types of vehicles that should be permitted to use the lane are discussed. Brief analyses of estimated costs and benefit/cost are presented.

Utilization of the Median HOV Lane

This section develops estimates of 1980 and 1995 utilization of the median HOV lane for the Katy Freeway. The estimates are for a two-hour period during the morning peak. The 1980 estimates are formulated assuming that buses, carpools and vanpools are allowed to use the HOV lane. Considerations regarding the types of vehicles that might actually be allowed to use the lane are discussed in the subsequent part of this section. It is assumed in these analyses that bus service will be available to Galleria/Post Oak and Greenway Plaza as well as the central business district (CBD).

Two sources of travel data are primarily used in developing these estimates. The "Houston Corridor Study" recently developed travel demand values along the major freeways destined to the major activity centers. Second, the Metropolitan Transit Authority, using their modal split model, provided 1995 travel estimates. Recognizing the limited experience Houston has had with quality transit service, utilization estimates developed in this section should be viewed with some caution.

1980 Usage

Prelimimary estimates of bus and vanpool/carpool travel are developed.

Bus. Current usage of the contraflow lane on I-45N is used to estimate initial bus usage on the Katy HOV lane. This should yield conservative estimates since the contraflow is not yet being fully utilized partially due to the fact that park-and-ride lots have not been completed. The analysis used is summarized as follows.

- Of those work trips destined to the CBD on I-45N 10 miles from the CBD, approximately 8% are presently being served by transit.
- Approximately 9,000 CBD work trips are on the Katy Freeway at a distance of 10 miles from the CBD. If 8% are captured by transit, this would result in 720 users.
- The Katy improvement will have midpoint entries and will be attractive to those vehicles entering the freeway between 7 and 10 miles from the CBD. Approximately 8,000 CBD work trips enter the Katy over that distance. Capturing 8% of those trips will result in 640 additional users.
- Approximately half as many trips to Galleria/Post Oak and Greenway Plaza are made on the Katy as are trips to the CBD. If the CBD generates 1360 bus riders, the other activity centers will generate approximately 700 riders.
- Total 2-hour bus riderships on the HOV lane will be approximately 2060. At 40 persons per bus, this results in an hourly bus volume of 26, about 1 bus every 2 minutes.

Vanpools. Approximately 100 vanpools use the I-45N contraflow over a 2-hour period. Total CBD travel volumes are similar for Katy and I-45N. Since most vanpools trips are relatively long, it is assumed that an insignificant number of vanpools will enter within the 10 mile distance. It is assumed that an additional 50 vanpools will use the lane destined to Galleria/Post Oak and Greenway Plaza. Thus, initially it is estimated that 150 vans, or 75 per hour, will use the lane.

Carpools. It is assumed that no traffic originating within 7 miles of the CBD will use the HOV lane. Presently, at 7 miles from the CBD, 16,000 CBD work trips are on the lane. Estimates developed above suggest that 3,000 of these

are using buses or vans, leaving some 13,000 using automobiles. Of that 13,000, 97%, or 12,610 are cars with two or less occupants. Approximately 1%, or 130 vehicles have 4 or more occupants (HGAC occupancy data for Katy Freeway). Previous TTI studies (Research Report 205-4) suggest that this number will increase by approximately 200% if priority treatment is implemented. This will result in 390 vehicles with 4 or more occupants going to the CBD, with possibly 200 more going to Galleria/Post Oak and Greenway Plaza. This would result in a total of 590 carpools in 2 hours, or approximately 300 per hour.

Total Per Hour 1980 Usage. Estimates developed above suggest that, if buses, vanpools, and carpools (4+ persons) were allowed to use the median HOV lane, usage would resemble that shown in Table 3.

Table 3: Estimated 1980 Peak Hour Usage of Median HOV Lane Assuming Usage by Buses, Vanpools, and Carpools Is Permitted

Type of Vehicle	No. of Vehicles	%	No. of Persons	%
Transit Bus	26	6	1040	37
Vanpools (8 persons)	75	19	600	21
Carpools (4 or more persons)	300	75	1200	42
Total	401	100	2840	100

1995 Usage

By 1995, if the HOV lane is still operational, the quality of bus service available will have improved significantly as will total travel volumes. The Metropolitan Transit Authority, especially for this study, used their computerized modal split model to estimate 1995 transit ridership for the 2-hour peak period. The results of that computer analysis show that 8700 persons will use the lane to travel to the CBD and 3800 will use the HOV lane for travel to

Galleria/Post Oak and Greenway Plaza. Total bus usage for the 2-hour period will be approximately 12,500. This will result, assuming 40 persons per bus, in 156 bus trips per hour, or about 2.5 per minute. As shown below, at this bus volume it is doubtful if other high-occupancy vehicles would be allowed to use the lane.

Considerations Involving Eligible Users

Determining what type(s) of vehicles will be permitted to use the priority HOV lane represents a policy decision, and it is a decision that can change with time. Indeed, the utilization estimates developed previously in this section suggest that it might be quite appropriate for the definition of eligible vehicles to change as time passes.

In essence, the following three types of vehicles might be considered for use of the priority lane.

- Buses (includes all types of common carriers)
- Vanpools (8 or more registered users)
- Carpools (definition based on number of occupants per vehicle)

The following considerations are pertinent in deciding the types of vehicles that will use the priority lane.

- Total flow volume should remain low (probably less that 400 vph at an average load point) to assure that a high level-of-service typically exists on the priority lane.
- A sufficient number of vehicles should be using the lane so that the public perception is that the lane is being highly utilized (probably at least one vehicle every 30 to 60 seconds during peak periods). A minimum flow rate of 100 vehicles per hour is necessary to be sure that the lane is used by at least one vehicle each minute.
- As more use the lane, the probability of a vehicle breakdown increases. Due to the lack of continuous emergency shoulders on the priority lane, a stalled vehicle may effectively shut the lane down until it is removed by an emergency vehicle. This will reduce bus schedule reliability and speed.

- Enforcement of eligible users is more difficult when vanpools and carpools are allowed to utilize the priority lane.
- Due to the differences in vehicle occupancy involved, allowing carpools to utilize the lane may greatly increase the number of vehicles in the lane but only marginally increase the volume of people moved in the lane. For example, as shown in the previous section, for the 1980 usage estimate, carpools (4 or more persons) would need to be 75% of vehicles in the lane to move 40% of total persons.

Potential Users

Based on the guidelines outlined above, during the initial operation of the lane it is highly doubtful whether bus volumes will be sufficient to generate flow rates higher than approximately one bus every two minutes. Addition of vanpools to the lane would appear to generate flow rates approaching what has been assumed to be the minimum acceptable level. If carpools are allowed to use the lane, the carpool should be defined as no less than 4 persons. Less stringent definitions will cause traffic volumes on the lane to become so high that the level-of-service provided by the narrow lane may become unacceptable.

By 1995 bus volumes alone will provide adequate lane utilization. Some 156 buses per hour (auto equivalency of approximately 235 vph) will be utilizing the lane, moving over 6,000 persons per hour. It appears that utilization of the lane by other vehicles might be prohibited to assure a high level of bus service in moving that volume of passengers.

Estimated Cost

For this preliminary study, a separate estimate of the cost of the median busway was not developed. Since the Department is planning major improvements on the Katy Freeway, some cost savings should result if the median HOV lane is constructed at the same time other freeway activity is undertaken.

A general indication of implementation cost can be obtained from the Gulf

Freeway study prepared by the Houston Urban Office (Cost-Effectiveness Analysis of Alternatives for Gulf Freeway Busway). A median busway, similar in most all respects to the one being considered for the Katy Freeway, was estimated to cost approximately $2.0 million per mile. A comparable cost should be applicable to the Katy Freeway.

Based on that comparison, the 13.1 mile median HOV lane improvement along Katy Freeway should cost approximately $26 million. This is the cost for the median busway and midpoint entrance connections only. Additional costs will be incurred in developing necessary "support" facilities such as park-and-ride lots.

Cost-Effectiveness

For this preliminary feasibility study, a separate estimate of cost-effectiveness was not developed for the median HOV lane on Katy Freeway. The extensive data collection required to perform simulation of traffic flow was not undertaken, nor was it considered necessary given the extensive evaluation of the Gulf Freeway which recently was performed.

The Gulf Freeway Study (Cost-Effectiveness Analysis of Alternatives for Gulf Freeway Busway) appears to provide sufficient data to at least conclude that the cost effectiveness of a Katy Freeway median HOV lane is favorable. In virtually every aspect of freeway operation, the Gulf and Katy Freeways are highly similar (Table 4). There is little reason to expect that the cost-effectiveness of similar improvements on the two freeways would be radically different.

Table 2 presented relevant data for four potential HOV improvements along Katy Freeway. That table is based heavily on the Gulf Freeway analysis. For the alternatives described in Table 2, the resulting benefit/cost ratio, as determined in the Gulf Freeway study, is shown in Table 5.

Table 4: Indications That Benefit/Cost Ratios Developed in the Gulf Freeway Study May Be Similar to Katy Freeway Values

Indicator of Freeway Activity	Gulf Freeway	Katy Freeway
Typical Cross Section[1]	6 lanes	6 lanes
Length of HOV Improvement[2]	15 miles	13.1 miles
Freeway Congestion Indices[3]		
Individual Driver's Perspective	2.8	2.7
Society Perspective	5.0	4.4
Highest ADT (1978)	177,000	176,000
Increase in ADT (1972-1977)	20%	25%
AADT Per Lane	25,000	25,000
Peak Period Delay Per Vehicle	15 min.	15 min.
Auto Occupancy	1.3	1.3
Daily CBD Work Trips Served, 1985	21,500	23,500
Peak Hour Factor	6%	7%

[1]This is the cross section that typically exists over the section in which the HOV improvement is being contemplated. Widening to 8-lanes is planned for both freeways.

[2]The HOV improvement in both cases is a one-lane median HOV lane, primarily at-grade.

[3]Indices are presented and explained in Research Report 205-7. Both are a relative measure of the intensity of congestion on the freeways.

The Gulf Freeway study found a one-lane median busway to have a benefit/cost ratio of 7.6. It appears reasonable, given the large similarities between the Gulf and Katy Freeways, to conclude that a similar improvement on the Katy Freeway would at least have a favorable benefit/cost ratio, and, quite possibly, a benefit/cost ratio as high or higher than that identified through extensive analysis for the Gulf Freeway. There is also no reason to expect that the

Table 5: Benefit/Cost Ratio for Selected HOV Improvements to the Gulf Freeway

HOV Improvement	Benefit/ Cost Ratio
One-Lane Median Busway	7.6
Two-Lane Elevated Busway	2.4
Frontage Roads[1]	-
Freeway Control w/Priority Entry[2]	1.0

[1]Rejected from further analysis due to insufficient capacity

[2]Rejected in that little or no increase in vehicular capacity resulted and successful implementation is questionable

one-lane HOV lane would not be, by a considerable amount, the most favorable improvement for the Katy Freeway.

CONCEPTUAL HOV LANE DESIGN AND OPERATION

The type of priority treatment (i.e., a one-lane, primarily at-grade, median HOV lane) most applicable to the Katy Freeway has been discussed in previous sections of this report, as has the justification for that improvement. It is recognized that this improvement is not optimal in all respects; design constraints will involve compromise between freeway operation and HOV lane operation. The HOV improvement, justified previously in this report, is viewed as an intermediate range action; it is something that might be operational over a 5- to 20-year period with the inherent flexibility to be converted to other uses (e.g., inside shoulders) with minimal time and cost requirements. The suggested improvement does not represent the optimal, long-range transit improvement in the Katy Corridor.

Design and operational considerations discussed in this section should be viewed as conceptual only. Many trade-offs are involved in laying out transportation improvements within the confines of restricted rights-of-way. It is the intent of this report to show a manner in which the suggested HOV improvement could be designed and operated. More detailed design studies, which are necessary prior to implementation, may identify better designs and/or operational procedures for the median HOV lane.

Compatibility With Department Plans

As discussed previously, the Department presently has plans to add one additional traffic lane in each direction to the Katy Freeway between Loop 610 and Beltway 8. The undertaking of this improvement, which requires expansion of the existing cross section, is what makes a median HOV lane feasible.

Existing traffic congestion and projected traffic volumes leave no doubt as to the need for adding the additional traffic lanes. Within 5-7 years, each

of those lanes will be serving 25,000 vehicles per day, or nearly 34,000 persons per day. This is considerably more persons than the suggested HOV lane will serve on a daily basis (refer to previous section of this report for estimates of utilization).

As a result, the HOV median lane needs to be compatible with the planned freeway widening, and provision of the HOV lane must not in any way preclude the possibility of providing those additional traffic lanes. Public acceptance may be enhanced by providing both more general traffic lanes and an HOV lane as part of the same construction process. The HOV improvement should be viewed as a complementary action which offers one more means of serving travel demands along Katy Freeway.

HOV Lane Operation

Rights-of-way restrictions place limitations on the roadway width that can be devoted to a median HOV lane. As a consequence, only a one-lane HOV facility can be provided. A cross-section and a rendering of a "typical" roadway section is shown in Figure 8. A continuous emergency shoulder, although highly desirable, cannot be incorporated into the entire length of the median HOV lane. Rather, emergency turn-outs will be provided at approximately one-half mile intervals (Figures 9, 10 and 11), plus the median lane will be widened at all midpoint access locations.

The HOV lane will be a reversible facility. It will operate inbound in the morning and outbound in the evening. Buses circulating in the off-peak direction will need to use the main freeway lanes. With the addition of one lane in each direction, off-peak direction travel speeds should not unduly impede necessary bus circulation in that directional splits of approximately 65/35 should result. Freeway metering can be used, if necessary, to assure high off-peak direction travel speeds.

Location of HOV Improvement

Traffic data dictate that improvements are needed that can serve both peak periods. As discussed previously, in the morning congestion presently occurs from as far west as Kirkwood to Loop 610. In the evening, congestion exists from just west of Washington to as far west as Kirkwood.

As a result, it is suggested that the median lane initially operate from a western terminus in the vicinity of SH 6 to an eastern terminus in the vicinity of Washington. This represents a distance of some 13.1 miles, and the improvement's eastern terminus (Washington) is located approximately 4.8 miles from the CBD (Figure 2). The ten-lane cross section from Washington to the CBD presently operates at an acceptable level-of-service during both peak periods.

The improvement will, quite possibly, be operational for 10 to 15 years until the time at which a more desirable, long-range solution is implemented. Since the distance over which congestion occurs can be expected to significantly increase over the 10- to 15-year period, flexibility should exist to extend the length of the priority HOV lane in both directions. Such extensions can be accomplished within the confines of the existing freeway design, although some operational compromises (primarily narrowing of lanes inside Loop 610) will be required to bring about those extensions.

Midpoint Entry Possibilities

For a number of reasons, including those listed below, it will be necessary to develop midpoint access to the median HOV lane.

- Length of Improvement. The improvement originates upstream of the traffic congestion, nearly 18 miles from the CBD. Insufficient utilization of the lane would result if that were the only access point.

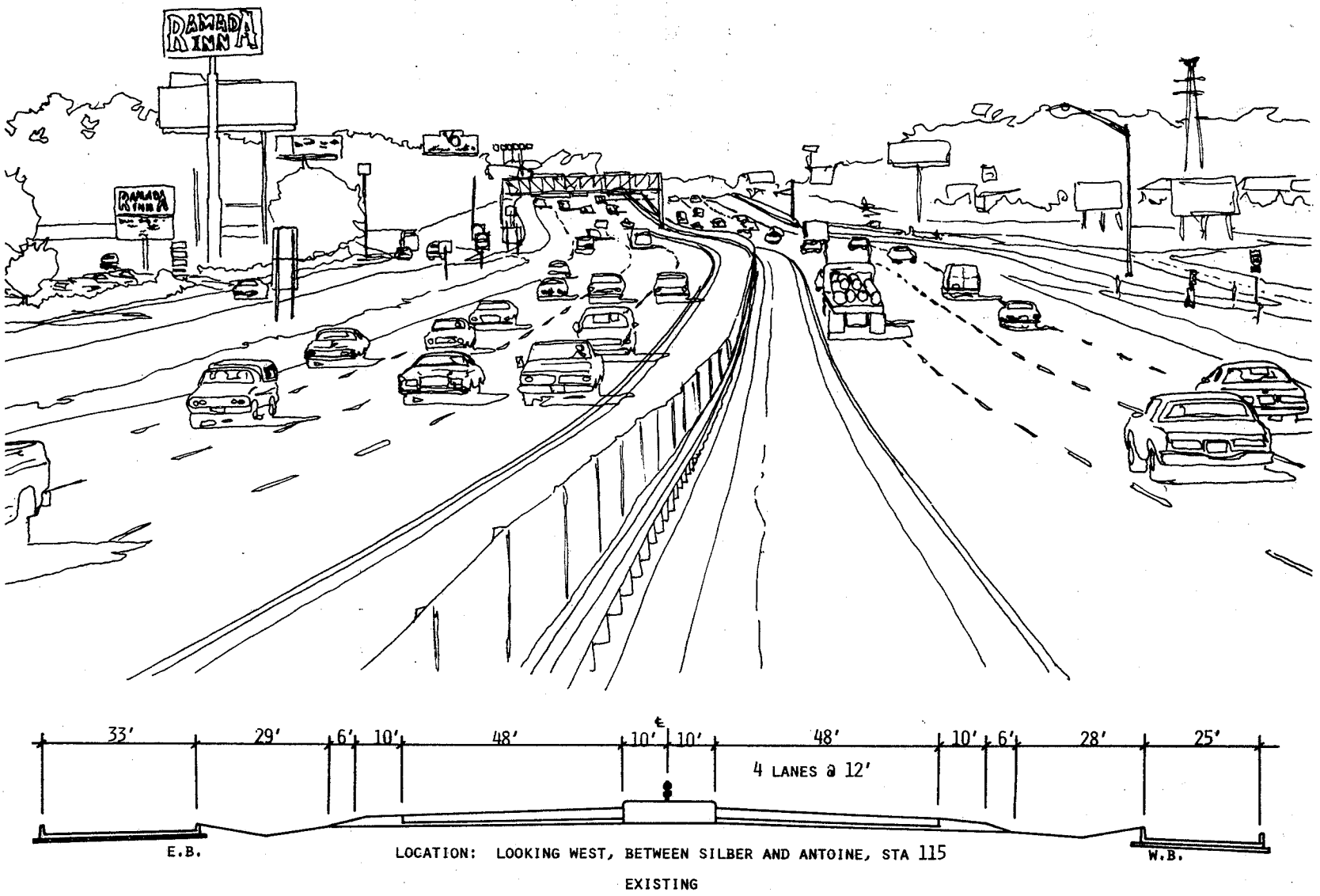


Figure 8: "Typical" Section of Possible One-Lane Median HOV Lane

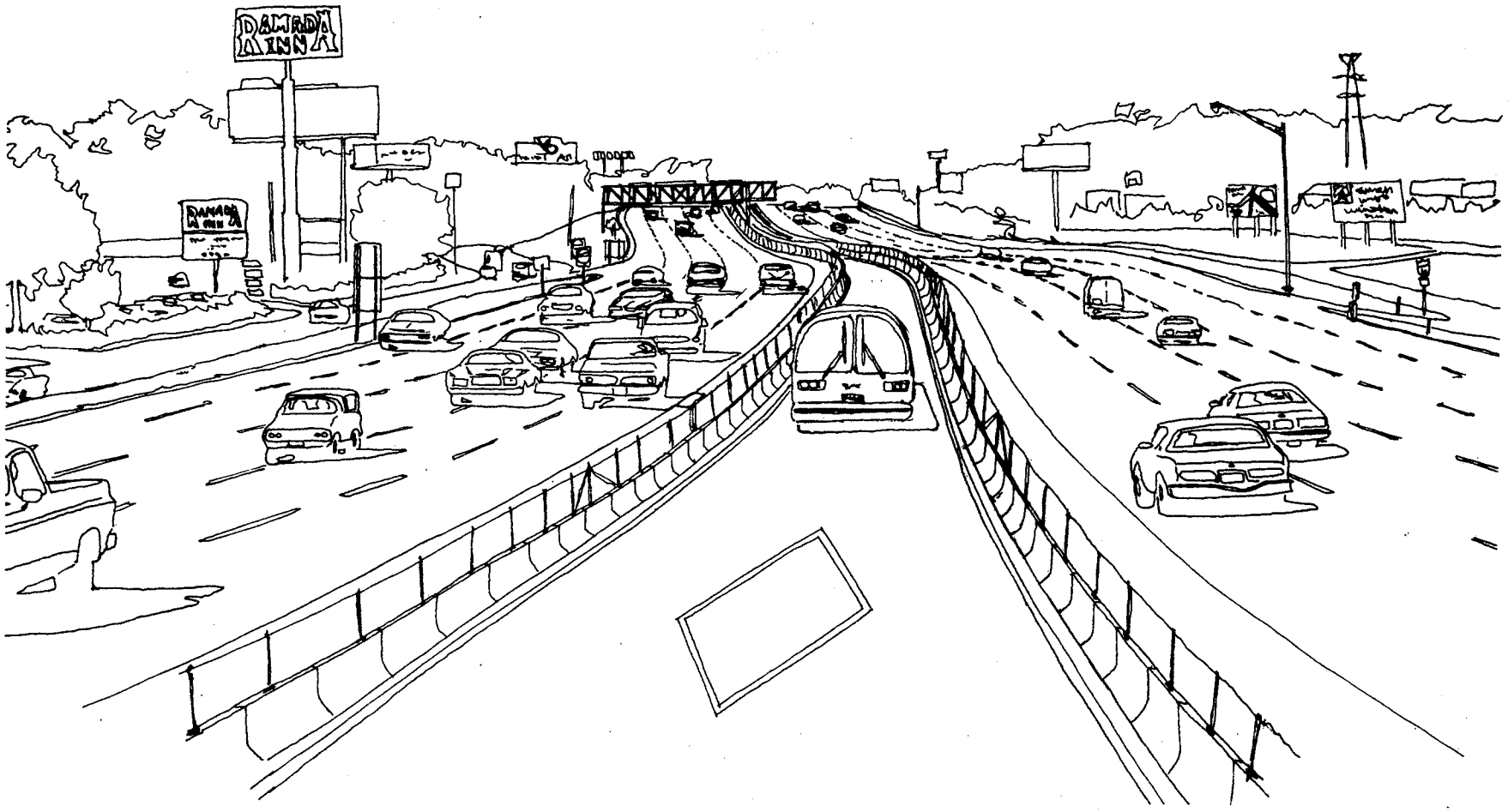


Figure 8: (Continued)

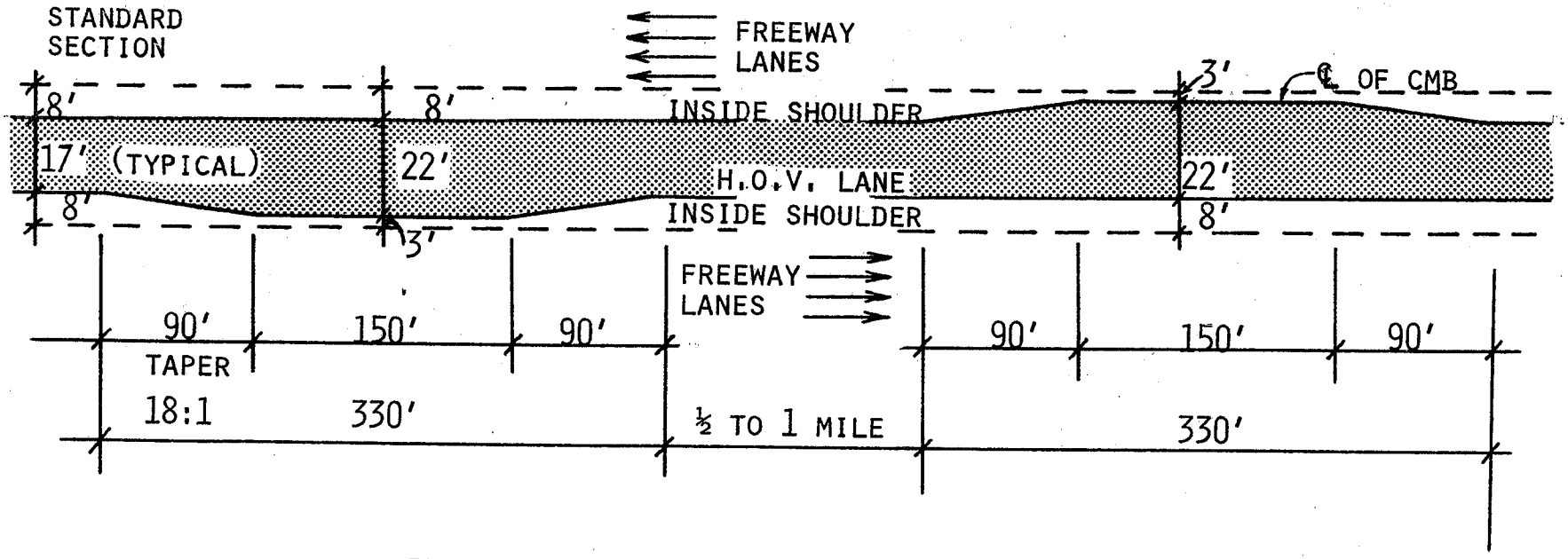


Figure 9: Median HOV Lane, Emergency Storage Areas
Possible Design

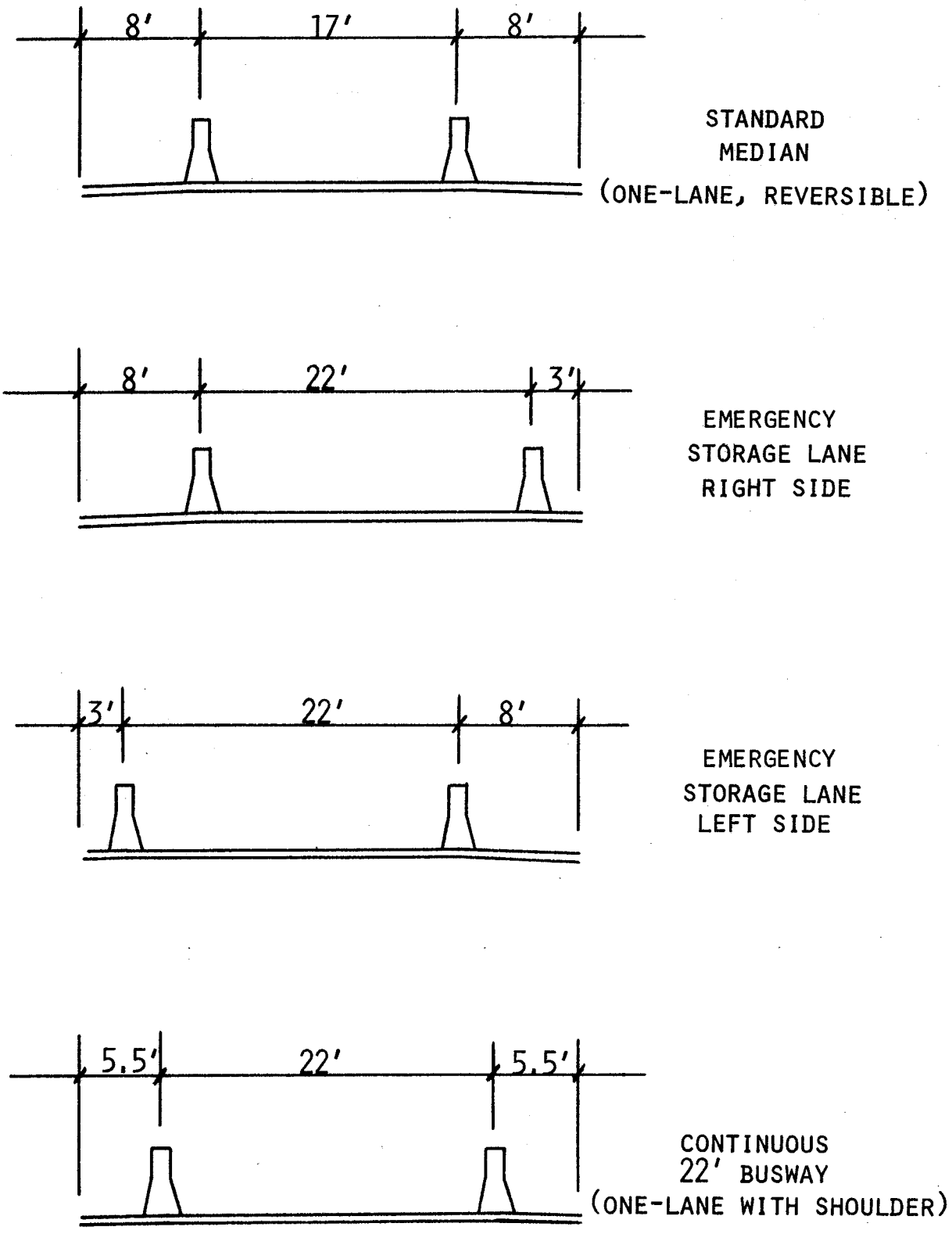


Figure 10: Possible Medians, For Katy Freeway HOV Lane

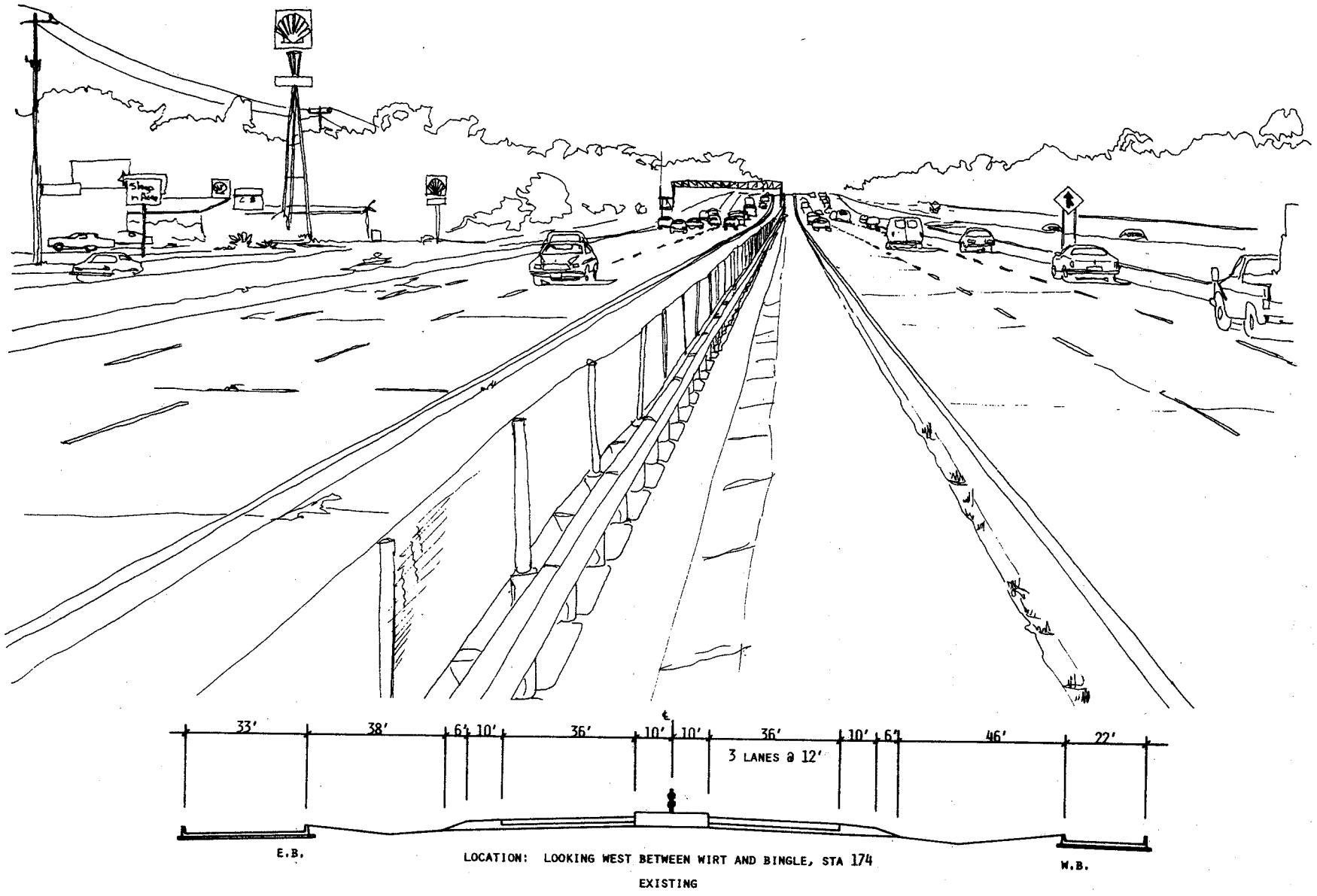


Figure 11: "Typical" Expanded Cross Section To Provide Emergency Turnouts on the Median HOV Lane

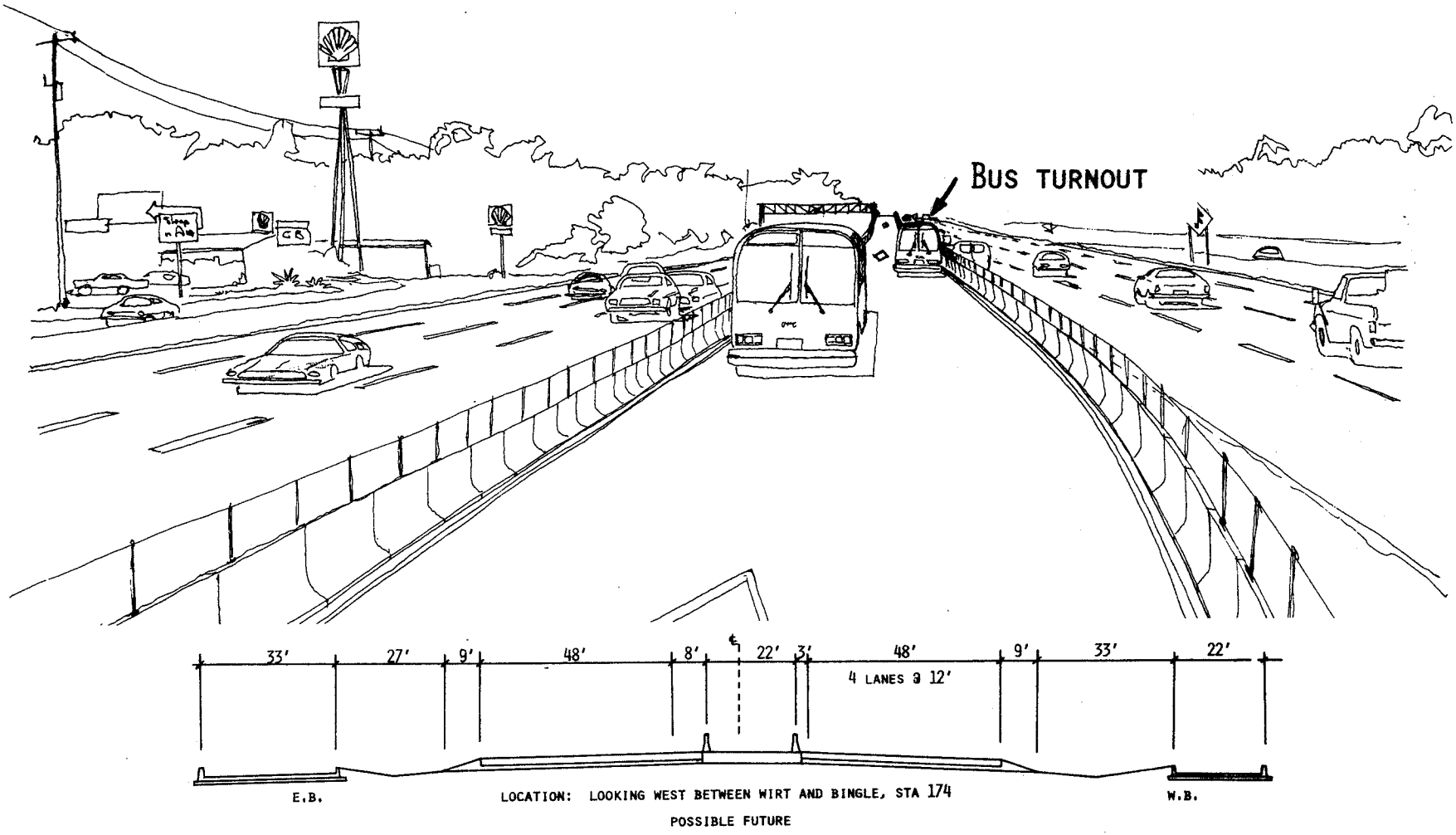


Figure 11: (Continued)

- Travel Patterns. Large volumes of CBD and Galleria/Post Oak trips enter Katy Freeway between Loop 610 and Gessner. Those traffic volumes should have at least some access to the lane. Also, current MTA plans suggest that bus volumes using the lane desirably should have access to the lane from some point in the vicinity of Gessner.

- Emergency Operation. Much of the length of the HOV improvement will be one lane wide without emergency shoulders. Midpoint entries may be necessary both to provide emergency vehicle access to stalled vehicles and to use as a means of getting traffic off of the HOV lane if that lane becomes blocked for an extended period of time.

Possible Designs and Locations

The median HOV lane will, for most of the length of the improvement, be at the same elevation as the main freeway lanes. This will be true except for those locations where midpoint access to the HOV lane is provided. At those locations, the median HOV lane will be elevated, and flyover ramps will be used to provide access/egress to the HOV lane (Figures 12 and 13).

Again, it is not the intent of this study to determine the specific locations at which midpoint entries will be provided. A number of locations at which it appears feasible to provide such access are identified in this section; however, none of these possibilities are optimal in all respects, nor do they necessarily represent the only possibilities available.

Access to the HOV lane from the north is complicated by the presence of the M-K-T Railroad track and a high-voltage power line. Although these factors do not necessarily make it impossible to provide connections to the HOV lane from the north, they do make it more difficult than providing similar connections from the south. As a result, this study focuses on manners in which access can be provided to the HOV lane from the south side of Katy Freeway.

A map showing some locations that might be considered for midpoint access locations is presented in Figure 14. That map is not intended to show all potential locations; rather, it is designed to illustrate that a number of potential locations appear to exist. Table 6 briefly describes the access locations shown in Figure 14.

It is not necessary that access be developed at all these locations. For example, acceptable operation would result if access/egress to the HOV lane were possible at SH6, Tully Road, Frostwood, Voss, North Post Oak, and Washington. If necessary, acceptable operation could occur with even fewer entry/exit locations.

Service to Galleria/Post Oak and Greenway Plaza

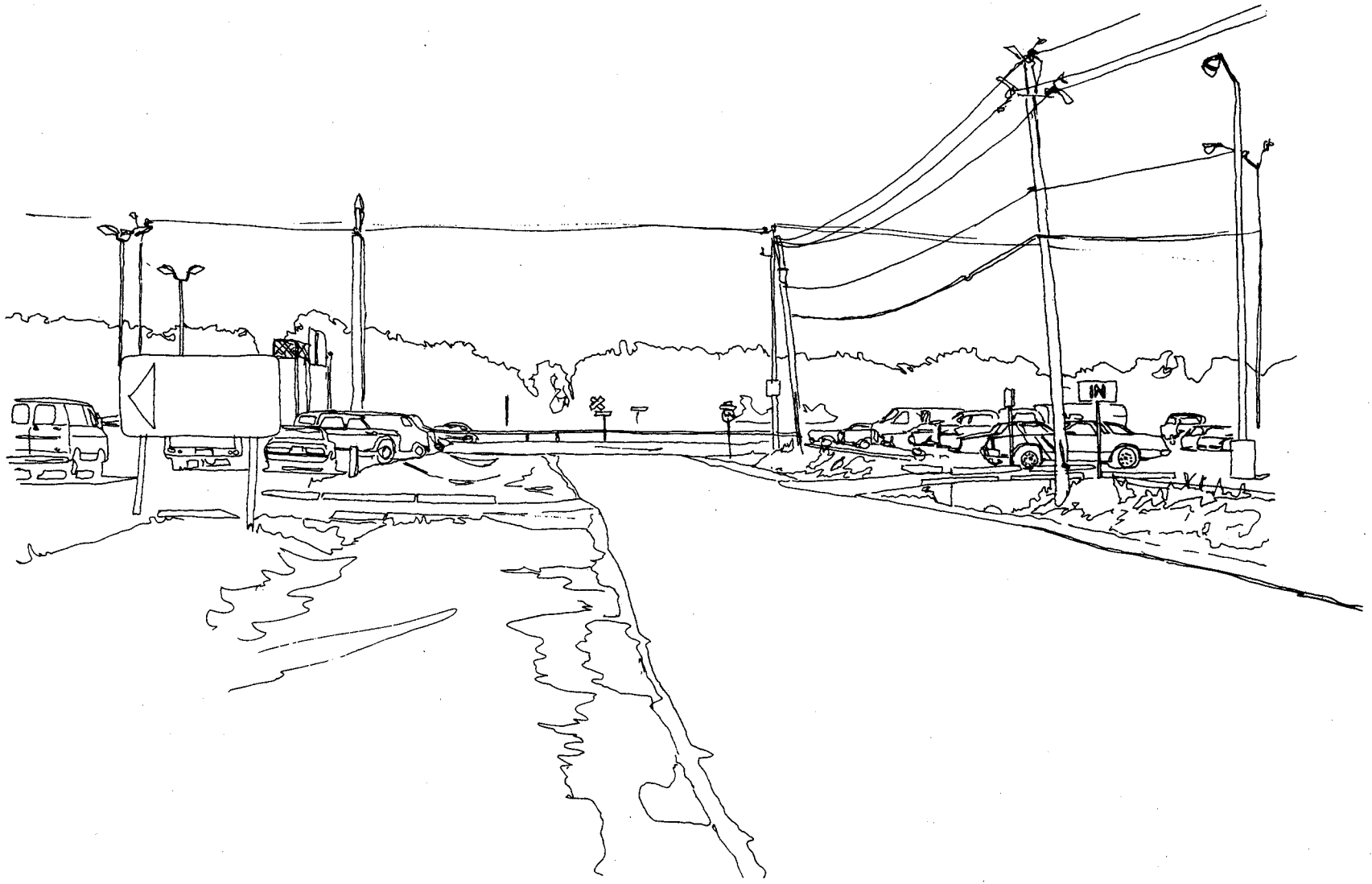
As shown previously, considerable traffic volumes using the Katy Freeway are destined to the major activity centers of Galleria/Post Oak and Greenway Plaza. The median HOV lane should be able to serve this travel demand.

Access/egress for the Galleria/Post Oak and Greenway Plaza traffic to the Katy Freeway HOV lane could occur at Post Oak Road. Traffic would utilize North Post Oak and the Loop 610 frontage roads to get from Katy Freeway to the Galleria/Post Oak center.

Several different approaches could be used to get traffic from the median HOV lane to North Post Oak Road. The two most likely approaches would appear to be:

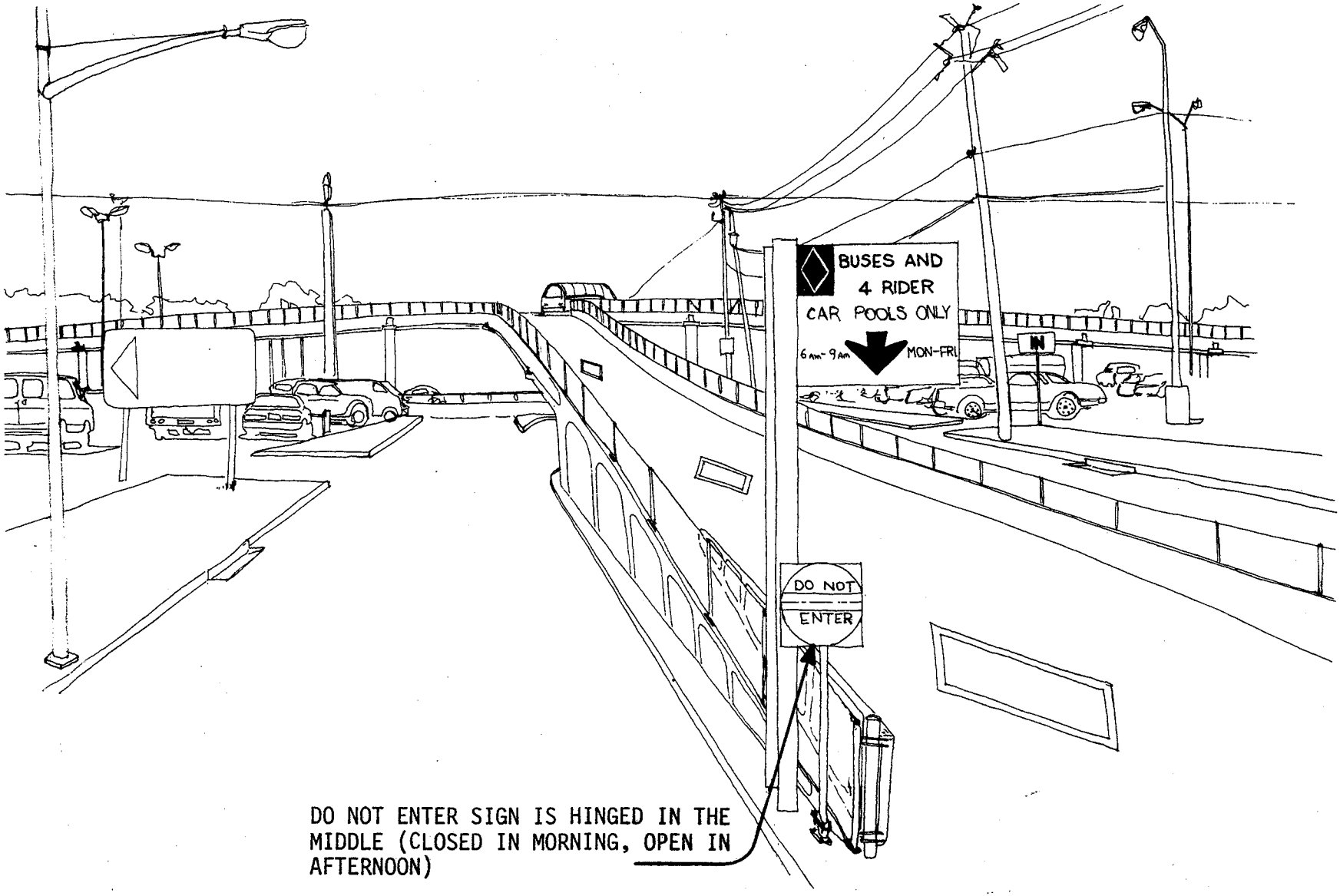
- Elevate the median HOV lane to a signalized intersection with the existing North Post Oak overpass (Figure 15).
- Provide a flyover ramp that would connect an elevated section of the median HOV lane with Old Katy Road. Eligible HOV vehicles would use Old Katy Road to get to North Post Oak. An at-grade intersection would not occur between the median HOV lane and North Post Oak Road under this alternative.

Either of the approaches result in reasonable connections from the median HOV lane to the Galleria/Post Oak and Greenway Plaza complexes.



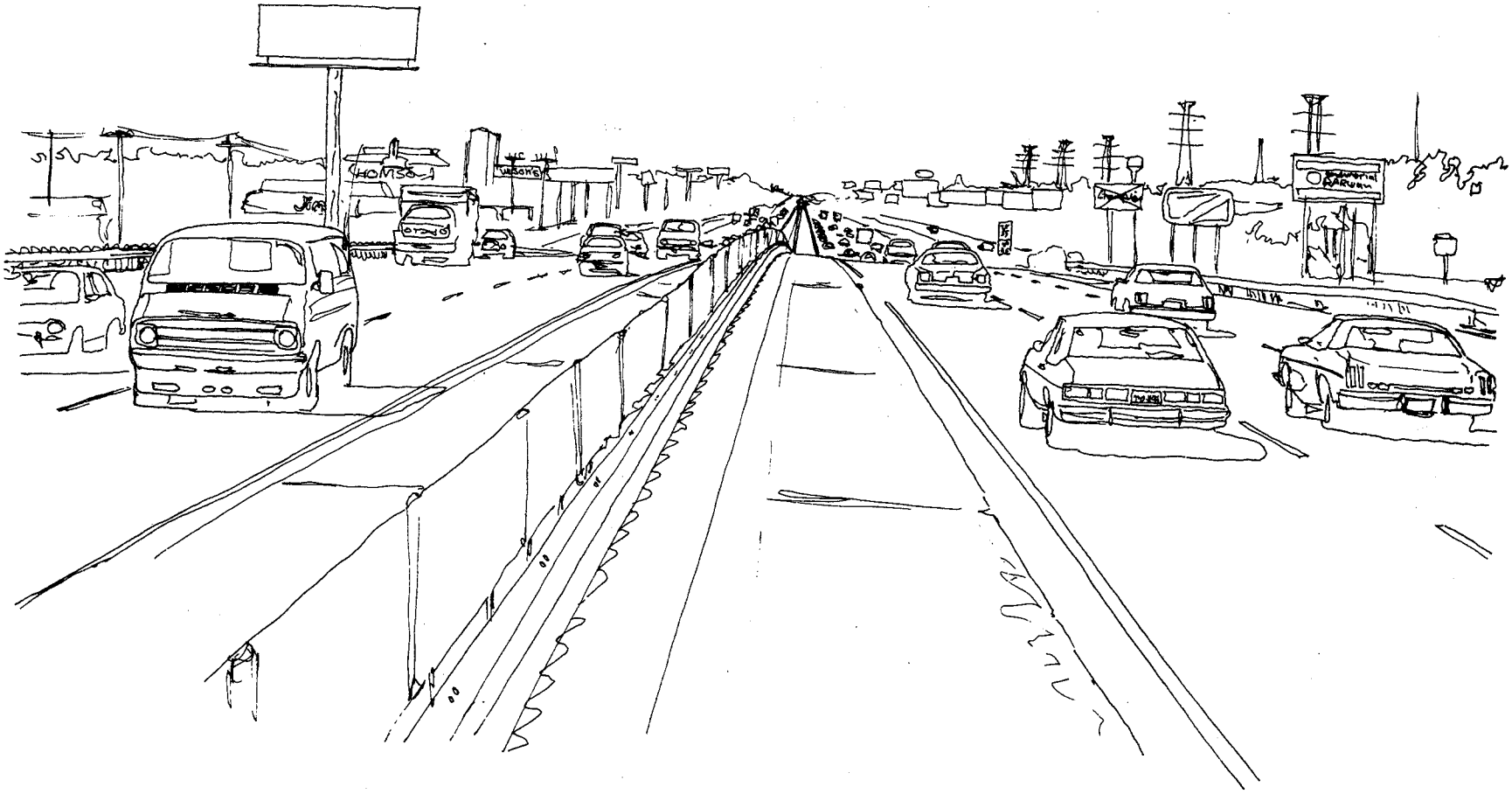
Location: Looking North at Katy Fwy. From Tully Rd. (Existing)

Figure 12: Example of a Manner in Which Midpoint Access Might Be Provided From the Median of an Improved Street



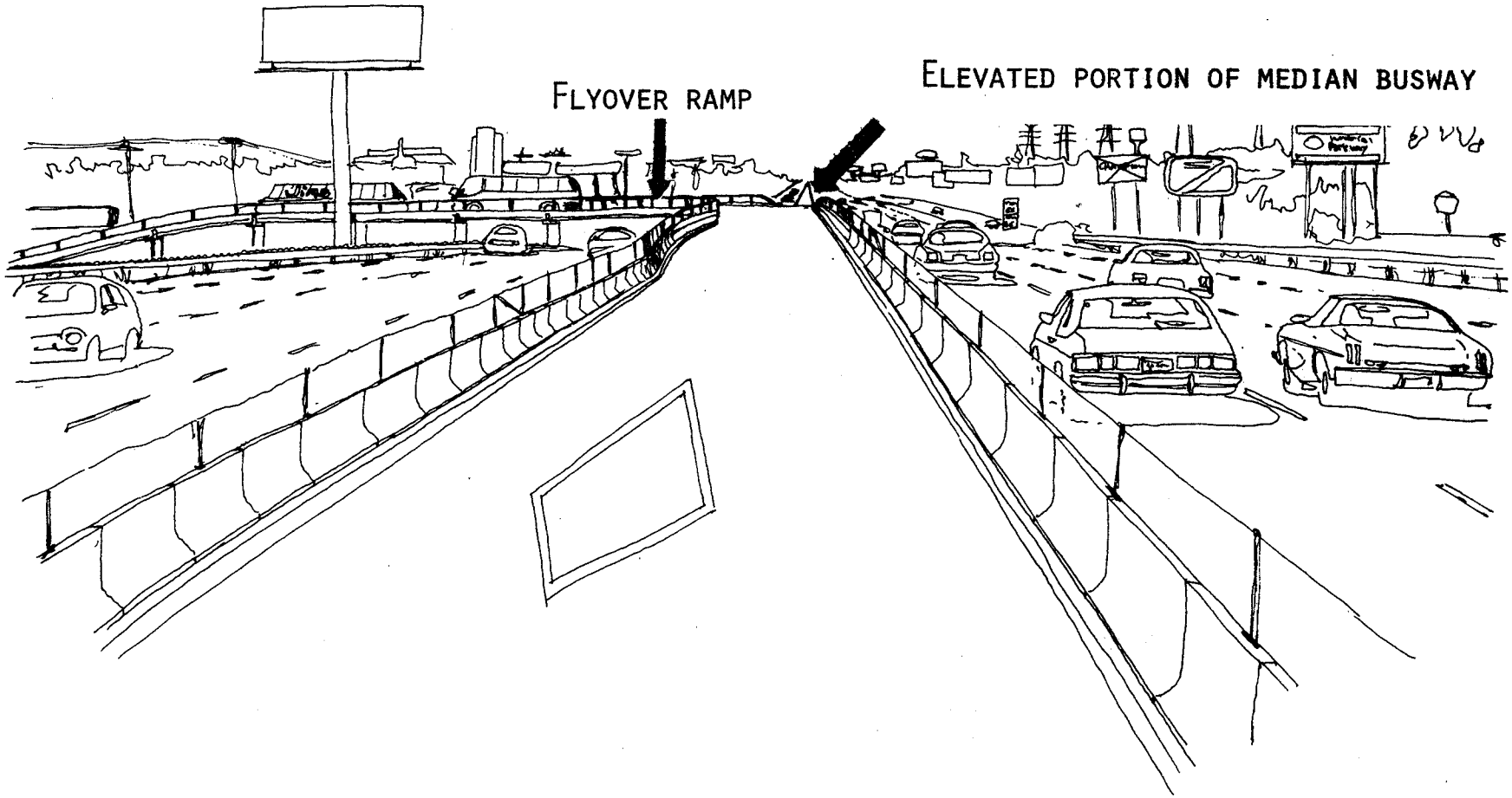
Location: Looking North at Katy Fwy. From Tully Rd. (Possible Future)

Figure 12: (Continued)



Location: Looking West From Gessner Overpass (Existing)

Figure 13: A Manner in Which Flyover Ramps Can Be Used to Provide Midpoint Access to the Median HOV Lane



Location: Looking West From Gessner Overpass (Possible Future)

Figure 13: (Continued)

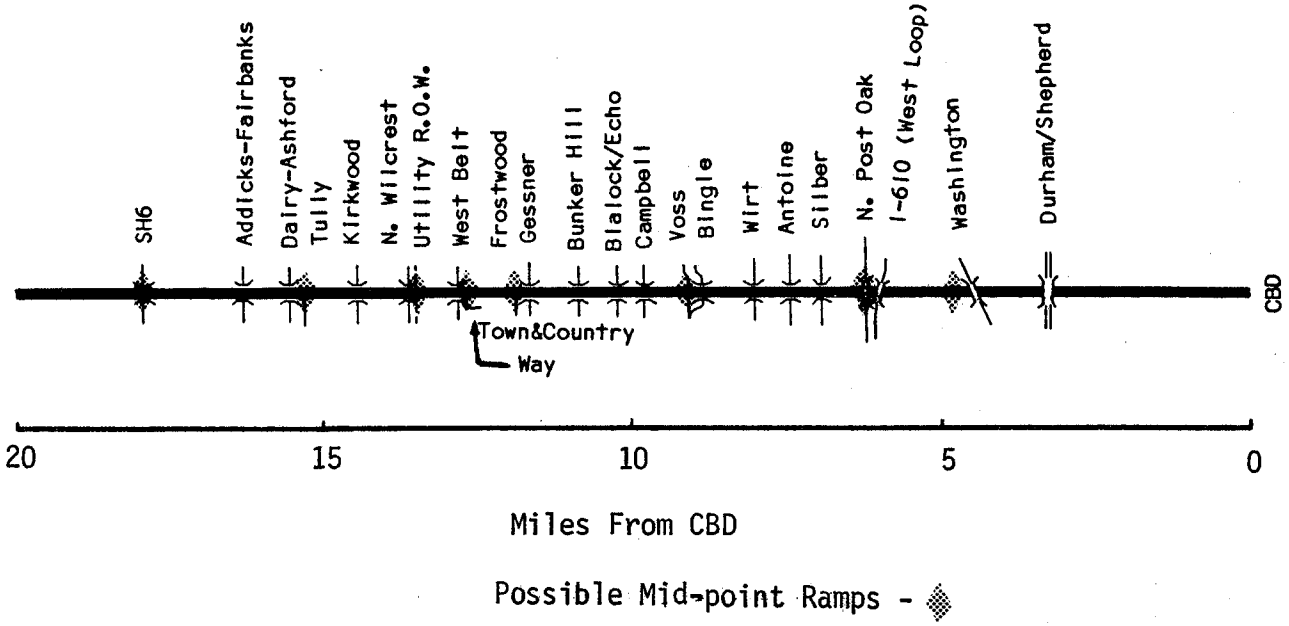
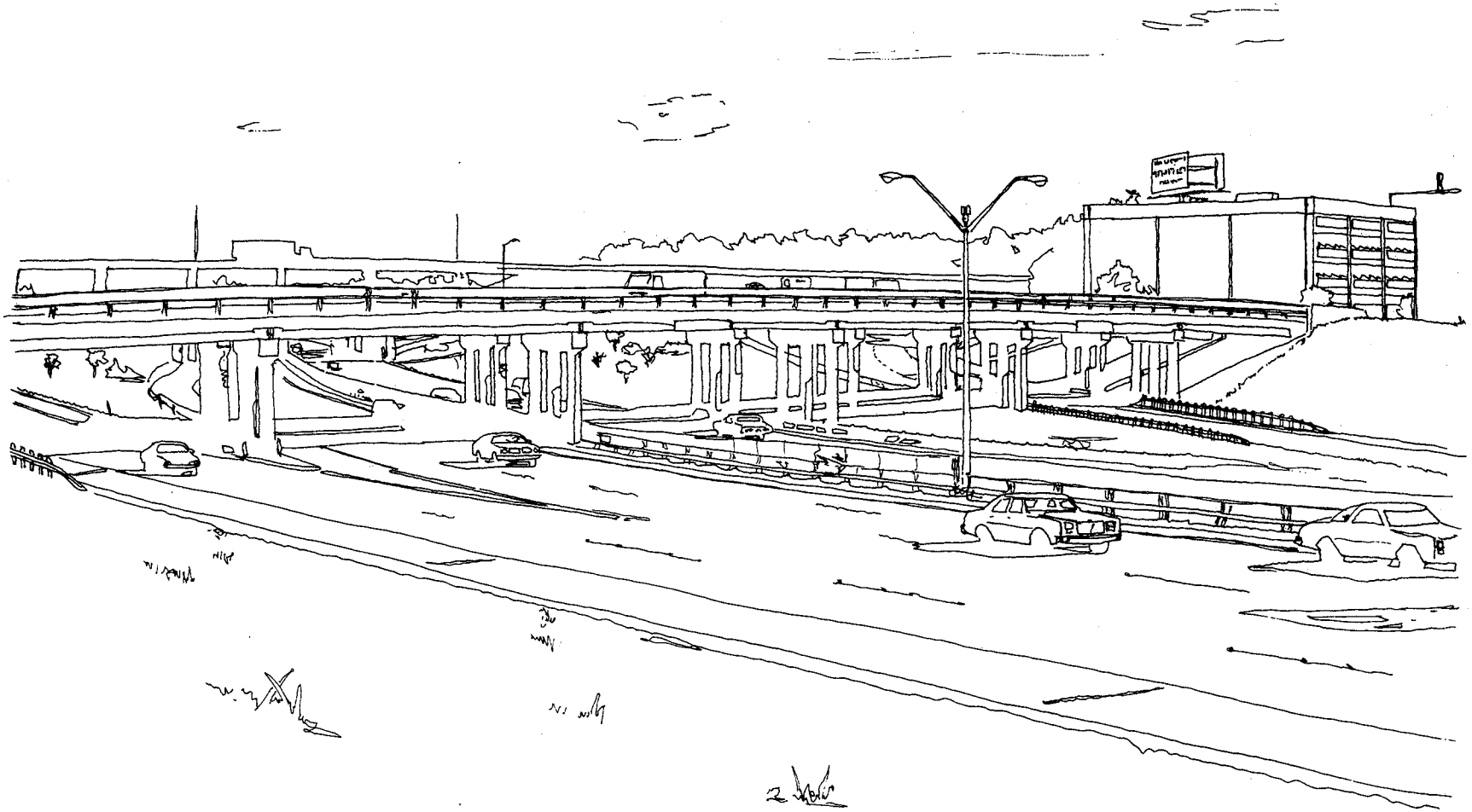


Figure 14: Possible Access/Egress Points to Median HOV Lane

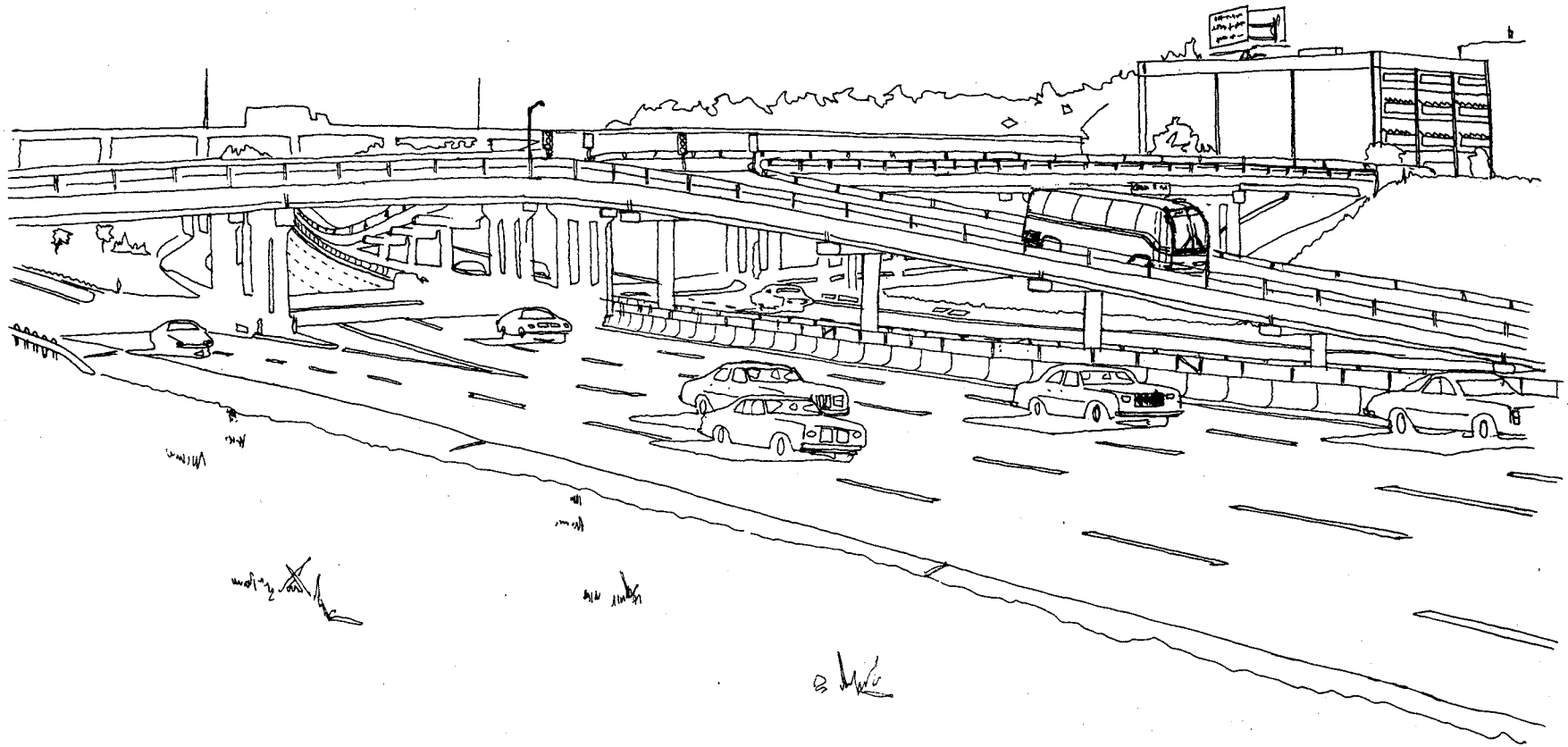
Table 6: Some Possible Locations at Which Midpoint Access to the Lane Can Be Developed

Possible Access Locations	Means of Access (Access from S. Side of Katy Freeway)	Potential Problems
Vicinity of SH 6	Opening in Median	• Safe design, enforcement
Tully Road	Ramp originates in median of expanded Tully	• Widening of Tully required • Careful attention to property access needs
Wilcrest	Access from ramp in utility easement just east of Wilcrest	• Connections to surface streets • Clearance from power lines
Town and Country Way	Ramp originates in existing median	• Conflicts with shopping center traffic • Connections to surface streets
Frostwood	Ramp originates in median	• Careful attention to property access needs • Major medical complex in vicinity
Voss Road	Ramp originates from all or part of existing Voss	• Careful attention to property access needs
North Post Oak	Median HOV lane elevated to at-grade intersection or flyover ramp to Old Katy Highway	• Signalization
Just W. of Washington	Opening in median	• Safe design, enforcement



Location: North Post Oak Intersection (Existing)

Figure 15: Example of a Manner in Which the Median HOV Lane and Post Oak Road Could Intersect, Providing Access to Galleria/Post Oak and Greenway Plaza



Location: North Post Oak Intersection (Possible Future)

Figure 15: (Continued)

Additional Cross Sections and Critical Segments

A number of cross section and renderings have been presented in previous portions of this section. Figure 8 presents a "typical" cross section, while Figure 11 shows the expanded typical cross section to provide emergency turn-outs. Figures 12 and 13 present views of what the midpoint access locations might look like.

Figure 16 presents those locations (with specific stations designated) at which cross sections of both the existing and future roadways have been drawn. Some of those cross sections are presented in Figure 17.

In general, the "typical" cross section (Figure 8) creates no major problems. Given the fact that the Department will be expanding the cross section between Loop 610 and Beltway 8, this typical section can be provided without significantly compromising freeway operations. Twelve-foot lanes exist, as do inside and outside shoulders. Adequate space exists between the frontage road and the main lanes in which to incorporate satisfactory entrance and exit ramp designs.

However, the "typical" cross section creates some difficulties as it is applied to three segments of the overall improvement. These three sections are:

- Between Beltway 8 and SH 6,
- Through the Loop 610 Interchange, and
- Between Bingle and Blalock.

These critical sections are discussed individually below.

Between Beltway 8 and SH 6

This section poses problems only if the Department does not expand the cross section from Beltway 8 to SH 6. If the cross section is not expanded, the median HOV lane will occupy at least the entire existing median; as a minimum, no inside shoulders will exist in this section and, possibly,

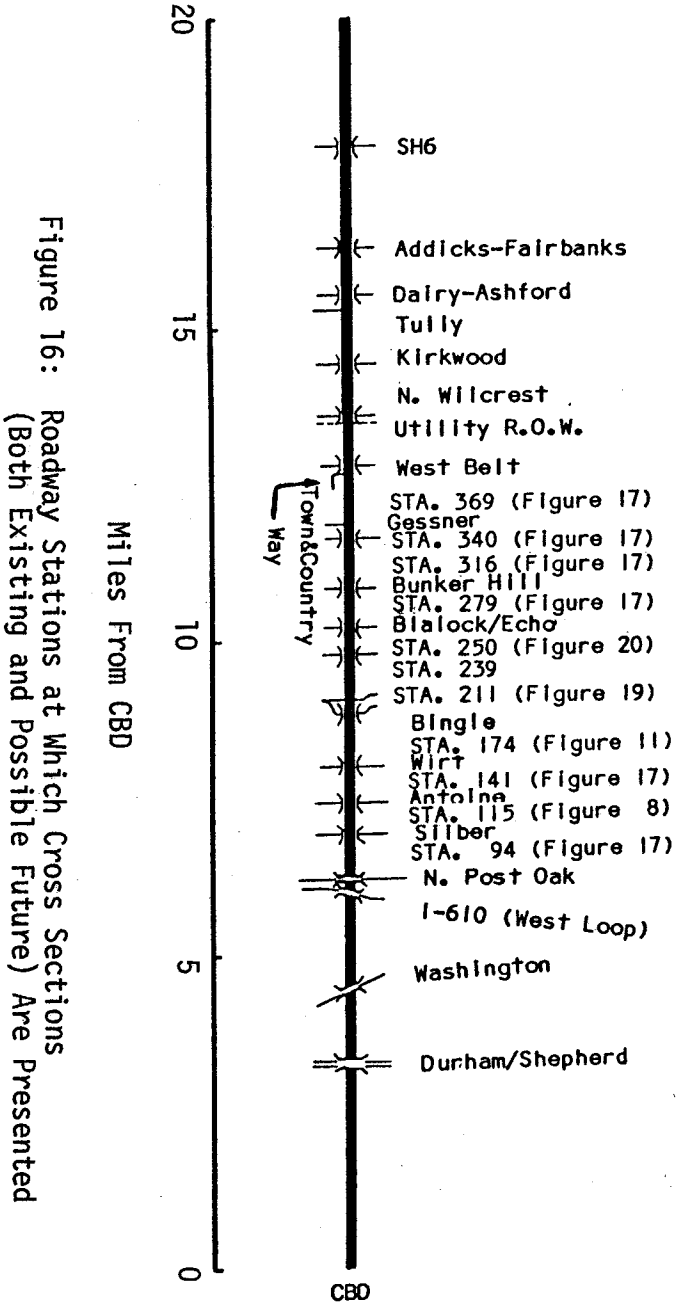


Figure 16: Roadway Stations at Which Cross Sections (Both Existing and Possible Future) Are Presented

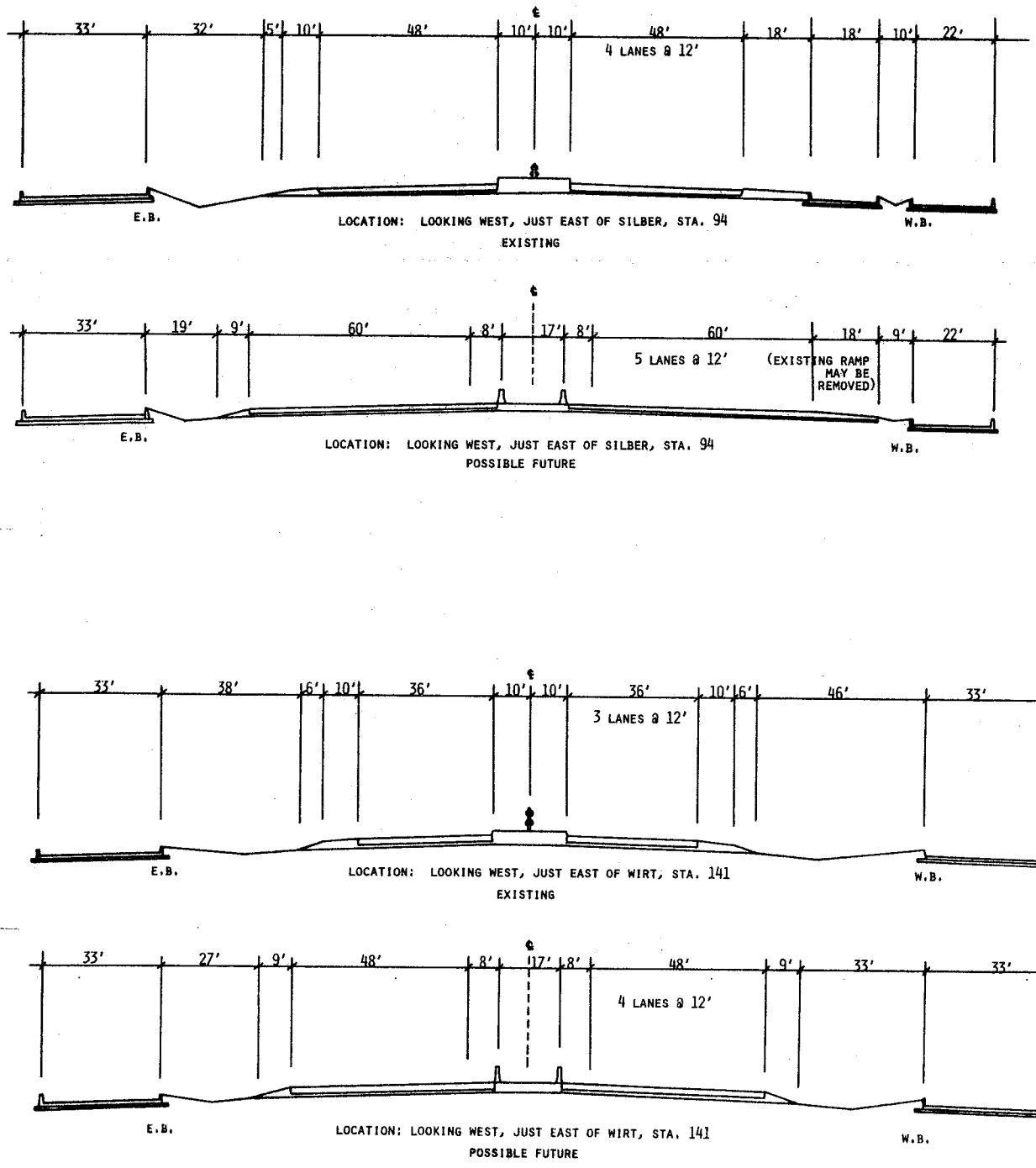


Figure 17a: Typical Cross Sections (Existing and Possible Future) At Selected Stations Along The Katy Freeway

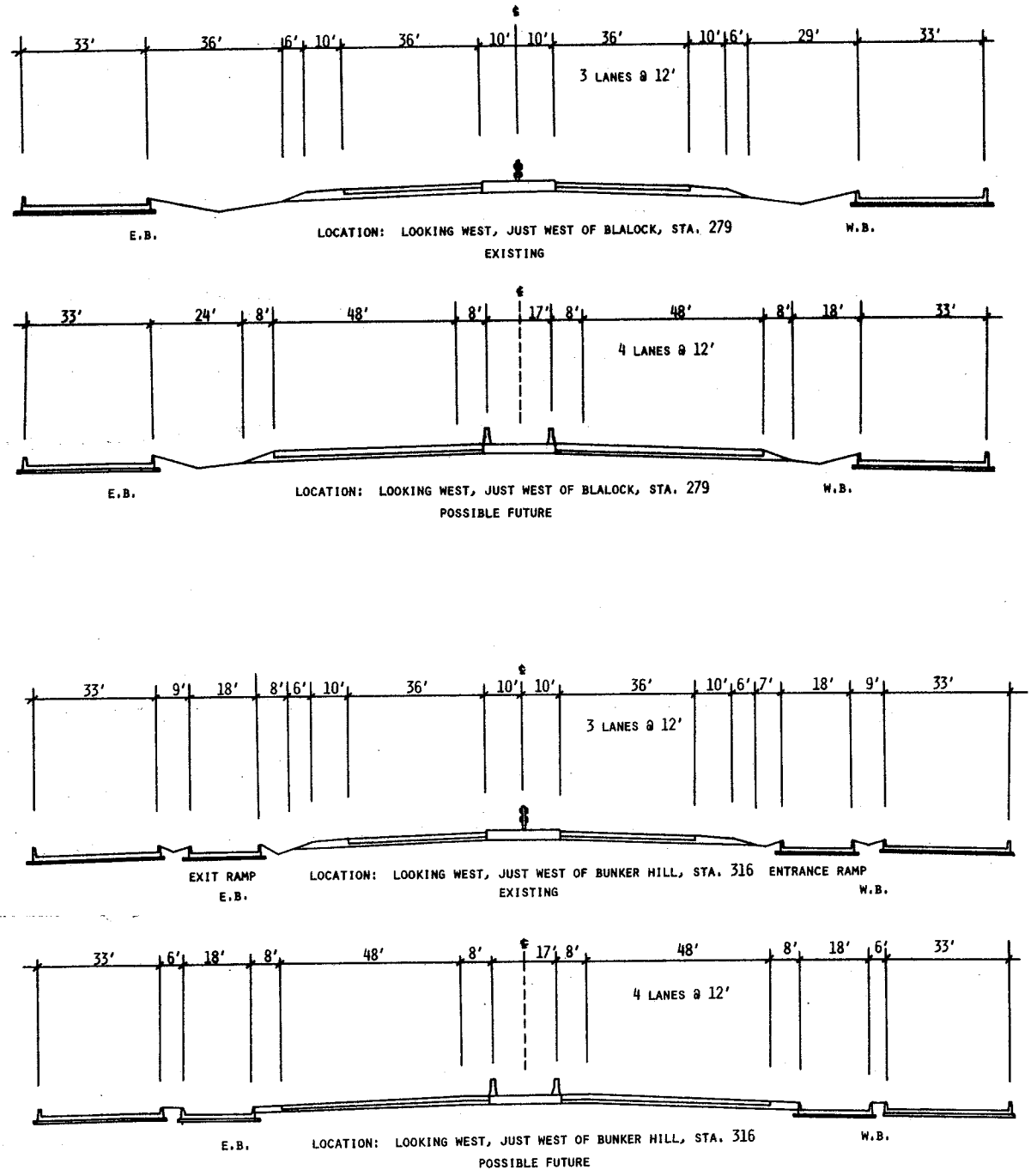
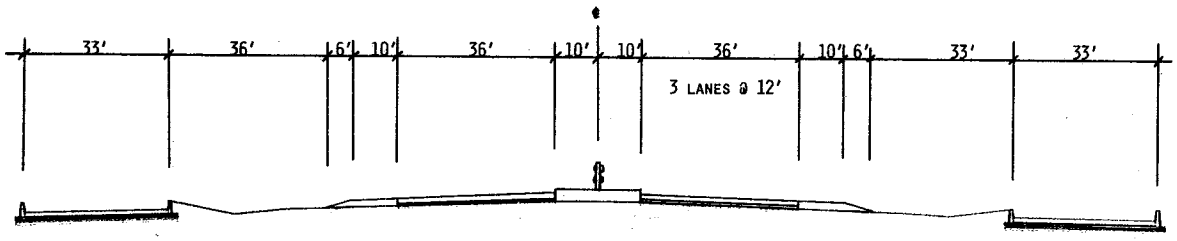
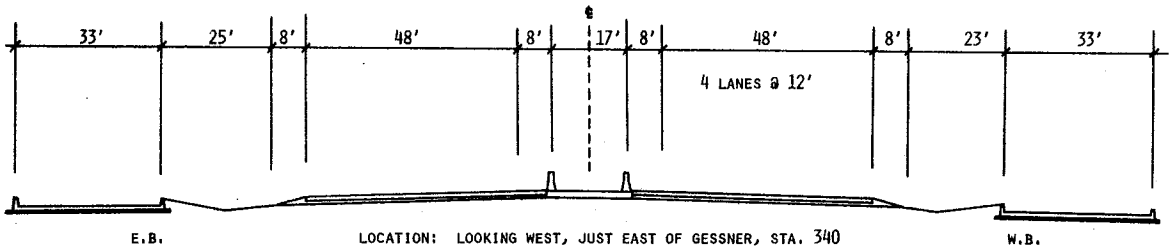
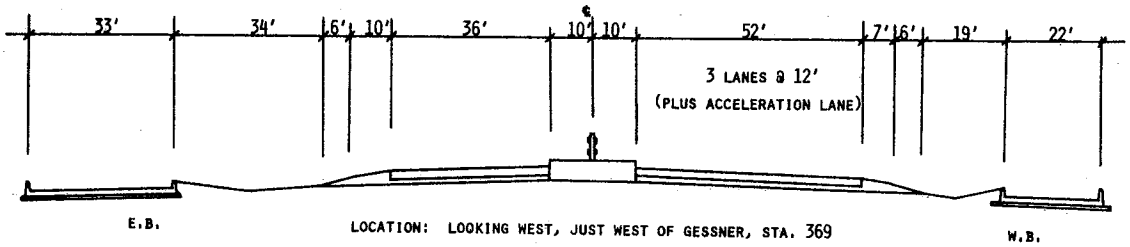


Figure 17b: Typical Cross Sections (Existing and Possible Future) At Selected Stations Along The Katy Freeway







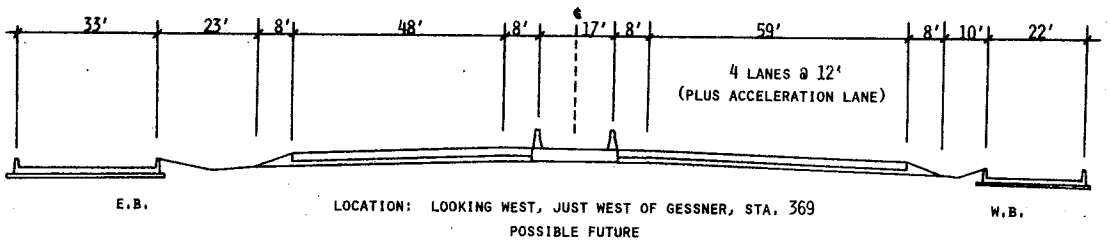


Figure 17c: Typical Cross Sections (Existing and Possible Future) At Selected Stations Along The Katy Freeway

narrowing of main lanes will be required. Provision of emergency turnouts along the HOV will not be possible.

All of these problems can be eliminated if the roadway is widened by approximately seven feet on both sides. That amount of widening should permit acceptable operation of both the freeway and the median HOV lane, and no significant difficulties should be encountered in undertaking that widening.

Loop 610 Interchange

Due primarily to afternoon traffic problems, it is necessary that the median HOV lane extend through the Loop 610 interchange to a point in the vicinity of Washington. Only about 54 feet of pavement exists between bridge columns at the Loop 610 location. For the side of the roadway on which the HOV lane is carried, main freeway lanes will need to be narrowed to 11 feet, and no shoulders will exist. This condition is depicted in Figure 18. Although not a desirable situation, this condition will need to exist for only a short section of roadway. Since evening traffic is more congested than morning traffic in this section, it would appear desirable to narrow lanes and eliminate shoulders on the inbound side of Katy Freeway.

Bingle to Blalock

For a distance of about 1.4 miles between Bingle and Blalock, significant right-of-way constraints already exist. Existing median widths vary from about 4 to 8 feet through this section.

A median HOV lane will place further constraints on this section. No space will exist for emergency turnouts on the HOV lane over that 1.4 mile section, although such turnouts can be provided at both ends of the tight section.

For the most part, freeway lane widths will need to be reduced, and the availability of space for inside and outside shoulders will be constrained (Figures 19 and 20). Certainly, the resulting cross sections are not, from a

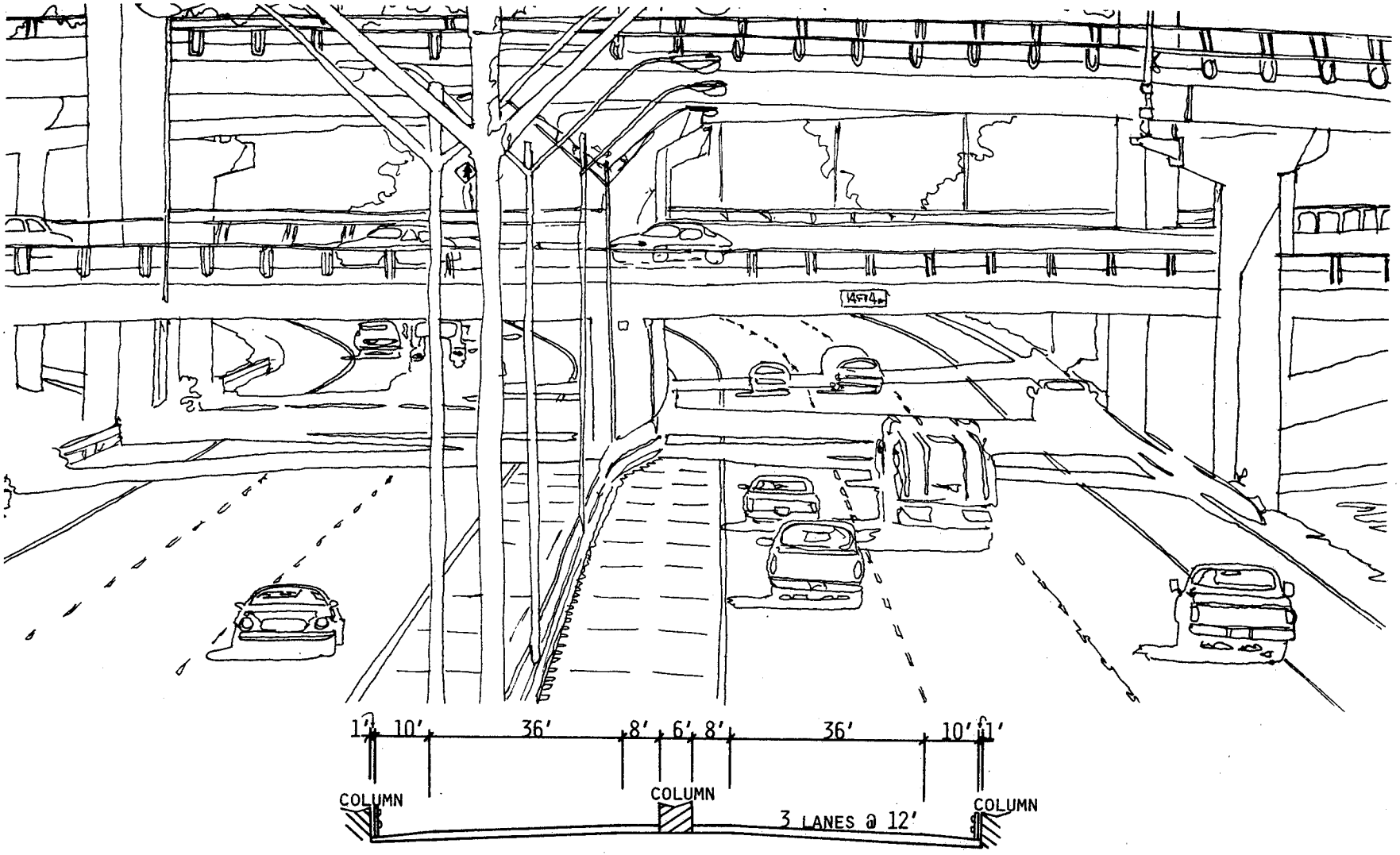
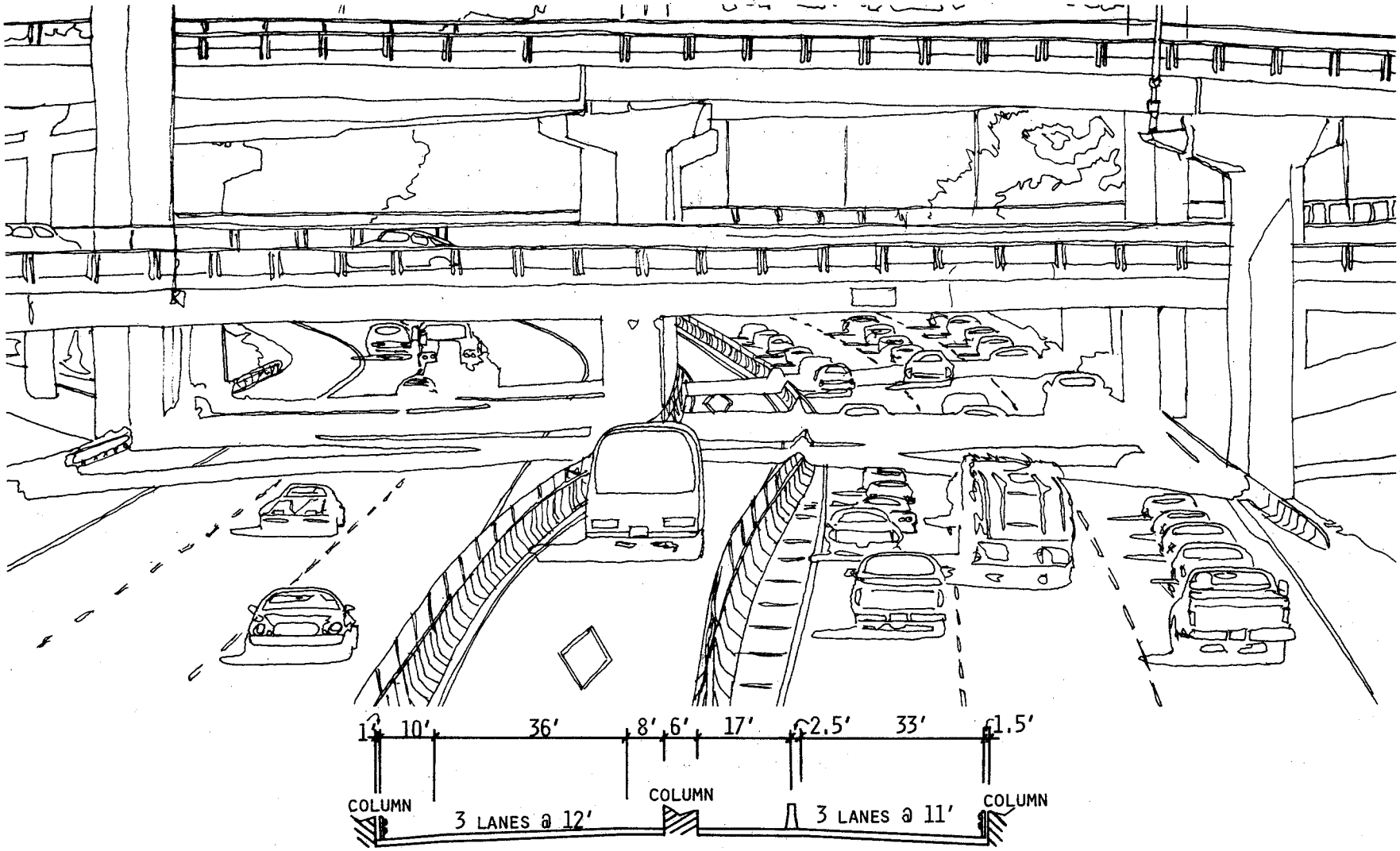


Figure 18: A Manner in Which the Median HOV Lane Could Be Continued Through the I-610W Interchange



LOCATION: LOOKING EAST AT WEST LOOP INTERCHANGE, STA 56

POSSIBLE FUTURE

Figure 18: (Continued)

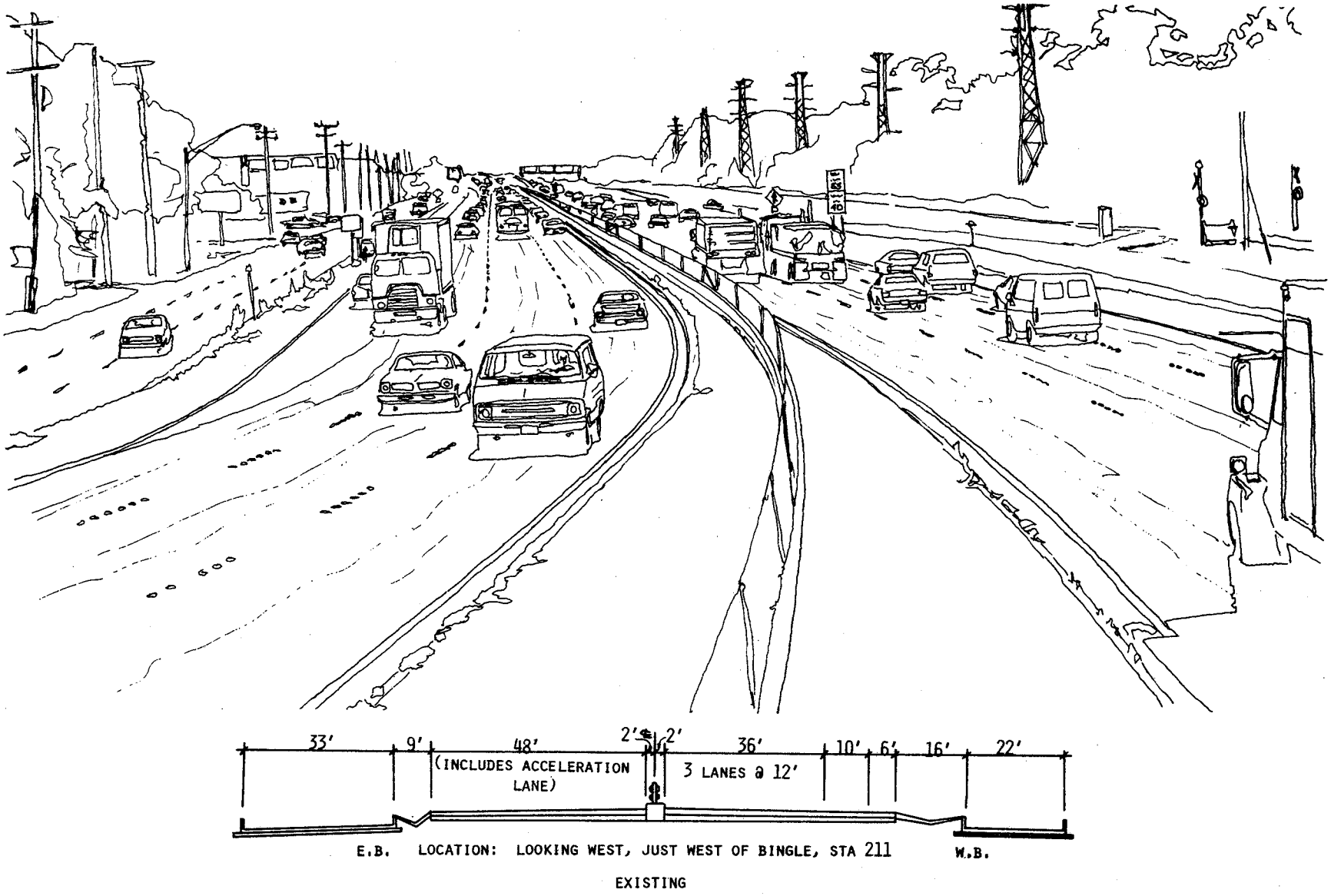


Figure 19: HOV Lane Located in Median Along "Tight" Section of Katy Freeway

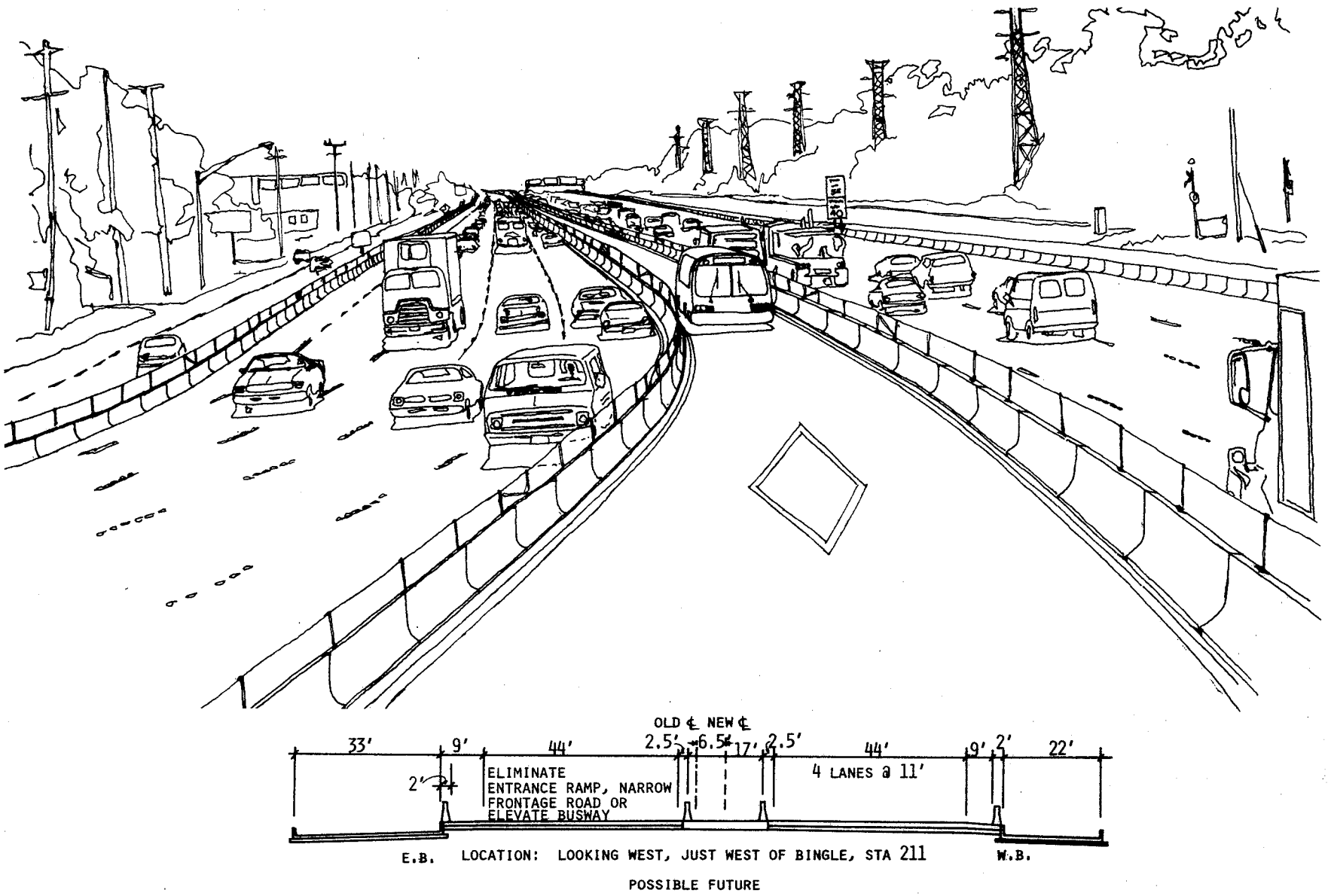


Figure 19: (Continued)

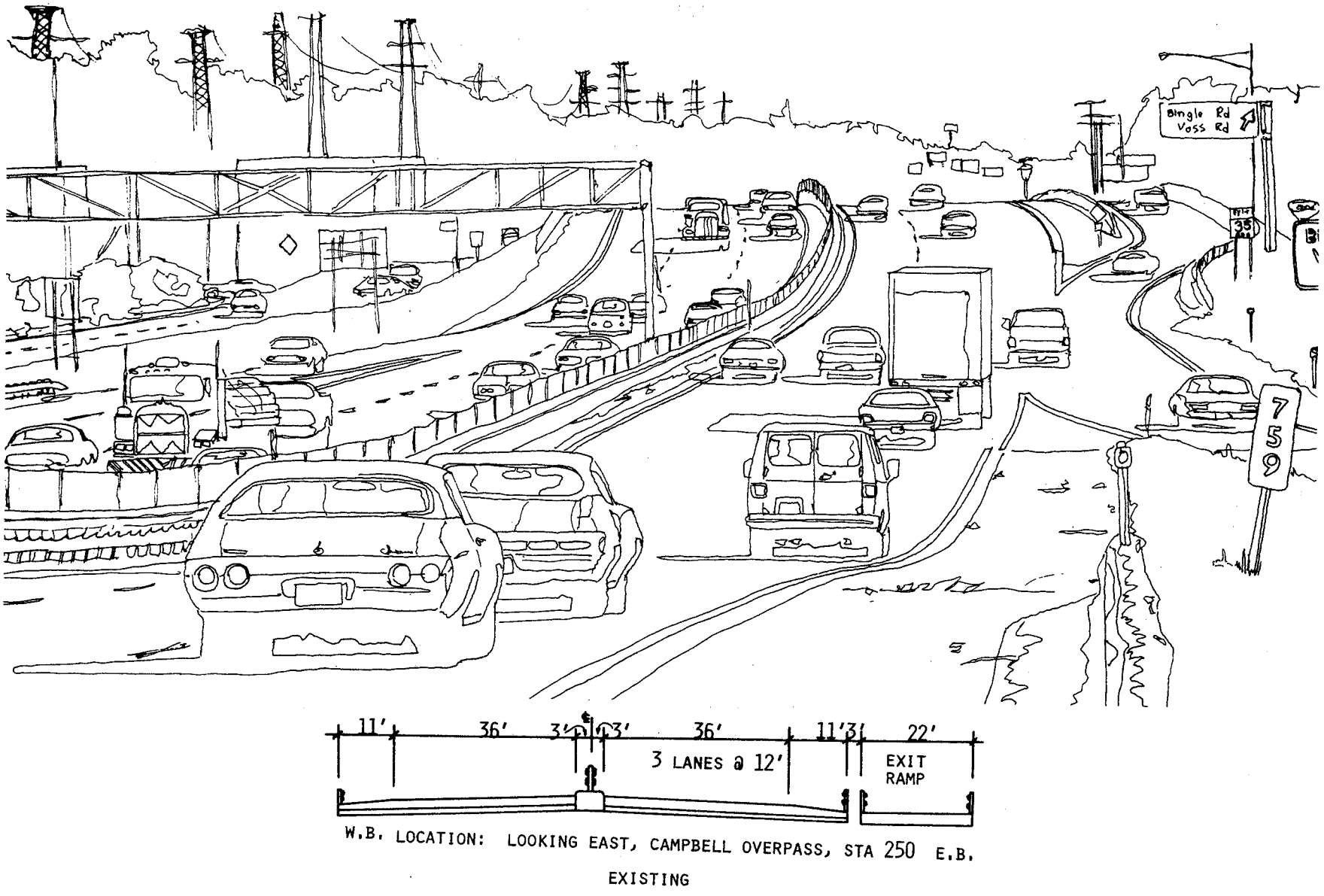


Figure 20: HOV Lane Located in Median Along "Tight" Section of Katy Freeway

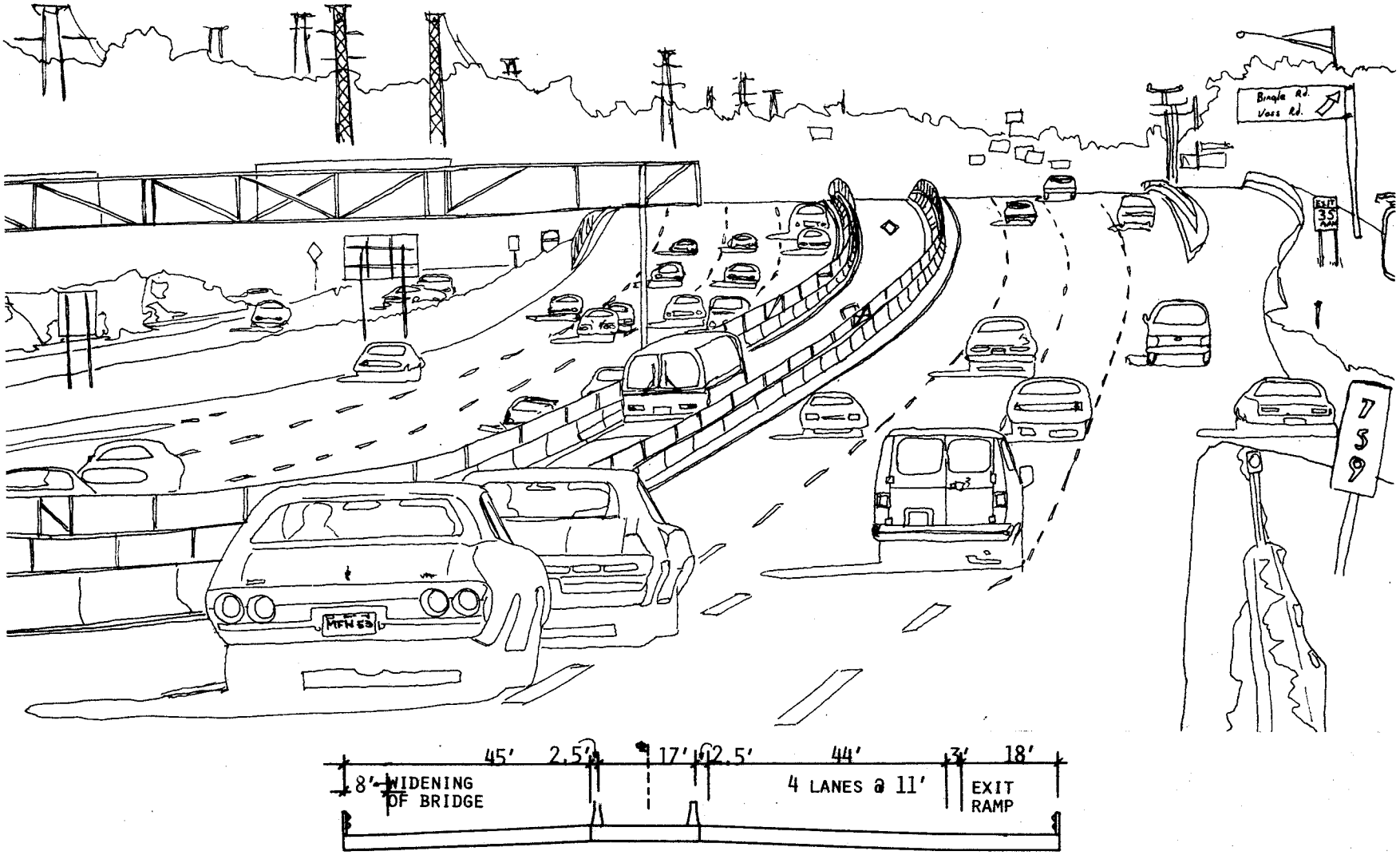


Figure 20: (Continued)

freeway operations standpoint, optimal. These less than optimal conditions will exist throughout the 1.4 mile section unless additional right-of-way is obtained. The feasibility of obtaining such right-of-way is uncertain.

The Department's proposed widening, combined with the provision of a sufficiently wide median to accommodate an HOV lane, will probably require the closing of the three existing ramps located between Bingle and Campbell; one of those ramps is located on the south side of the freeway (entrance ramp), and the other two ramps are located on the north side (one entrance, one exit).

One alternative is simply to close those three ramps. Other alternatives include:

- Acquire additional right-of-way.
- Narrow the frontage road on the south side of the freeway from three lanes to two, which will provide only marginally adequate space in which ramps can be functionally located and operated.
- Relocate some of the closed ramps to either the east or the west. Some "braiding" of ramps might be required.
- Elevate the median HOV lane and have no inside shoulder.
- Some combination of the above alternatives.

Implications of Design/Operational Features

The HOV median lane is viewed as an "intermediate" range improvement; an action that might be operational over a 5- to 20-year period. Provision of the improvement includes compromises concerning both the design of the HOV lane and the design of the freeway. The HOV improvement must be in addition to, not in replacement of, the Department's plans to add one traffic lane in each direction. In addition to the need for the lanes, public reaction is likely to be more favorable if both lane expansion and an HOV improvement are being undertaken.

The median lane will be one lane wide, the typical section having no shoulders. Emergency turnouts will be provided at approximately one-half mile intervals. The lane will be reversible. The initial improvement will involve a length of approximately 13.1 miles. Several midpoint access locations will be developed, and a connection between the HOV lane and North Post Oak Road will provide service opportunities to Galleria/Post Oak and Greenway Plaza.

At three particular locations--west of Beltway 8, between Bingle and Blalock, and through the Loop 610 interchange--provision of the median HOV lane causes more problems than at other locations. Compromises between the HOV lane design and the freeway design will be particularly necessary at these three locations.

CONCLUSIONS AND RECOMMENDATIONS

The feasibility and desirability of pursuing a variety of alternative HOV improvements in the Katy Freeway were evaluated. The following briefly summarizes major findings regarding the applicability of the various improvements.

Exclusive Busway. Insufficient width is available to develop a two-lane median busway at-grade. A one-lane median facility appears feasible. At this time, the one-lane busway is viewed as superior to a two-lane, elevated busway because: it can be implemented in 6 to 10 years rather than 10 to 20 years; the one-lane busway improvement is compatible with the Department's plans to widen the Katy Freeway and can be implemented simultaneously as a complementary improvement; the one-lane HOV lane is a low cost, low risk option that can readily be converted to other uses when, and if, necessary; MTA has not yet developed the long-range plan that would be needed to justify an expensive, elevated busway; the one-lane facility provides an excellent means of testing demand prior to committing large sums of money; there is strong reason to suspect that the one-lane facility is the most cost-effective action to take, and even though the one-lane median facility compromises, it does not destroy the functionality of the freeway main lanes.

Contraflow Lane. Given the Department's widening plans, at least between Beltway 8 and Loop 610, a contraflow lane appears feasible, though not necessarily desirable. Given a choice between contraflow and an exclusive median HOV lane, the median lane is superior because: it does not incur the very high daily operational cost ($2,000 to $3,000) required to set up, take down, and enforce contraflow; the contraflow eliminates the positive separation of opposing traffic flows; contraflow penalizes off-peak direction traffic by reducing the number of lanes serving that traffic; less control and concern need to be given to the types of vehicles allowed to utilize an exclusive median facility; and, since the HOV facility must be elevated to provide midpoint access/egress, it is more feasible to provide that access/egress with an exclusive median lane.

Freeway Control With Priority Entry. This concept can be expected to have a relatively low benefit/cost ratio. This concept does not provide the same degree of schedule reliability nor line haul travel speeds that an exclusive lane can provide. Furthermore, this concept does not greatly increase total freeway capacity; if anything, that capacity is reduced in order to maintain acceptable operating speeds. Inability to meter freeway to freeway traffic causes this concept to not be applicable to the Katy Freeway, at least during the afternoon peak.

Frontage Roads With Signal Preemption. Some short term gains can be achieved through this approach, and those improvements are currently being pursued. The effectiveness of those improvements is limited and will decrease as traffic volume increases. Sufficient bus capacity cannot be generated using this approach to be able to serve projected travel volumes.

Based on these analyses, as an interim improvement that is compatible with the Department's current plans to add one additional traffic lane in each

direction from Loop 610 to Beltway 8, a one-lane, reversible, median HOV lane appears to be feasible and justifiable on the Katy Freeway. Of the priority treatments available, the one-lane HOV lane represents the preferred action at this time. Such an improvement is not the optimal, long-range improvement, but is an improvement that should be useful over a 5- to 20-year time period, at which time its flexibility will permit it to easily be converted to other uses, if necessary. It appears that the cost-effectiveness of such an HOV improvement is highly favorable. Implementation of the HOV lane does require compromises between HOV lane operation and the operation of the freeway main lanes, but its implementation does not necessitate destroying the functionality of the freeway.

The HOV improvement will initially extend just over 13 miles, from an eastern terminus near Washington to a western terminus near SH 6. Midpoint access to the median HOV lane will be provided at several locations, and the lane will serve traffic bound for the central business district, Galleria/Post Oak, and Greenway Plaza. An initial implementation cost of $20 to $30 million will be required.

The feasibility and cost-effectiveness of the median HOV lane appear sufficiently favorable to justify a detailed evaluation of the concept as part of the design process for the planned freeway expansion.