



# Final Report

Prepared for:

**Colorado Department of Transportation**

Prepared by:

**Carter & Burgess, Inc.**

July 1997

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**Final Report**

**Southeast Corridor**

# Major Investment Study

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## Executive Summary

### Introduction

This report is the Final Report for the Southeast Corridor Major Investment Study. It summarizes information provided in three earlier reports:

- *Definition of Purpose and Need, April 1996.*
- *Definition and Screening of Conceptual Alternatives, April 30, 1996*
- *Development and Evaluation of Detailed Alternatives, April 1997.*

The study was initiated in April 1995. It was conducted for the Colorado Department of Transportation and had as its intent to:

- Examine overall corridor mobility needs, focusing on the peak demand problem;
- Identify and analyze all possible solutions, from a community impact, mobility impact and cost-benefit perspective;
- Closely involve the public and policy-makers in the process; and

- Recommend a multi-modal alternative that most closely responds to the mobility needs in the corridor, while preserving and enhancing community character. The solution must also be fiscally constrained in order to fit within the region's fiscally-constrained 2020 Plan.

The study was one of three which was conducted simultaneously in the Denver metropolitan area, initiated to define the preferred mode and design for three corridors designated in the Year 2015 Regional Transportation Plan for rapid transit. The recommendations from these studies will be incorporated into the Region's 2020 Fiscally-Constrained Plan.

The main factors that defined corridor purpose and need were the existing severe congestion throughout most of the corridor today, the high accident rate in the northern part of the corridor, the deficiencies in the existing transit service (including the inability to compete with highway travel) and the growing population and employment in the corridor.

## **Recommended Corridor Investment**

The corridor investment which is recommended for implementation in the Southeast Corridor has been endorsed by the Southeast Corridor Policy Committee and consists of a light rail element, highway improvements to address safety and operational problems, improved pedestrian facilities, and transportation management elements.

The light rail transit element consists of 19.7 miles of new double-tracked light rail transit, running along I-25 for 15.2 miles from Broadway to Lincoln Avenue and along I-225 for 4.5 miles to Parker Road. The light rail tracks will be placed adjacent to I-25 on the south and west sides and in the median of I-225. Ten stations are planned at major intersecting streets and at existing park-n-Rides. The bus system will be modified to provide feeder bus service to the stations and to provide frequent circulator service in the southern business park area.

Improvements which are recommended to the highway system include adding outside shoulders along I-25 and I-225 to improve congestion associated with accidents and to improve emergency vehicle response times. Eight interchanges will be improved, auxiliary lanes will be added and drainage will be upgraded. In addition, two viaducts need to be replaced (the Broadway/Santa Fe viaduct and the Evans Avenue viaduct), although the cost for these have not been included within the \$390 million corridor budget.

Transportation management type recommendations include:

- Five pedestrian crossings of I-25 and I-225;
- Intelligent Transportation System elements including continuation of the Mile High Courtesy Patrol, upgrading ramp metering equipment, providing real-time multi-modal transportation information, expanding traffic signal coordination on arterial streets and providing transit enhancements; and
- Transportation Demand Management elements, including supportive land use in the vicinity of stations, and continuation of the programs offered by the Downtown and Southeast Transportation Management Organizations.

This recommended corridor investment is estimated to have a total capital cost of \$510 million and an annual operating cost of \$21 million.

## Benefits of the Recommended Corridor Investment

The benefits of this recommendation are that it:

- Provides a clear travel time advantage (a difference of over 30 minutes) for transit users compared to single occupant auto travelers in the year 2020, from Lincoln Avenue to 16th and California during peak travel times:
  - 66 minutes on highway, compared to
  - 35 minutes on LRT;
- Substantially improves transit travel time in the corridor. Transit travel time in 1995 is 43 minutes from Lincoln Avenue to the downtown area. In the Year 2020 without a major investment, travel time on transit would be 66 minutes; with a major investment it will be 35 minutes.
- Slightly improves travel time on the freeway system. In the Year 2020 without a major investment, it would take 68 minutes to travel from Lincoln Avenue to the downtown area. With the major investment in place, this same trip will take 66 minutes.
- Provides almost as much peak hour, peak direction maximum potential capacity as five highway lanes:
  - Peak hour, peak direction capacity for LRT is 13,500 people;
  - Peak hour, peak direction capacity for one highway lane is 2,800 people;
- Has a capital cost that is significantly less than the other major investment options;
- Has a relatively low cost per vehicle miles traveled reduced and person hours of delay reduced;
- Provides a reliable and safe travel choice;
- Relieves travel on local streets;
- Has the potential to concentrate land use at stations;
- Removes 15,700 trips from highway lanes;
  - Work drive-alone trips to the downtown area will decrease from 50 percent to 44 percent
  - Work drive-alone trips to the Denver Technological Center (DTC) area will decrease from 84.4 percent to 82.9 percent
- Reduces congestion associated with incidents, through the provision of full width shoulders and ITS elements;
- Improves safety and operations at several key locations in the corridor including the I-25/I-225 interchange area and the "Narrows" area (between Broadway and Evans);
- Reduces vehicle miles traveled by 222,000 region-wide;
- Attracts almost 16,000 new riders;
- Increases peak hour transit usage;
  - Work transit trips to the downtown area increase from 32 percent to 42 percent
  - Work transit trips to the DTC will increase from 1.7 percent to 3.6 percent; and
- Has support from the elected officials in the cities and counties in the Southeast Corridor, from Denver University, from business groups, and from the majority of the members of the general public who were involved in the process. Letters of support are included in the Appendix.

# Chapter One: Major Investment Study Background

## 1.1 Relationship to Regional Planning Process

With the passage of the Intermodal Surface Transportation Efficiency Act (ISTEA) in 1991, and the Clean Air Act Amendments in 1990, long range transportation plans were required to be fiscally constrained. The Denver region's adopted *Year 2015 Interim Regional Transportation Plan* (RTP) responded to the ISTEA requirements by identifying the most needed projects that the region can afford over the next 20 years. Since the Denver region is a non-attainment area for carbon monoxide and PM<sub>10</sub>, the 2015 RTP also considered air quality in the identification of transportation projects for the region.

The *Year 2015 Interim RTP*, and the *1995-2000 Transportation Improvement Program* (TIP) identified three corridors to be the subject of a Major Investment Study.

The Southeast Corridor (as shown in Figure 1-1) was selected as a candidate for rapid transit, the mode and alignment to be determined by a "Major Transportation Investment Study," or MIS. The Southeast Corridor was identified as a transit corridor because:

1. Severe congestion will occur without capacity improvements;
2. It has the highest ridership potential outside of the North I-25 corridor;
3. Right-of-way is limited; and
4. Roadway improvements are more expensive than rapid transit costs.

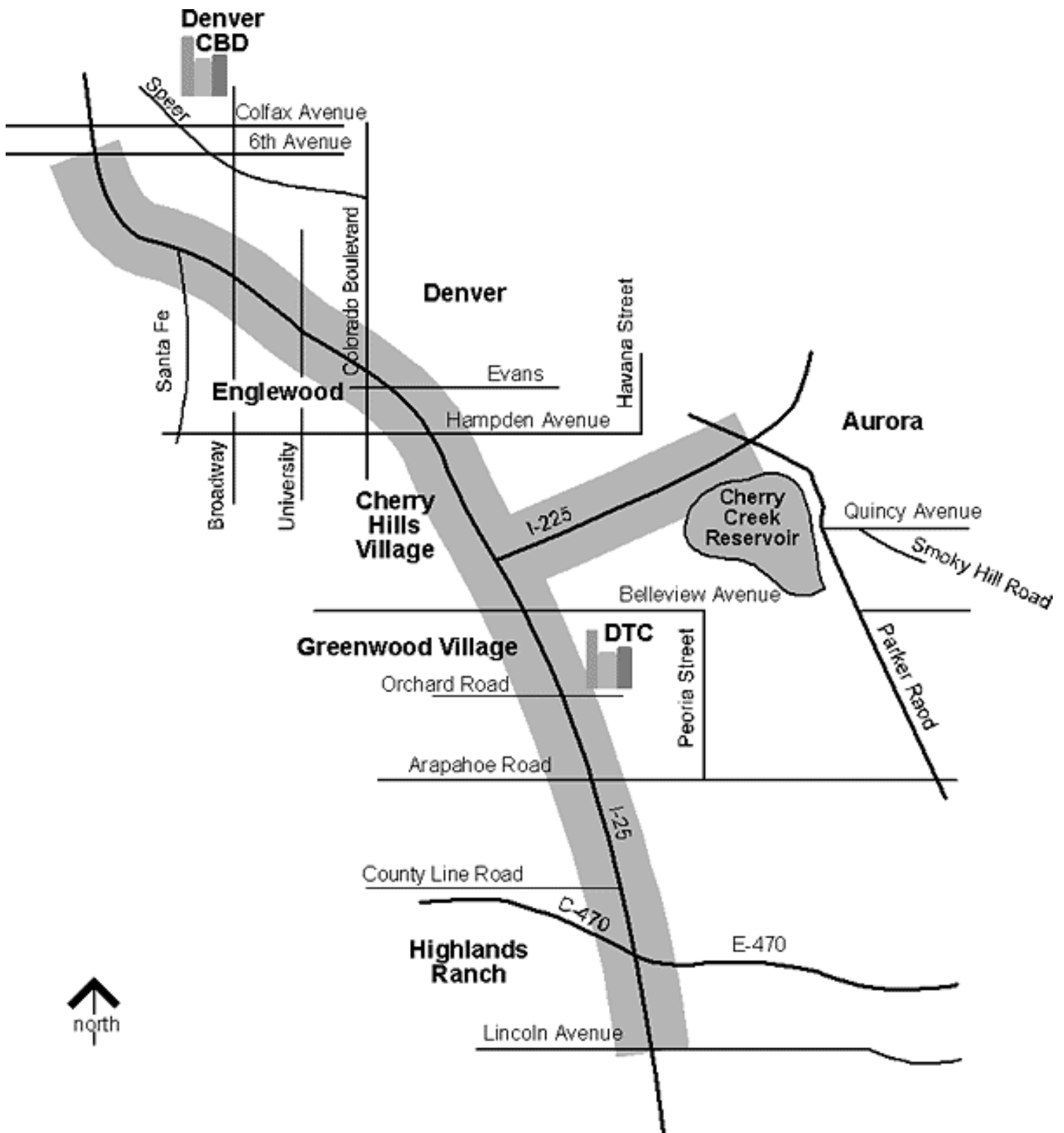
In addition, since the I-25 corridor was "at risk" for exceeding air quality standards in the future, this was a criterion for its designation as a rapid transit corridor.

ISTEA requires that Major Investment Studies (MISs) be conducted to give decision-makers the details of costs and benefits related to transportation investments in a corridor. MISs are essentially a subset of the more comprehensive metropolitan transportation system planning process, and are thus closely tied to the goals and policies identified in a RTP. An MIS identifies the type (mode) and limits of the transportation investment and results in the selection of a locally preferred alternative for a corridor. The preferred alternative is then incorporated into the RTP to allow programming of funds for the transportation investment.

## 1.2 Major Investment Study Process

The purpose of an MIS is to examine the transportation needs of a subarea or corridor, and to develop and analyze multimodal solutions to meet these needs. The MIS should generate information about the probable impacts and consequences of alternative transportation strategies

Figure 1-1



so that informed decisions can be made regarding transportation investments. The information regarding each alternative should be comprehensive and consider both quantitative and qualitative data on costs, benefits, and impacts so that the alternatives can be compared to one another. In addition, the financial element or "affordability" of the alternatives is crucial, considering the financial constraints of the overall RTP. The MIS process is unique in that multimodal solutions are developed and compared to one another. Previous study efforts have generally focused on one mode, such as highway or rapid transit; with no comprehensive determination of the total package of mobility improvements that may be needed in any given corridor.

Metropolitan planning regulations state that MISs shall include the following elements:

- a cooperative and collaborative process to establish the range of alternatives to be studied and factors to be addressed;
- an evaluation of the efficiency and cost effectiveness of alternative investments or strategies in attaining local, state, and national goals and objectives;
- consideration of the direct and indirect costs of alternatives and factors such as mobility improvements; social, economic, and environmental effects; safety; operating efficiencies; land use and economic development; financing, and energy consumption;
- a proactive public involvement process that provides opportunities for the public and various interest groups to participate; and
- documentation of the consideration given to alternatives and their impacts.

The Southeast Corridor MIS was conducted within the context of the National Environmental Policy Act (NEPA), in that alternatives were developed, evaluated and either discarded or carried forward for additional development in a manner which meets the intent of NEPA requirements. This MIS was conducted prior to the preparation of a formal environmental document, such as an Environmental Impact Statement or Environmental Assessment.

### **1.3 Coordinated Major Investment Study Approach**

The Southeast Corridor Major Investment Study was one of three MIS projects conducted simultaneously in the Denver region over a two-year period. In 1994, the region's major planning agencies -- the Denver Regional Council of Governments (DRCOG), the Regional Transportation District (RTD), and the Colorado Department of Transportation (CDOT) agreed to initiate three Major Investment Studies in three critical corridors in the Denver region:

- the East Corridor (along I-70 from Downtown to DIA);
- the West Corridor (along US 6/West Colfax from Downtown to Golden); and
- the Southeast Corridor (along I-25 from Downtown to Lincoln Avenue, including I-225 to Parker Road).

The three agencies agreed to conduct these Major Investment Studies simultaneously while sharing the management responsibilities of the three studies among the agencies. The determination of the level of analysis, forms of interagency coordination, and processes for public involvement for the Southeast Corridor MIS and the other two projects were developed based on a collaborative process including relevant federal agencies, local governmental bodies, and the three sponsoring agencies. To assist in that process, the three agencies and their consultants developed a "Guidance Manual" that established common criteria, methodologies, and procedures for conducting the technical analysis of the transportation alternatives developed in the three corridors. This common analysis process is aimed at giving regional decision makers consistent information as to benefits, costs, and impacts of the various transportation alternatives developed in the three corridors. Based upon that technical analysis, and after considering community comments, the region's decision makers will decide which corridor or which improvements will be implemented and in what time frame.

A \$390 million budget (in 1995 dollars) has been identified for a major transportation investment in the Southeast Corridor. The budget was derived from the approximately \$355 million in the 2015 RTP that was allocated for an MIS and other projects in the Southeast Corridor, inflated to 1995 dollars. The budget is for major capital expenditures and is considered above funds already programmed for maintenance, operations, and major rehabilitation or reconstruction of transportation facilities in the corridor.

## 1.4 Inter-Agency Involvement Process

The Southeast Corridor MIS was a collaborative process involving federal and state agencies, local governmental bodies, and the three sponsoring agencies. Throughout the study, several techniques were used to keep all interested parties involved and informed on its progress, including:

- development of a Committee of Technical Staff: This Committee was composed of federal, state, regional and local government staff who had an interest or stake in the project, in addition to other agency representatives as appropriate. Participants were given opportunities to review and comment on all technical issues developed for the study.
- individual and group meetings and briefings for staff members and officials from interested agencies, allowing in-depth discussions of specific issues of concern to those individuals. Neighborhood groups were also actively involved in this process, as described in Chapter Two. This process was extremely valuable during the course of the study, especially as alternatives went through more detailed development and analysis processes. Discussions resulted in the uncovering of specific and important political, economic, physical, environmental, and other issues that affected the design and operations of specific alternatives.

Agencies involved in this process were:

- City and County of Denver;
- City of Aurora;
- City of Greenwood Village;
- Arapahoe County;
- Douglas County;
- Denver Regional Council of Governments;
- Colorado Department of Transportation;
- Colorado Department of Health and the Environment;
- Colorado Division of Wildlife;
- Regional Transportation District;
- Regional Air Quality Council;
- Federal Highway Administration;
- Federal Transit Administration;
- Federal Aviation Administration;
- Environmental Protection Agency;
- Downtown Denver Partnership;
- Southeast Transportation Management Organization;
- Downtown Transportation Management Association;

- Denver Chamber of Commerce;
- Aurora Chamber of Commerce;
- Southeast Metro Chamber of Commerce; and
- Southeast Douglas County Economic Development Council.

## Chapter Two: Corridor Study Process

### 2.1 Overview of Tasks

Figure 2-1 illustrates the overall process used for the Southeast Corridor Major Investment Study. The basic steps in this process were:

- Development of initial alternatives.
- Pre-screening of the initial alternatives.
- Development of modal conceptual alternatives.
- Screening: Step One, to determine the best of the modal alternatives.
- Development of nine alignment and modal alternatives.
- Screening: Step Two, to determine the best modal and alignment combinations.
- Recommendation of four alternatives to be advanced to the detailed development and analysis stage.
- Development of the four alternatives in detail.
- Evaluation of the four alternatives, based on their relative natural resource, community, effectiveness and cost impacts.
- Refinement of the four alternatives and subsequent re-evaluation.
- Recommendation of one preferred alternative that has multi-modal elements.
- Final evaluation of the preferred alternative.

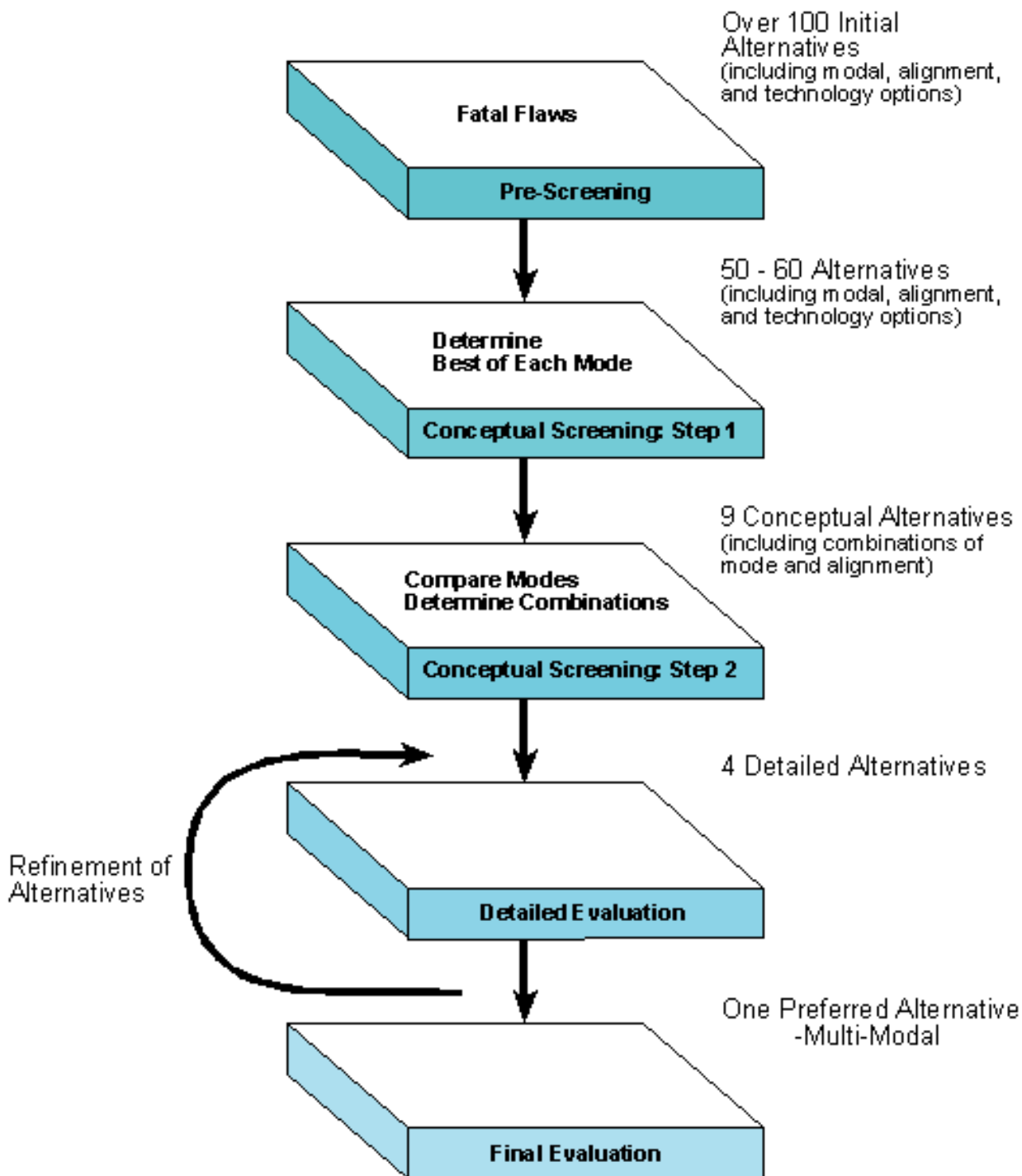
### 2.2 Public and Agency Involvement Program

An extensive public and agency involvement program was implemented to provide input to the overall process and to endorse the final recommendation.

Over 90 meetings were held with approximately 40 groups. Key elements of this program included:

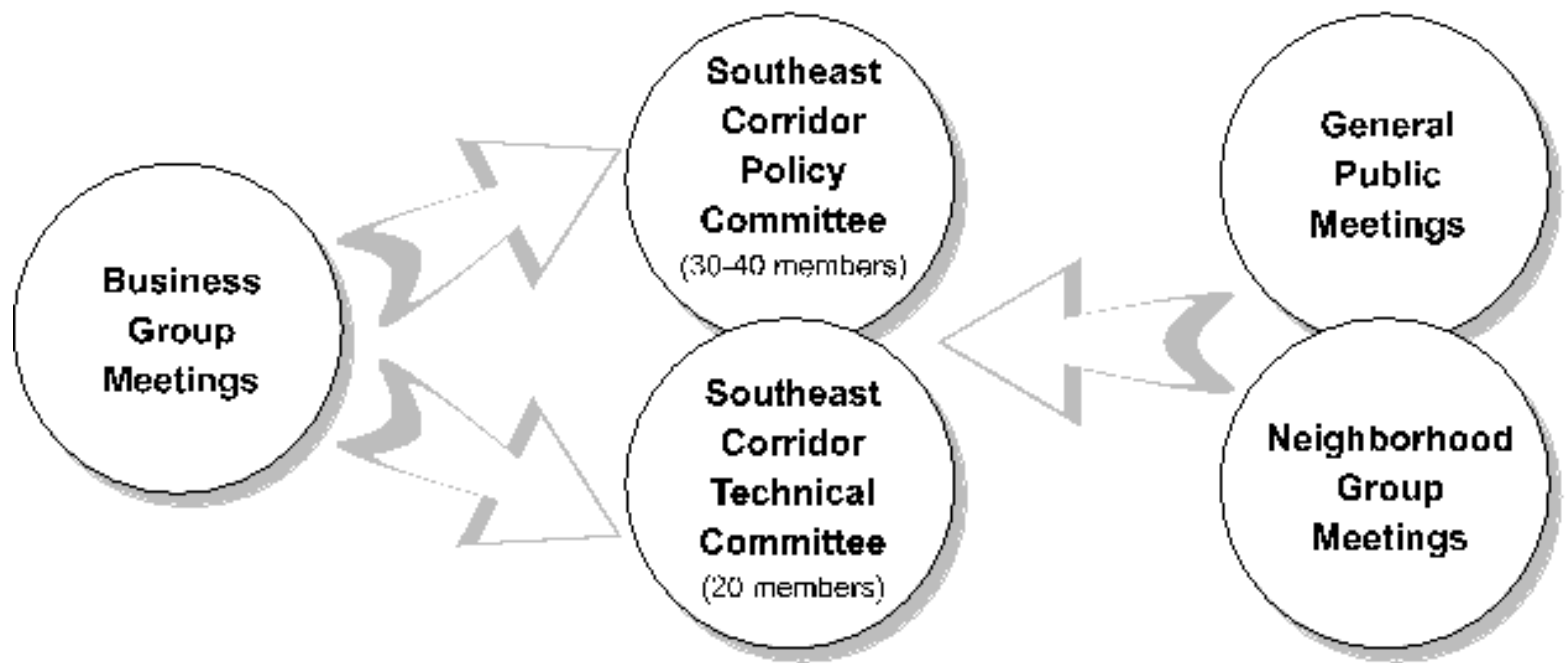
- Corridor committees, including a Technical Committee, Policy Committee, and South Business Focus Group.
- General public meetings.
- Neighborhood group meetings.

Figure 2-1



- Meetings with business groups.
- Newsletters.

Relationships of the various groups are shown below. The Policy Committee, which was made up of elected officials from Denver, Greenwood Village, Aurora, Arapahoe County, Douglas County, RTD Board, CDOT Transportation Commission and State Representatives, was the primary group which endorsed the technical recommendations.



## Chapter Three: Corridor Summary of Purpose and Need

Full documentation of Southeast Corridor Purpose and Need is included in the report entitled, *Definition of Purpose and Need*, dated April 1996. The following text summarizes information provided in the April 1996 document.

### 3.1 Corridor Overview

The Southeast Corridor has long been recognized as one of the region's highest priority travel corridors. The corridor follows I-25, the only north-south freeway in the region, and I-225, which provides access to I-70, the region's major east-west freeway. The Southeast Corridor connects the two largest employment centers in the region, the Denver central business district (CBD), with over 100,000 employees in 1995 and the South I-25 business area, with approximately 80,000 employees in 1995. With employment centers at both ends of the corridor, traffic congestion occurs in both directions during the morning and evening rush hours. Traffic volumes continue to rise faster than increases in population and employment, and the length of the peak rush hours has grown over the years. All of these factors combine to make the Southeast Corridor the highest volume, most congested corridor in the region.

In 1992, the metropolitan planning organization for the region, the Denver Regional Council of Governments (DRCOG), initiated the development of a congestion management system for the region. Congested corridors throughout the region were identified and analyzed to determine whether travel demand reduction and operational management strategies would be sufficient to alleviate congestion through the year 2015. In this study, the Southeast Corridor was projected to be 15 percent over capacity by the year 2015. The Southeast Corridor was identified as a corridor where management actions alone were not considered sufficient to alleviate the congestion, and capital improvements such as rapid transit, high occupancy vehicle (HOV) lanes or general purpose lanes should be considered.

The Colorado Department of Transportation (CDOT) and the Regional Transportation District (RTD) have studied the corridor and recommended capacity enhancements. Both the widening of I-25 and I-225, and the construction of a rapid transit line along these interstate facilities have historically been identified in the region's long range transportation plans. To address congestion in the short term, CDOT has implemented ramp metering and interchange improvements, and RTD has steadily added park-n-ride capacity and Express bus service to both the CBD and the DTC to meet the ridership demands. While these efforts have helped, the Southeast Corridor remains the most congested corridor in the region.

### 3.2 Traffic Volumes and Congestion

The south I-25 corridor is the metro area's most congested corridor with 1995 severe congestion measured by the Denver Regional Council of Governments (DRCOG) at three or more hours on a daily basis. The congestion is experienced in both directions. This congestion is projected to get much worse by the year 2020, resulting in travel times which are 30 to 50 percent longer than current travel times.

Congestion documented by DRCOG does not include congestion related to incidents. Accidents along I-25 and I-225 cause major delays. The frequency and severity of accidents increase during periods of recurring congestion.

There are also points of "spot congestion" along the corridor, such as at the Broadway viaduct area, at I-25/I-225 and in the Evans/Colorado area.

## 3.3 Transportation Services and Facilities

### 3.3.1 Freeway Facility Deficiencies

Figure 3-1 notes deficiencies along I-25 and I-225. Some of these include:

- Deteriorating pavement condition.
- Substandard shoulder widths along I-25 and I-225.
- Substandard horizontal curves, especially in the Santa Fe interchange area.
- Substandard weaving lengths, especially between Evans and Colorado and between I-225 and Bellevue.
- Bridge deficiencies, including inadequate weaves, substandard geometrics, and substandard vertical clearances for the interstate facility.
- Interchange deficiencies.

### 3.3.2 Transit System Deficiencies

Study area transit facilities are illustrated in Figure 3-2. Deficiencies or issues associated with these are listed below:

- Broadway/I-25 LRT Station and park-n-Ride: Since the opening of the LRT system with free parking south of the Denver CBD, the demand for parking at this location has exceeded the supply. People from the southern portion of the region are driving to the LRT station and riding the LRT line into the CBD. This issue has consistently been expressed during public meetings for the Southeast Corridor MIS.

Southmoor park-n-Ride: While the facility has good visibility from I-25, bus and auto access to this facility is a problem because there is no direct connection to the park-n-

Figure 3-1

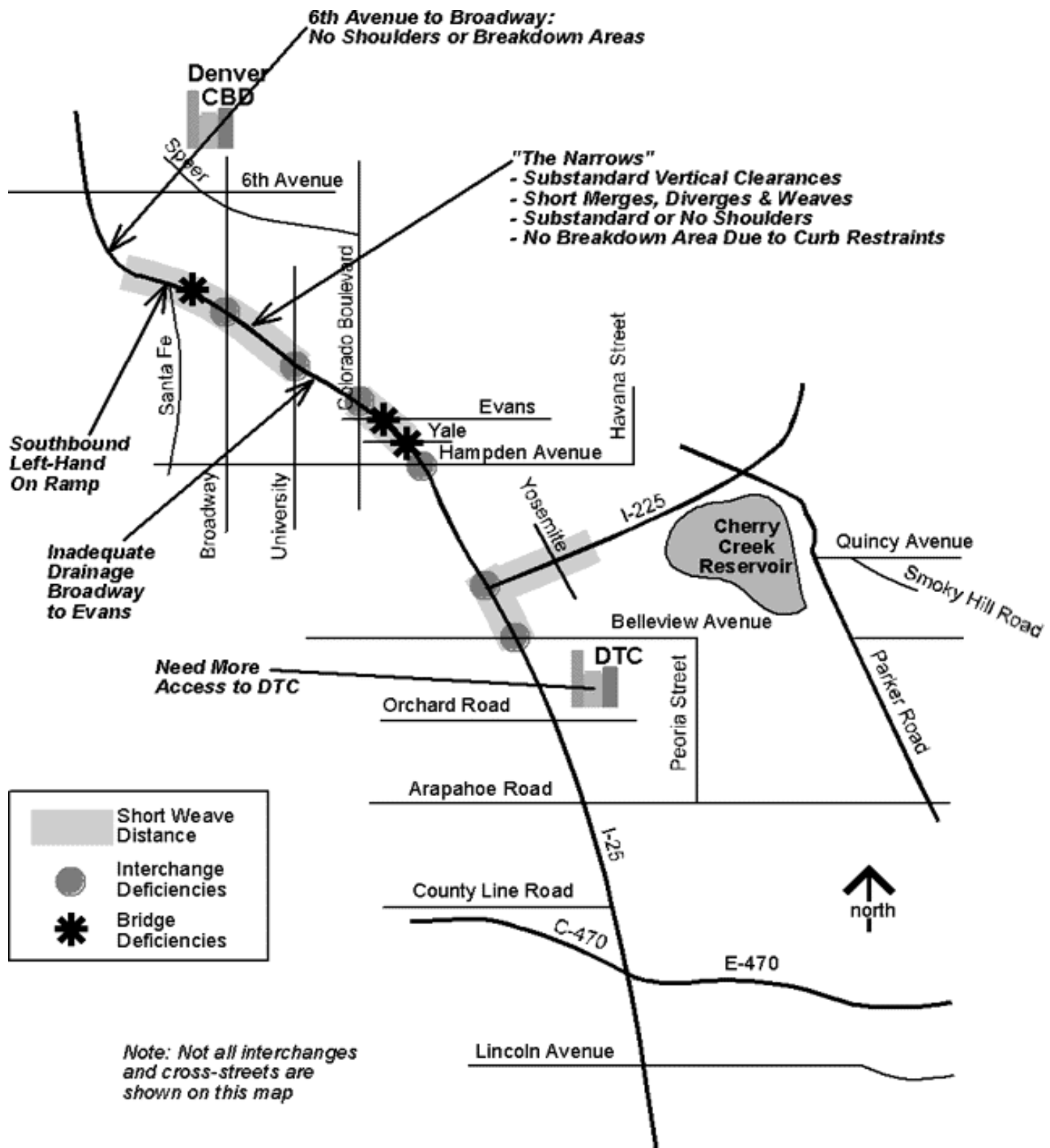
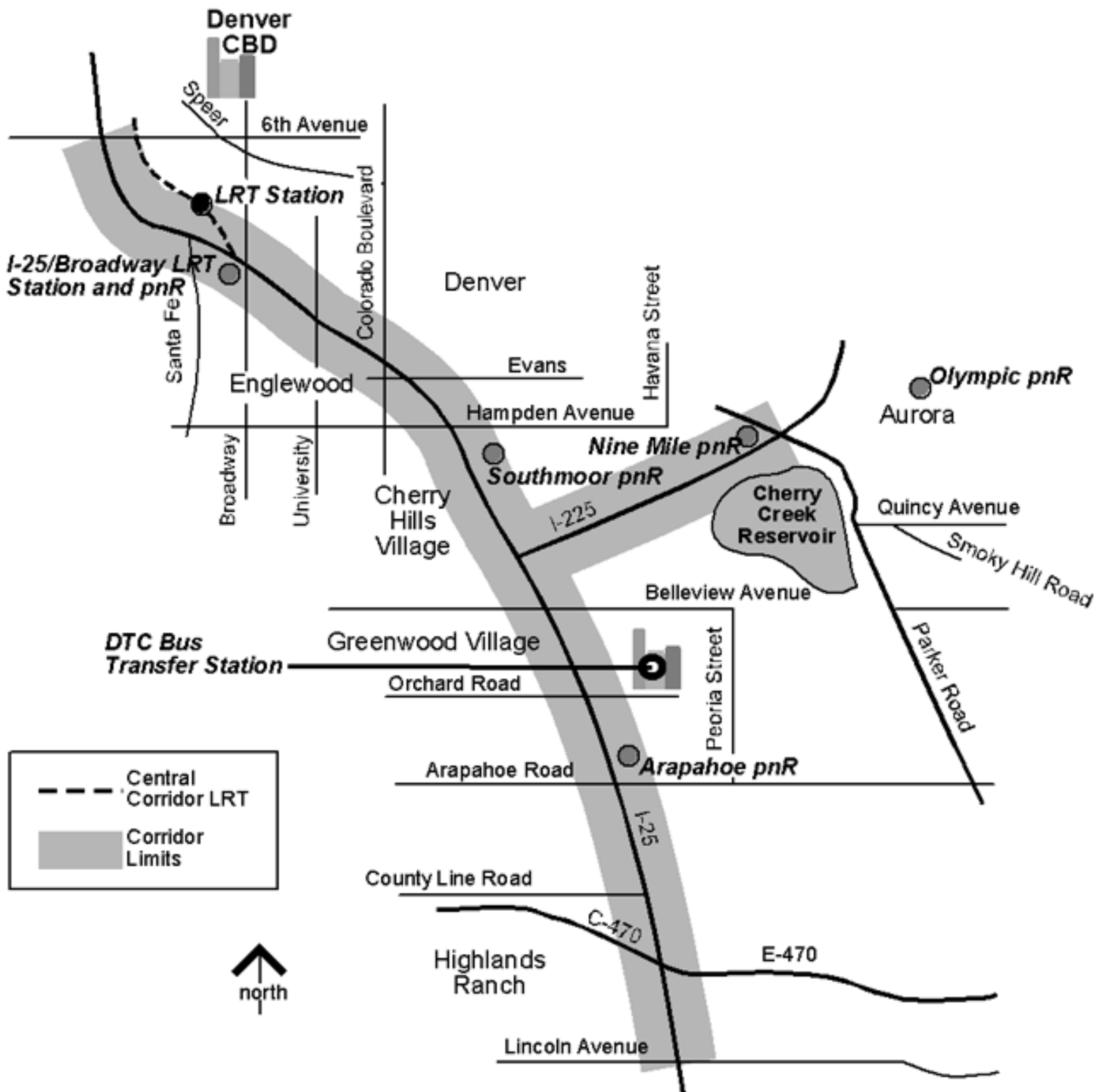


Figure 3-2



Ride from I-25. Local streets must be used to access the location. The facility's location also makes access from the west of I-25 difficult, limiting its draw area to the east side of I-25.

- DTC Bus Transfer Station: The size of this facility limits RTD's capability to significantly expand service to this location. In addition, the passenger amenities are limited and provide little shelter from the elements.
- Arapahoe park-n-Ride: Direct access for buses from the park-n-Ride to northbound I-25 is provided.

Improvements to the southbound access from I-25 are needed to improve bus travel times to the facility.

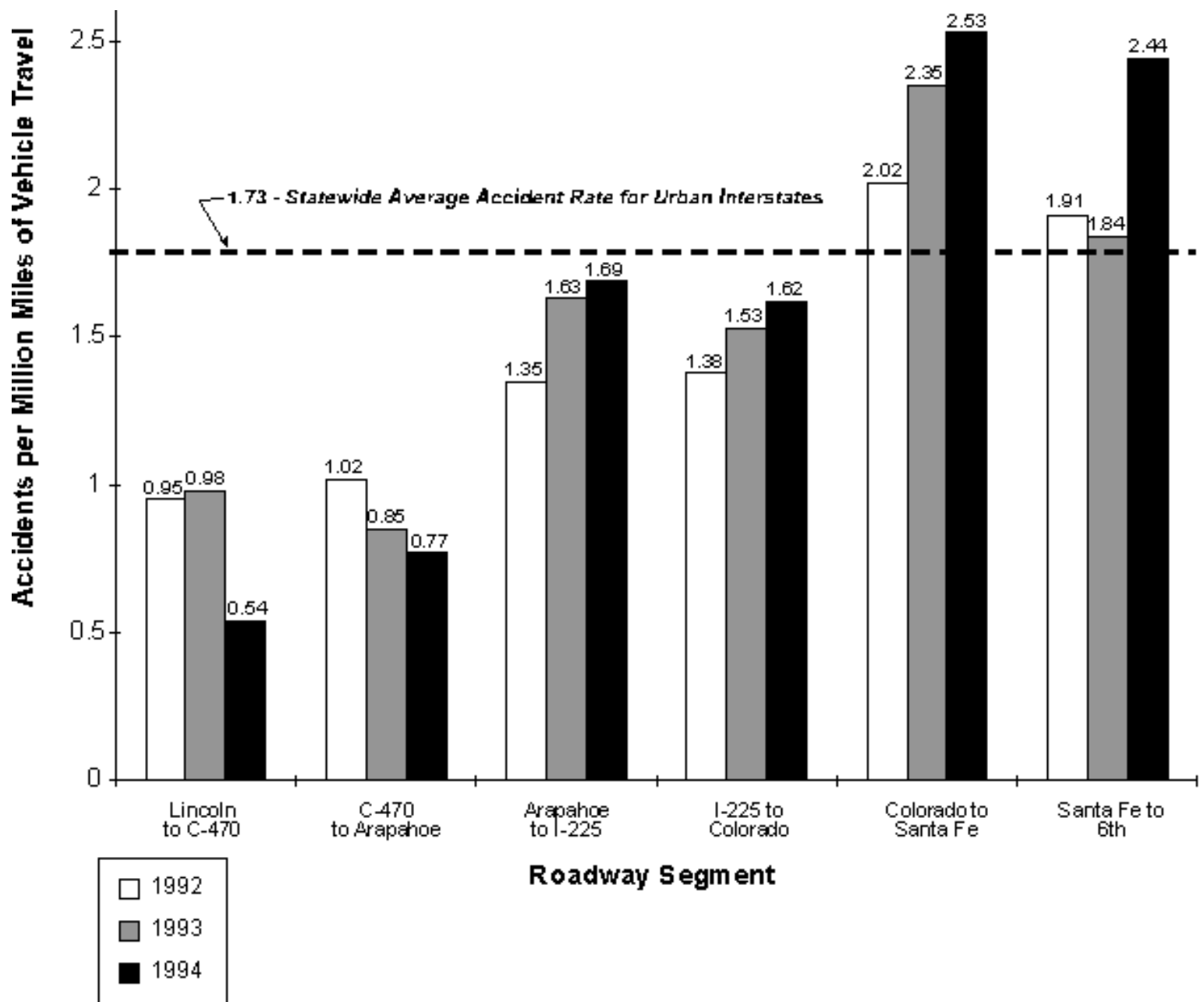
- Lack of park-n-Ride capacity to the south: There are no park-n-Ride facilities south of the Arapahoe park-n-Ride. Most of the residential growth in the general southeast area is taking place to the south of Arapahoe Road. Additional park-n-Ride facilities are needed to intercept motorists and provide transit service to both the DTC and the Denver CBD.
- Nine Mile park-in-Ride: This park-n-Ride is located at one of the most congested interchanges in the region. Access to the park-n-Ride for buses, automobiles and pedestrians is difficult. Planned interchange improvements will address some of these access issues, however, congestion will remain a major factor in the operation of the park-n-Ride. In addition, the planned interchange improvements may include an expansion of the Nine Mile park-n-Ride. The current average monthly utilization for this park-n-Ride is between 65 and 70 percent.

Another major deficiency that affects the competitiveness of transit when compared to general highway usage is the travel time for buses. Buses are affected by severe congestion which currently occurs not only on I-25 but also on the side streets such as Broadway. Throughout the public involvement program, a desire was expressed to provide a true choice for commuters to use transit.

### 3.3.3 Accident History

Throughout the northern part of the corridor, north of Arapahoe Road, accident rates have been increasing and are above the statewide average north of Colorado Boulevard. This trend is illustrated on Figure 3-3. The type of accidents which occur are indicative of increasing congestion.

Figure 3-3



### 3.4 Land Use

Population and employment in the Southeast Corridor area has been increasing steadily since 1970. Regional population growth has occurred more rapidly in the south and southeastern portions of the region. It is expected this will continue (*Year 2015 Interim RTP*).

This study area serves three areas of substantial and growing employment:

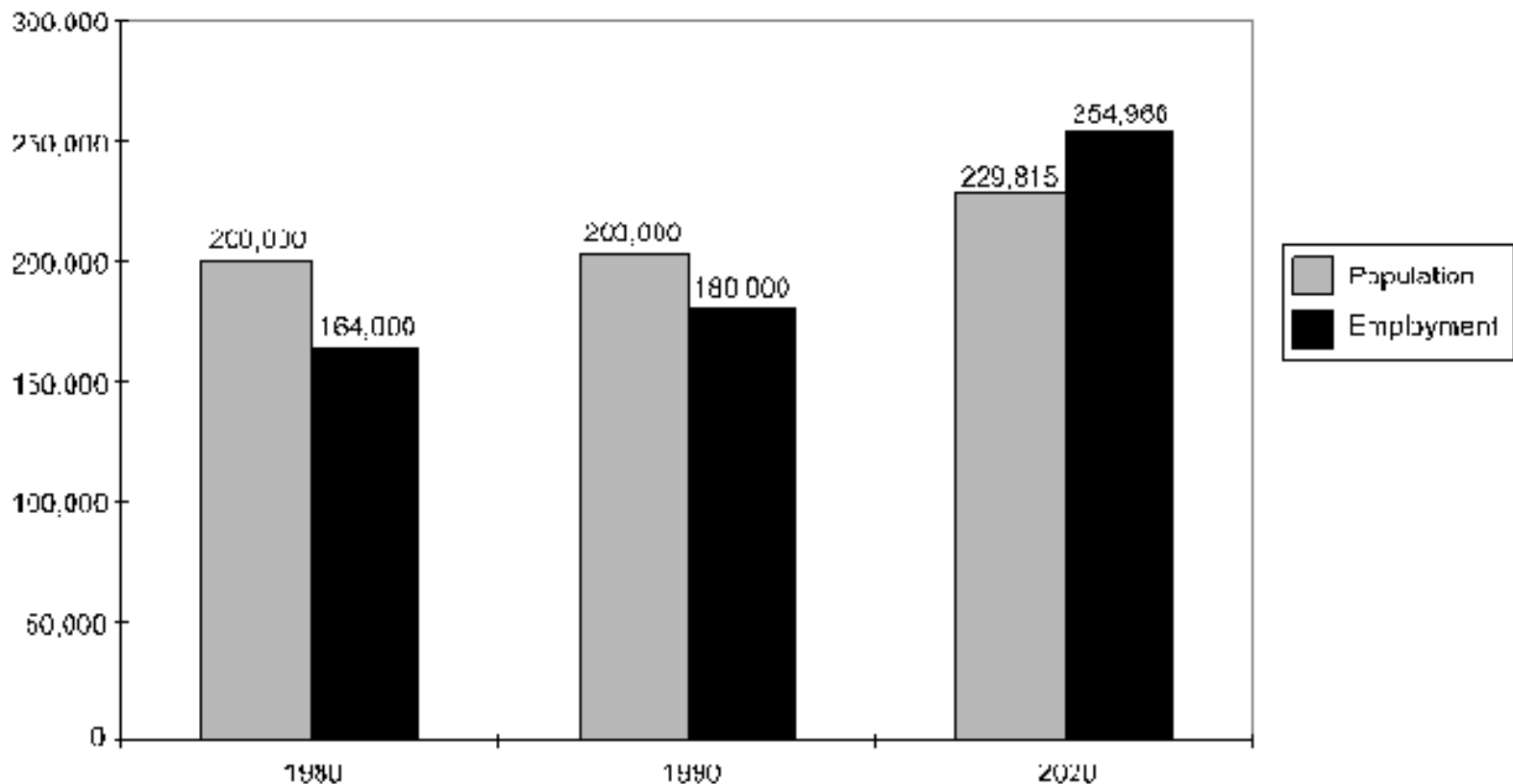
- Downtown Denver, which had a 1995 estimated employment of 101,518. Its year 2020 employment is projected to be 150,840.
- Colorado Boulevard employment center, which had a 1995 employment of 26,230. Its year 2020 employment is projected to be 31,820.
- South I-25 business area, including the Denver Technological Center, Meridian, Inverness and Greenwood Plaza, which had a 1995 employment of 78,483. Its year 2020 employment is projected to be

103,409.

The large suburban employment growth in the southeast area will result in continued dispersion of travel from suburban residential areas to these three employment concentrations. In addition to this dispersion of travel, according to representatives of the Southeast TMO, the growth will likely generate demand for a lower income labor pool which largely resides in the central area. This lower income labor pool is transit dependent and will increase the demand for frequent, reliable transit service to the southeast employment concentrations.

Based on DRCOG household and employment estimates, the Southeast Corridor accounted for 15 percent of the region's employment in 1995 and the same -- 15 percent -- in 2020. Although employment in the Southeast Corridor is projected to maintain its existing share of the region's employment, the amount of households does not. In 1995, 10 percent of the region's households were in the Southeast Corridor, whereas in 2020, the amount of households decreases to 8 percent of the region's total.

**Southeast Corridor Study Area Population and Employment**



Between 1995 and 2020, it is projected that in the Southeast Corridor, the number of households will increase by 19,848, which is 22 percent. For the same time period (1995 to 2020) employment increases by 61,015, or 31 percent, representing an annual average growth rate of 1.2 percent over the 25-year period.

Analysis of pending development in the corridor shows substantial employment growth occurring along Arapahoe Road and Colorado Boulevard.

In addition, housing is currently planned or under construction within or immediately adjacent to the southeast commercial areas.

## 3.5 Public Opinion/Support for Transit

There have been four public opinion polls conducted to determine public support for a transit investment. These polls, conducted by DRCOG, RTD, the South Metro Chamber of Commerce, and the Rocky Mountain News, all identified light rail as a preferred transportation mode, with service to the Denver Technological Center identified as a priority.

This general support for light rail transit in the Southeast Corridor was expressed in the general public, neighborhood group, and business group meetings held during the course of the Southeast Corridor Major Investment Study process.

## Chapter Four: Transportation Alternatives Evaluation Process

### 4.1 Overview of Evaluation Process

The evaluation process that was conducted included development of an initial list of modal and alignment alternatives; pre-screening of those to eliminate any that were clearly unsuitable for application in the Southeast Corridor; development of nine alignment and modal alternatives; evaluation of these to select the best modal and alignment alternatives; development of these four alternatives in detail; detailed evaluation of the four alternatives; and finally, selection of one preferred alternative, with multi-modal elements.

### 4.2 Pre-Screening of Mode and Alignment Options

The intent of this step in the evaluation process was to "pre-screen" modal alternatives to determine if any were clearly unsuitable for application in the Southeast Corridor.

Table 4-1 summarizes this step.

**Table 4-1**

#### Pre-Screening Summary

Alternative	Consistent with Regional Goals?	Capital Cost?	Affordable?	Irresolvable Impacts or Significant Opposition?	Proven Application?	Advanced?
<b>No-Build</b>	No	\$5M to \$10M per mile	Yes	No	Yes	Yes
<b>Transportation Management</b>	No	\$10M to \$15M per mile	Yes	No	Yes	Yes
<b>Light Rail Transit</b>	Yes	\$20M to \$30M per mile	Yes	No	Yes	Yes
<b>Bus/HOV</b>	Yes	\$20M to \$30M per mile	Yes	No	Yes	Yes
<b>Automated Guideway Transit</b>	Yes	\$70M to \$100M	No	No	Yes	No
<b>Personal Rapid Transit</b>	Yes	\$50M to \$100M	No	Unknown	No	No
<b>Guided Bus</b>	Yes	\$20M to \$30M per mile	Yes	No	Yes	Yes
<b>Bike Tube</b>	No, it is not rapid transit	Unknown	Unknown	No	No	No

Table 4-1

(continued)

Alternative	Consistent with Regional Goals?	Capital Cost?	Affordable?	Irresolvable Impacts or Significant Opposition?	Proven Application?	Advanced?
<b>General Highway</b>	Yes, although highway widening along I-25 (adding additional general purpose lanes) is not consistent with the region's transportation goals for the Southeast Corridor. In addition, it specifically violates one of the goals which is to "not provide significant additional competing single occupant vehicle capacity in corridors where a rapid transit investment is committed."	\$15M to \$25M per mile	Yes	No	Yes	Yes
<b>Alternative Corridor</b>	Unknown	Unknown	Yes	Potentially significant opposition	Yes	Yes

### 4.3 Conceptual Alternatives Definition and Screening

Full documentation of Southeast Corridor Conceptual Alternatives development is included in the report entitled, *Definition and Screening of Conceptual Alternatives*, dated April 30, 1996.

The range of modal and alignment alternatives which were examined in the conceptual alternatives development process were:

- ü No-Build Alternative
- ü Low Cost or Transportation Management Alternative
- ü Light Rail Transit along Buchtel Corridor
- ü Light Rail Transit along the Freeway (East Side)
- ü Light Rail Transit along the Freeway (West Side)
- ü Bus/High Occupancy Vehicle (HOV) Facilities
- ü General Highway Improvements
- ü Double-decking south I-25
- ü Fully Grade Separated (Elevated or Depressed) Light Rail Transit
- ü Improvements along the Parker/Leetsdale Corridor
- ü Guided Bus Facility

Evaluation criteria (such as affordability or proven operations) were applied to these alternatives and nine

conceptual alternatives were defined to be examined further. Figures 4-1 and 4-2 illustrate the primary findings of the conceptual alternatives screening process. The recommendation from the examination of the nine conceptual alternatives is that the following four alternatives should be developed for detailed evaluation:

1. **Alternative 1: No Capacity Increase** (assumes historically programmed improvements and maintenance-type activities to maintain the existing transportation system without any operational or capacity improvements). This alternative also includes basic improvements to I-25 and I-225 to rebuild these highways to current standards. The No-Build alternative is required to be developed and analyzed as a part of the National Environmental Policy Act process.
2. **Alternative 2: Transportation Management** (low cost enhancements to roadway and transit operations).
3. **Alternative 3 (Light Rail Transit)**. From Broadway to the respective ends-of-line along I-25 and I-225, LRT will be either adjacent to or in the median of the freeway or will be located along the Buchtel right-of-way from Broadway to University.
4. **Alternative 4 (Bus/HOV Lanes)**. This facility will be bi-directional, either buffer or barrier separated. The possibility of joint use of this facility as a toll facility for single occupant vehicles will continue to be explored. This joint use of the Bus/HOV Lane facility is termed "fare lane."

The primary alternatives which were eliminated during the conceptual screening process were:

- Highway widening, because of its capital cost and impacts, due primarily to the built-up nature of this corridor.
- Elevated or depressed transit, because of its substantially greater capital cost.
- Improvements along the Parker/Leetsdale corridor, because these would not address the needs of travelers in the I-25 corridor. Improvements are needed along both corridors.

## 4.4 Development and Evaluation of Detailed Alternatives

Full documentation of the Southeast Corridor Detailed Alternatives development is included in the report entitled, *Development and Evaluation of Detailed Alternatives*, April 1997.

figure 4-1

	<b>1</b>	<b>2</b>	<b>3.1</b>	<b>3.2</b>	<b>4.1</b>	<b>4.2</b>	<b>4.4</b>	<b>5.2</b>	<b>5.3(c)</b>
	<b>No-Build</b>	<b>Enhanced TSM</b>	<b>LRT along freeway</b>	<b>LRT: Buchtel</b>	<b>Continuous Access Bus &amp; HOV</b>	<b>Barrier Separated Bus &amp; HOV</b>	<b>Fare Lane</b>	<b>Highway Minimum Standards</b>	<b>Highway Capacity Increase</b>
<b>1. Consistency with Regional Goals and Policies</b>	Not consistent with Regional Plan	Somewhat consistent with Regional Plan	Consistent with Regional Plan	Consistent with Regional Plan	Consistent with Regional Plan	Consistent with Regional Plan	Consistent with Regional Plan	Somewhat consistent with Regional Plan	Not consistent with Regional Plan in this corridor
<b>2. Capital Cost (\$M)</b>	120-150	200-300	400-600	400-600	240-325	275-400	300-425	200-500	600-1,000
<b>3. Affordability (corridor limit: \$355M)</b>	Less than corridor limit	Less than corridor limit	More than corridor limit	More than corridor limit	Less than corridor limit	Slightly more than corridor limit	Slightly more than corridor limit but revenue producing potential	Varies	More than corridor limit
<b>4. Utilization (Ridership)</b>	No additional capacity	Some additional capacity	Approximately 10-15,000 riders/day	Approximately 10-15,000 riders/day	Approximately 10-15,000 riders/day	Approximately 10-15,000 riders/day	Approx. 10,000-15,000 riders/day & additional SOV capacity	No additional capacity	Some additional capacity
<b>5. Travel Time (peak period, includes access time)</b>	Severe degradation	Minimal improvement (transit, ped/bike demand mgmt)	Most improvement	Most improvement	Most improvement	Most improvement	Most improvement	Minimal improvement	Some improvement
<b>6a. Environmental Impact noise &amp; traffic</b>	Traffic diversion in neighborhoods due to congestion	Least impact	Noise impacts due to expanded ROW	Noise & traffic impacts in Buchtel area	Minimal impacts	Noise impacts due to expanded ROW	Noise impacts due to expanded ROW	Least impact	Noise increase due to expanded ROW
<b>6b. Environmental Impact wetlands &amp; parks</b>	Least impact	Some impact	Moderate impact at Southmoor & Cherry Creek	Moderate impact at Southmoor & Cherry Creek	Some impact	Moderate impact at Southmoor & Cherry Creek	Moderate impact at Southmoor & Cherry Creek	Some impact	Wetland and park impacts
<b>7. Relocations (takings)</b>	None	None	More	Some	Some	More (access ramps)	Most (toll booths)	Some	Most
<b>8. Community Impacts (residential proximity, safety, and visual)</b>	Least impact	Least impact	Impacts at stations & residential areas along freeway	Residential proximity, safety & visual concerns in Buchtel area	Some impacts due to residential proximity	More impacts: access ramps	More impacts: access ramps & toll booths	Least impact	Much impact

figure 4-2

	1	2	3.1	3.2	4.1	4.2	4.4	5.2	5.3(c)
	No-Build	Enhanced TSM	LRT (in median south of I-225, in median along I-225)	LRT Buchtel (adjacent to I-225 south of I-225; along side of I-225)	Continuous Access Bus & HOV (south of Broadway; HOV north)	Barrier Separated Bus & HOV (south of Broadway; HOV north)	Fare Lane	Highway Minimum Standards	Highway Capacity Increase
1. Consistency with Regional Goals and Policies									
2. Capital Cost									
3. Affordability (capital cost vs. corridor funding limit)									
4. Utilization/ Air Quality									
5. Travel Time (peak period, includes access time)									
6a. Environmental Impact noise & traffic									
6b. Environmental Impact wetlands & parks									
7. Relocations (takings)									
8. Community Impacts (residential proximity, safety, and visual)									
Advanced?	Yes	Yes	Yes for portions of corridor	Yes for portions of corridor	Yes	Yes	Yes	Yes to be combined with other alternatives	No



#### 4.4.1 Description of Detailed Alternatives

The four alternatives that were developed and evaluated in detail were:

- No Capacity Increase Alternative
- Transportation Management Alternative
- Bus/High Occupancy Vehicle (HOV) Lane Alternative
- Light Rail Transit Alternative

##### 4.4.1.1 No Capacity Increase Alternative

The No Capacity Increase Alternative was developed to provide a baseline condition for analysis purposes. This alternative is used to compare the effectiveness of the major investment alternatives with a 2020 year situation with a major transportation investment.

This alternative includes two basic components:

- Package A - No-Build, which includes all programmed projects (or those that have funding already in place) and projects on the Year 2015 Regional Transportation Plan. These projects have no capital cost implications on corridor budgets.
- Package B - Rebuild, which includes reconstruction of existing transportation facilities (I-25 and I-225) to current design standards.

#### 4.4.1.2 Transportation Management Alternative

The goal of this alternative was to implement management-type and less capital intensive-type strategies to minimize the need for a major transportation investment. Each strategy was chosen with the intent to maximize the effectiveness of the existing transportation facilities and service.

Specific elements included:

- Bus transit improvements, including improvements to three existing park-n-Rides and three new park-n-Rides, substantially enhanced bus service, and additional amenities at park-n-Rides and bus stops.
- Pedestrian and bicycle facilities, including enhancing access to all park-n-Rides and providing pedestrian overpass or underpass facilities.
- Highway facility improvements, including reconstruction of five interchanges, arterial street improvements, construction of Bus/HOV bypass lanes on selected ramps, "spot" auxiliary lane construction on I-25 and painting and lighting under certain bridges along I-25.
- Intelligent Transportation System elements, including upgrading ramp metering equipment, providing some additional ramp metering lanes, implementation of real-time, multi-modal transportation information, expand traffic signal coordination, enhance the incident response program, and provide transit enhancements.
- Demand Management elements, including expansion of the programs currently provided by the Downtown and Southeast Transportation Management Organizations (TMOs), forming a new TMO which will cover the Cherry Creek/South Colorado Boulevard area, and construction of fringe or intercept parking lots in the south business park area.
- Land Use elements, including policies to promote transit supportive redevelopment at appropriate park-n-Rides; policies to promote improved transit-oriented design; and policies to promote joint development, joint use or shared parking.

#### 4.4.1.3 Bus/HOV Lane Alternative

This alternative assumes construction of two new lanes on I-25 and I-225 to be designated for bus, vanpool or carpool use only. This facility would be bi-directional and placed in the median.

#### 4.4.1.3.1 Bus/HOV Alternatives Considered But Not Advanced

Three Bus/HOV alternatives were considered during the development of alternatives, but were not advanced. These are:

- Bus/HOV Lanes along the outside of the freeway lanes, rather than in the median.
- Continuous Access Lanes.
- Bus/HOV Lanes Built to Reduced Standards.

The following text describes these alternatives and the reasons why they were not advanced.

##### Outside Bus/HOV Lanes

An alternative was considered to provide Bus/HOV Lanes along the outside edges of the freeway lanes, rather than in the median.

Due to the close interchange spacing (one mile or less) and high traffic volumes throughout the I-25 and I-225 corridor, weaving to and from an "outside lane - Bus/HOV" facility would substantially impact:

- Exit and entrance operations.
- Through traffic along the highway impacted by short, concentrated weave sections.
- Arterials crossing the highway.
- Bus/HOV travel times and access.

For these reasons, this alternative was not developed further.

##### Continuous Access Bus/HOV Lanes

Continuous access Bus/HOV Lanes are in place along US 36 and Santa Fe Drive in Denver. This alternative was initially explored for the south I-25 corridor. It was not advanced for the following reasons:

- Congestion on I-25 is so severe that the addition of carpools and buses entering I-25 and then needing to weave across general purpose lanes to the Bus/HOV facility would result in accident potential and increased severity of congestion on the general purpose lanes.
- Vehicles needing to leave the HOV facility will encounter severe congestion and traffic traveling at much slower speeds, such that the service and safety on the HOV facility will be compromised.
- The time and distance required for vehicles to weave across the general purpose lanes will effectively eliminate any travel time advantage provided by the Bus/HOV facility.

##### Reduced Standards

The primary reason the Bus/HOV Lane Alternative has more physical impacts than the Light Rail Alternative is because of the wider cross-section needed for the travel lanes and shoulders. For this reason, the possibility of reducing the width of the shoulder was examined.

The primary advantages of having a full width shoulder are:

- Snow storage
- Breakdown lane for buses and car pool vehicles
- Emergency vehicle access
- Provision for sign and bridge pier foundations
- Enforcement area
- Improvement in level-of-service

The primary disadvantage is additional physical impact and cost. A reduced width shoulder will save approximately six percent in overall construction cost.

Primarily for the advantages listed, the full-width shoulder was retained for overall corridor application. There may be some spot locations where a slightly reduced width could be considered.

#### 4.4.1.3.2 Alternatives Advanced

Three sub-alternatives were developed:

- A buffer-separated facility with access allowed only at certain locations.
- A barrier-separated facility with access allowed only at certain locations.
- A fare lane facility, which is a revised operation of either the buffer-separated or the barrier-separated facility to allow for single-occupant vehicle use of the facility if a toll is paid.

Figures 4-3 and 4-4 illustrate this alternative and the following text describes the major elements included in the Bus/HOV lane alternative.

##### Highway:

- Each of the three sub-alternatives requires complete removal and reconstruction of I-25 and I-225, so reconstruction of I-25 and I-225 to current design standards is assumed.
- Each alternative requires closure of ramps at Washington and Emerson and conversion of Buchtel in this location to a frontage road.
- Each alternative requires full reconstruction of the I-25/I-225 interchange.
- Each alternative also assumes construction of spot auxiliary lanes on I-25 south of I-225.
- Each alternative assumes construction of a collector/distributor road system between Colorado and Evans and between Dayton and Yosemite along I-225.

##### Ends-of-Line:

- Buses will terminate at the Broadway station, or will continue into downtown on Lincoln.
- Carpools/vanpools only could continue north on I-25.

figure 4-3

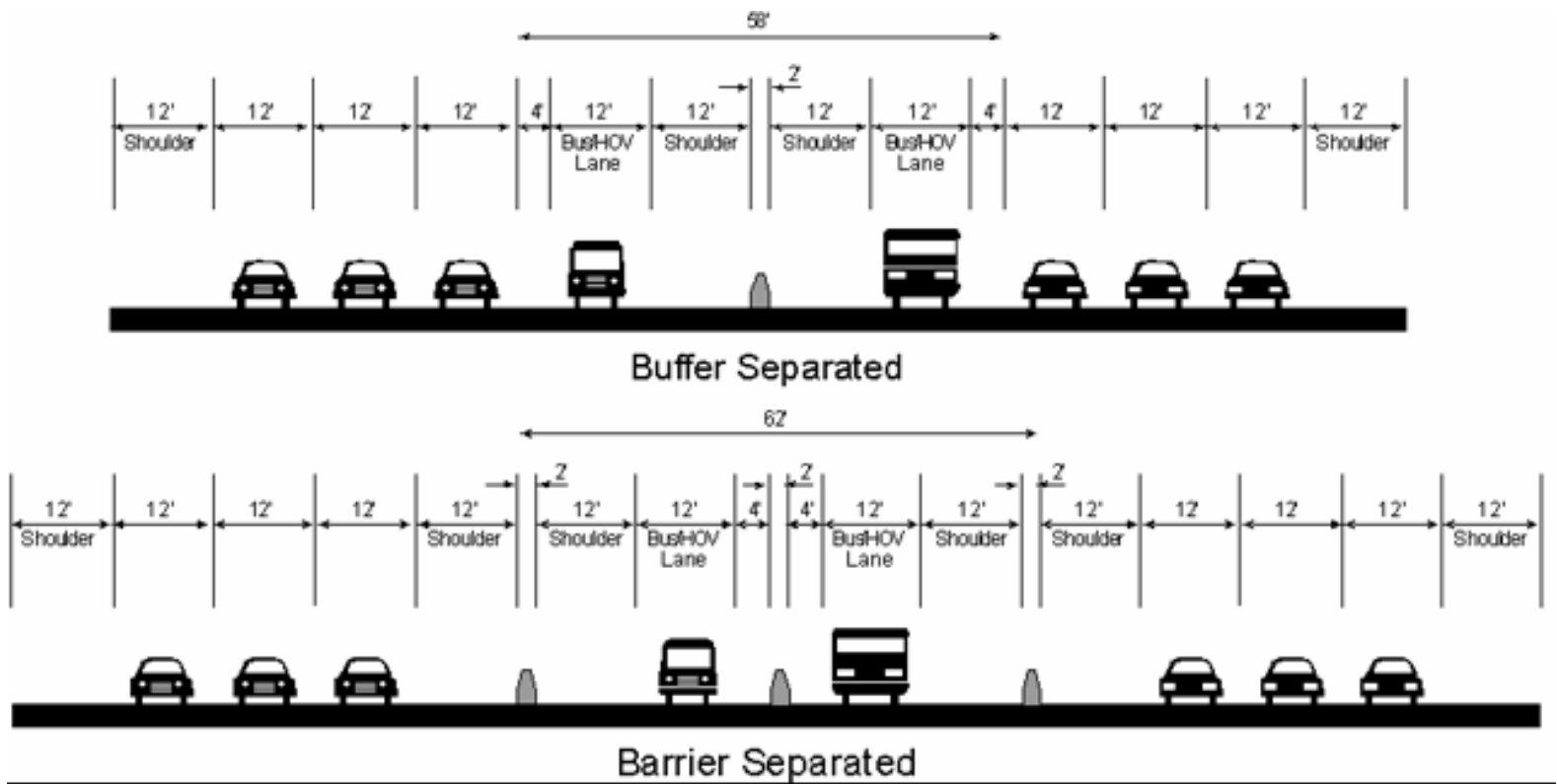
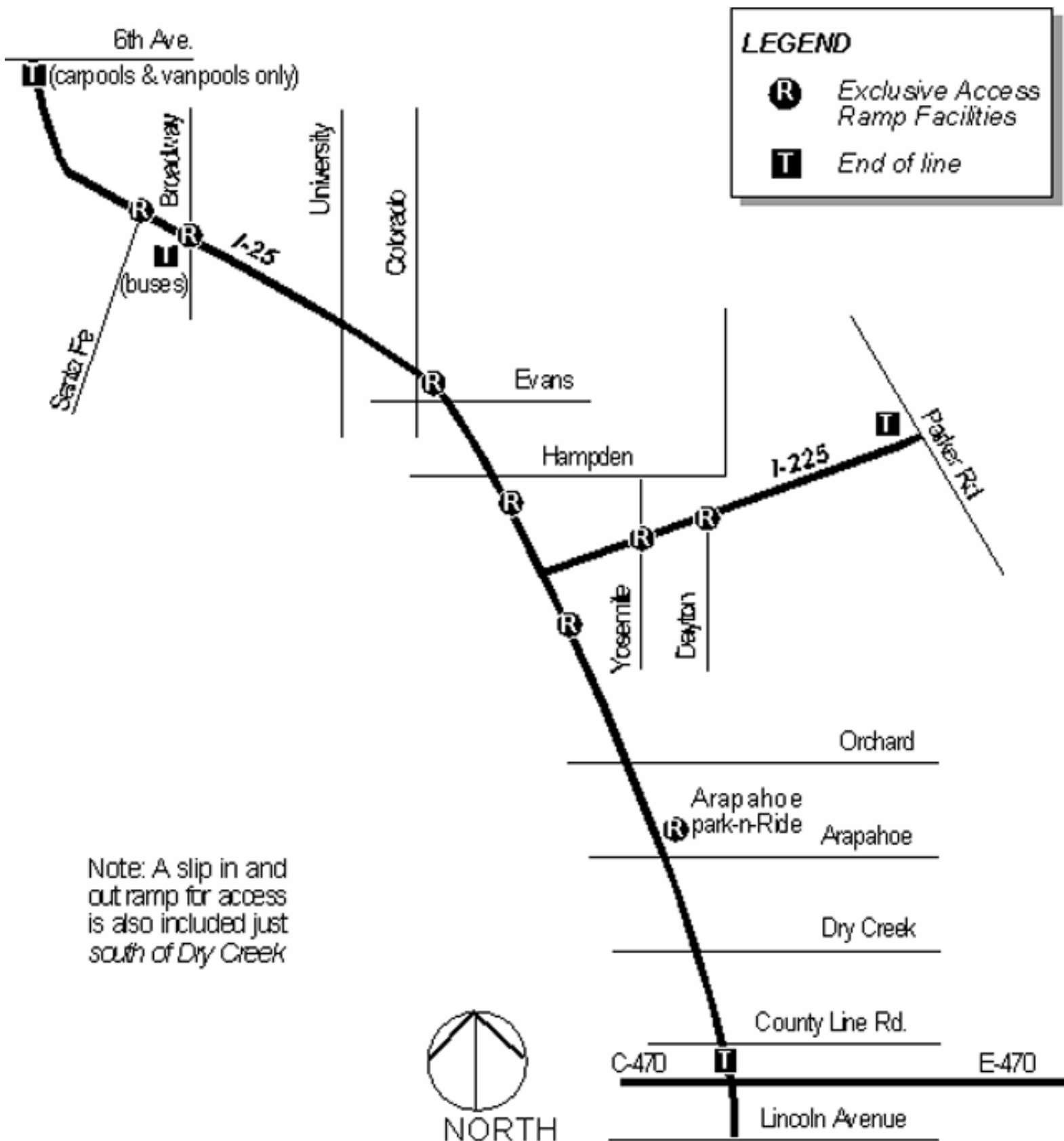


figure 4-4



- The Bus/HOV facility begins just north of C-470 (just south of County Line) and on I-225 just west of Parker Road.

Direct Connections (construct direct access ramps) for all sub-alternatives at:

- Santa Fe (to Santa Fe HOV lanes)
- Broadway
- Colorado/Evans
- Southmoor park-n-Ride
- Union Overpass
- Arapahoe park-n-Ride or Yosemite
- Yosemite/I-225
- Dayton/I-225 (future)

Note: Between the end of line (south of County Line Road) and the Dry Creek slip ramp, the facility for each of the three sub-alternatives would be continuous access.

Park-n-Rides/Stations:

**Table 4-2**

**Bus/HOV Stations**

Station	Buses	Carpools	Park-n-Ride	Kiss-n-Ride	Walk
6th Ave Slip Ramp		X	N	N	N
Santa Fe		X	N	N	N
Broadway	X	X	X	X	X
Colorado/Evans	X	X	X	X	X
Southmoor	X	X	X	X	X
Union Overpass	X	X	N	X	X
Arapahoe	X	X	X	X	X
Dry Creek Slip Ramp	X	X	N	N	N
County Line Road Slip Ramp *	X	X	X	X	X
Dayton / I-225 *	X	X	X	X	X
Nine Mile Slip Ramp	X	X	N	X	X

*\* These are assumed to be the end-of-line locations with larger parking lots proposed for carpool parking.*

Special Fare Lane Assumptions:

- For Automatic Vehicle Identification vehicles only (no need for toll plazas).
- All cars will need a transponder, but there will be provisions to purchase a daily transponder.
- Transponder readers will be placed at direct access points.
- If congestion increases on Bus/HOV facility, will increase toll to maintain LOS on Bus/HOV facility.
- Charges for tolls are undetermined at this point.

- Use by trucks is undetermined.

#### Enforcement:

Each sub-alternative will include construction of special enforcement areas at:

- a. North of C-470 around Dry Creek
- b. North of I-225
- c. North of Colorado Boulevard
- d. At or near Broadway

#### Bus Service:

Figure 4-5 illustrates bus service assumed for the Bus/HOV Alternative.

#### 4.4.1.4 Light Rail Alternative

This alternative assumes extension of the Central Corridor LRT line to provide two-way service along I-25 and I-225.

Basic LRT alignment alternatives which were developed include:

- LRT on Buchtel right-of-way between Broadway and University.
- LRT adjacent to I-25 between Broadway and University.
- LRT on west side of I-25 with a spur along I-225.
- LRT crosses to the east side of I-25 north of I-225; then returns to the west side north of C-470 with a spur along I-225.

figure 4-5



#### 4.4.1.4.1 Light Rail Alternatives Considered But Not Advanced

The following text describes alternatives that were considered but not advanced and the reasons why.

##### Buchtel Right-of-Way

Following is a summary of the analysis conducted and results found from a special study conducted for the Southeast Corridor. The special study examined two alternate locations for Light Rail Transit between Broadway and Colorado Boulevard:

- Use of the RTD-owned Buchtel right-of-way.
- Use of CDOT right-of-way, adjacent to I-25.

The Buchtel location would be at-grade, with seven crossings of city streets, operate at slower speeds and would be closer to neighborhoods. The Freeway location would be at the same grade as I-25, would operate at higher speeds and would be exclusively grade-separated. (See attached drawings, Figures 4-6 and 4-7.)

During the special study, input was solicited from:

- City and County of Denver
- Denver University
- RTD
- CDOT
- Southeast Corridor Policy and Technical Committees
- Specific neighborhood groups
- General public at public meetings

This input took the form of several meetings held with each group over a period of several months to gather input on issues, to present the advantages and disadvantages of the two basic alternatives, to discuss possible mitigation, and solicit opinions about the alternatives.

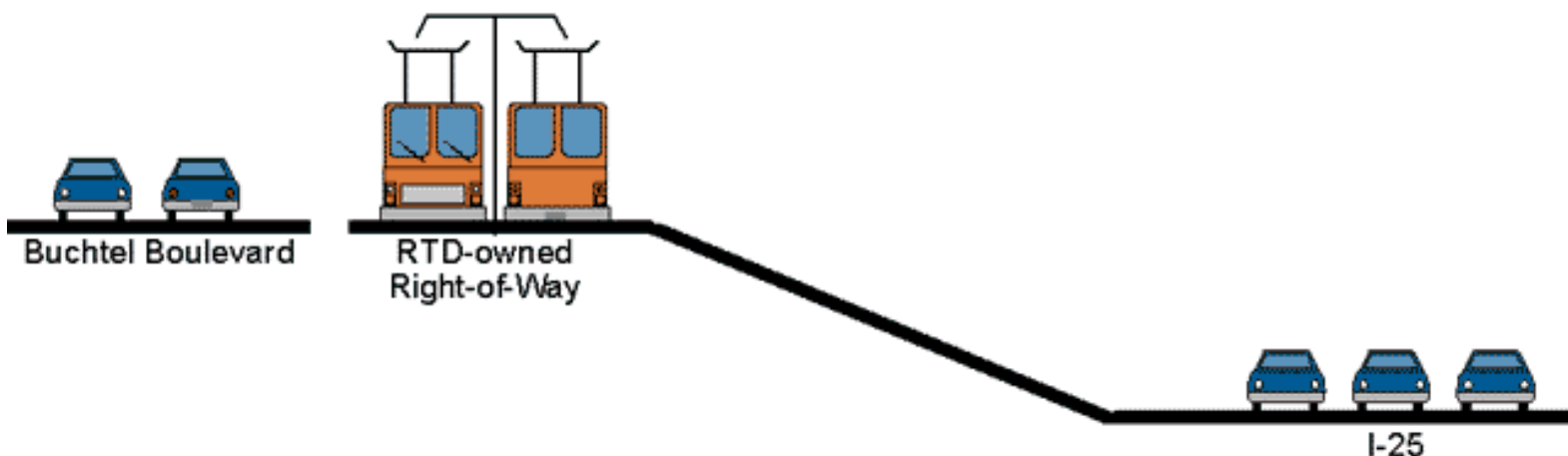
A summary of the major findings of this special study is described in the following chart:

**Table 4-3**

##### **Evaluation of Freeway Versus Buchtel Alignment**

<b>Criteria</b>	<b>In Freeway Right-of-Way</b>	<b>Buchtel</b>
<b>Travel Time / Speeds</b>	4 to 5 minutes faster.	4 to 5 minutes slower.
<b>Reliability</b>	Very little potential for train delay since it is fully grade separated.	Reliability compromised due to at-grade crossings.

figure 4-6



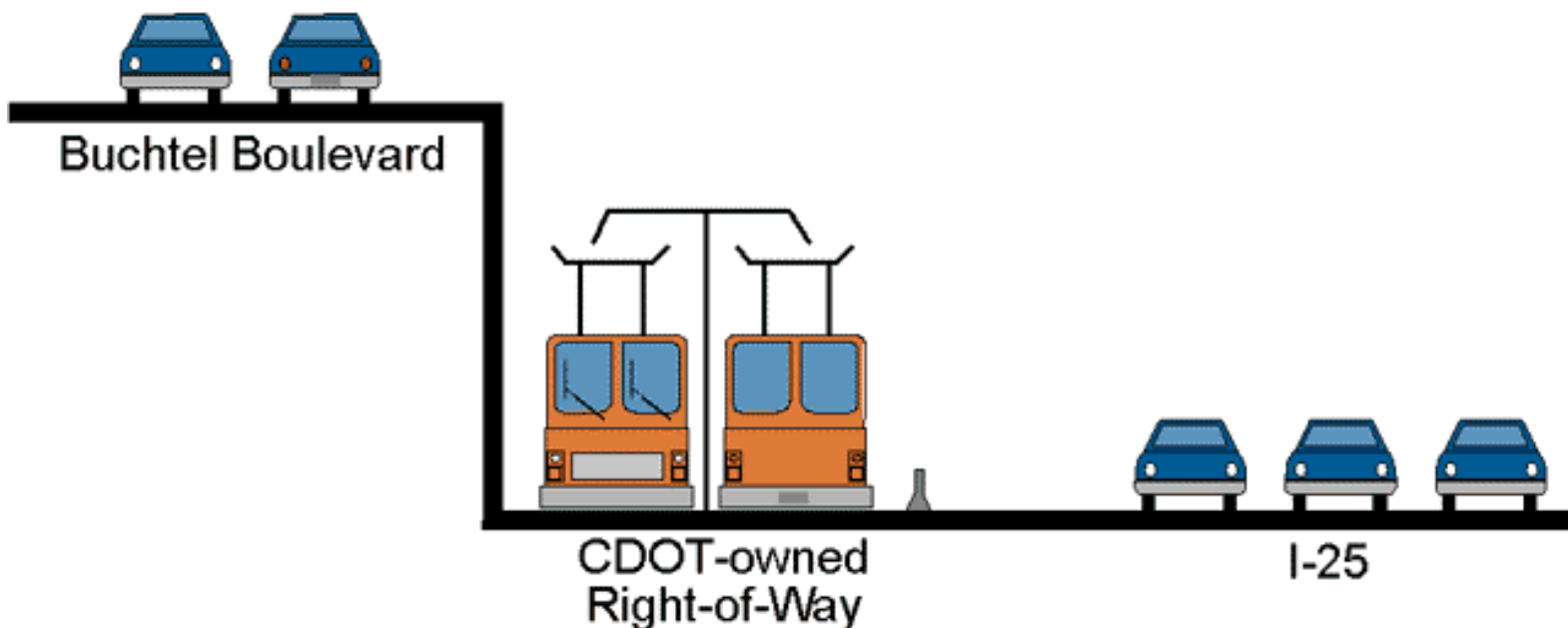
## Advantages

- This alignment is approximately \$10 million less expensive than using the Freeway R.O.W.

## Disadvantages

- Numerous (7) at-grade crossings of city streets (Denver staff have expressed concerns about this).
- LRT will operate more slowly: travel time increase of 4 to 5 minutes is anticipated when compared to an alignment adjacent to I-25.
- Reliability of LRT is compromised because of increased potential incident occurrences.

figure 4-7



## Advantages

- LRT is fully grade separated.
- LRT operating speeds are 4 - 5 minutes faster than an alignment along Buchtel.
- LRT reliability is greater (very little potential for incident-related delay).
- Fewer neighborhood impacts (noise, visual).

## Disadvantages

- Some impact to traffic on I-25 during construction will occur.
- Overall capital cost is approximately \$10 million greater than an alignment on the Buchtel R.O.W.

**Table 4-3 (continued)**

### Evaluation of Freeway Versus Buchtel Alignment

Criteria	In Freeway Right-of-Way	Buchtel
<b>Safety</b>	No safety issues associated with at-grade crossings.	Safety issues associated with 7 at-grade crossings (pedestrian and auto-related accidents).
<b>Neighborhood Impacts</b>	More compatible with neighborhood since transportation uses are consolidated. Impacts associated with LRT will be mitigated by grade change from Broadway to University and noise fences between University and Colorado.	Visual impact, noise of bells, horns, community disruption.
<b>Capital Cost</b>	\$10M more than Buchtel  (approx. \$100M).	\$10M less than Freeway Right-of-Way alternative (approx. \$90M).
<b>Right-of-Way Availability</b>	CDOT right-of-way is available.	RTD right-of-way is available.
<b>Neighborhood Support</b>	Yes, from a majority of people.	No, from a majority of people.
<b>Impact to City Streets</b>	Very little impact since there are no at-grade crossings.	Traffic flow on streets with at-grade crossings will be negatively affected.
<b>Neighborhood Mobility</b>	No issue.	Mobility will be compromised by closures of 4 streets.
<b>Neighborhood Access to Stations</b>	Identical neighborhood access at University and Colorado; vertical pedestrian access needed at Downing.	Slightly better (no vertical access issues at Downing).
<b>Agency Input</b>	Supported by City and DU.	Not supported.
<b>Opportunity for Mobility Improvement</b>	Would allow for a reconfiguration of Buchtel which would improve overall circulation in the area (and allow for enhancement opportunity, including median and bike path).	No opportunity.

The recommendation from the special study, which has been endorsed by the Southeast Corridor Policy Committee, DU, City and County of Denver staff and neighborhood groups is that the Freeway location is

preferred. The primary issues that led to this determination are:

- The higher operating speeds and greater reliability which would be obtained by a primarily grade-separated alignment.
- The greater safety which will result if at-grade crossings are minimized.
- The availability of sufficient right-of-way along I-25 to provide for a transportation investment. Very little additional right-of-way would be needed.
- From a neighborhood perspective, the generally more compatible nature of a location that provides for joint use of an existing transportation corridor.
- From DU's perspective, the opportunity for a mobility improvement which presents itself if the Buchtel right-of-way is made available for a reconfiguration of circulation in the area.

The disposition of the Buchtel right-of-way, which is owned by RTD, was discussed as a part of this special study. This right-of-way was purchased in 1980 for \$1.195 million and included 4.1 miles from Broadway to Holly. The recommendation from the special study is that the portion generally from Broadway to just west of University will be used for a transportation investment. This is approximately 2 miles, or 50 percent, of the total length owned by RTD.

The remainder of this property could be disposed of in a manner consistent with the *RTD Board Resolution Regarding Joint Development and Disposition of Property Rights*. Options outlined in this resolution include:

- Out-right sale of property.
- Lease of property.
- Other methods as long as no negative impact will result to RTD's mass transportation system and to reasonably ensure that the development does not detract from the aesthetic, social and economic well-being of the community.

### East Side Alignment Between Colorado and Lincoln

Alignments for light rail along the east side and the west side of I-25 were examined. Examination included calculations of Year 2020 employment and population estimates within average transit walking distance of LRT station locations. The evaluation considered east side versus west side I-25 station locations and the walk access capture area (1/3 mile radius) which they would likely serve.

From a ridership perspective, each alignment provides the opportunity to capture similar land use concentrations. For the four stations (Southmoor, Union, Arapahoe and Dry Creek) impacted by east versus west alignment options, the overall land use located within station capture areas differs by only four percent to six percent. Approximately 250 more people and 2,650 employees are located within walking distance (1/3 mile radius of a station) of the west side station capture areas compared to the east side stations. Given the projected transit mode share for this area, daily ridership would only differ by approximately 100 to 200 trips.

When comparing land use densities within one mile of I-25 (between I-225 and Lincoln Avenue), population densities are higher on the west side while employment densities are higher on the east side. Since a large percentage of this land use is beyond reasonable walk distances (1/3 mile), bus feeder or bus circulator service are required to serve the LRT stations.

Pedestrian cross-overs of I-25 have been assumed at Southmoor, Dayton, Nine Mile, Union, Arapahoe and Dry Creek. These were assumed at a capital cost of \$1 to \$2 million each. If these are upgraded to be heated, covered and equipped with moving sidewalks, the cost would be \$6 million each.

Research was conducted regarding pedestrian cross-overs serving existing transit systems. Some of the following characteristics were identified:

- There was no specific evidence that pedestrian cross-overs discouraged ridership. Most facilities serve high transit demand areas and are well utilized.
- Americans with Disabilities Act (ADA) requirements can result in extensive ramp lengths. Some agencies use elevators and have considered underpasses to reduce crossing distances.
- Open structures have presented problems when poor weather conditions exist.
- Alternate funding sources (municipalities, state, developers) have been used to construct pedestrian facilities and operate supplemental shuttle services to enhance transit station access.

It is likely that south of I-225, pedestrian crossings would be needed with either an east or a west side alignment, so the cost for these is not a differentiator.

The end-of-line is a differentiator between east and west, however. If the end-of-line is at Dry Creek or north, the cost savings with a west alignment is approximately \$15M. If the end-of-line is south of Dry Creek, the cost savings with a west alignment is approximately \$30M. These cost differences can primarily be attributed to the crossing of I-25 with LRT.

**Table 4-4**

**Evaluation of East Versus West Side Alignment for Light Rail Transit**

<b>Criteria</b>	<b>West Side</b>	<b>East Side</b>
<b>Capital Cost</b>	\$30M less than east.	\$30M more than west.
<b>Service to Properties/ Economic Development</b>	Closer to more walk-in patronage (within 1/3 mile radius of a station).	Farther away from walk-in patronage; more employment is within 1 mile.
<b>Neighborhood Impacts</b>	Comes closer to approx. 30 properties.	Farther away from residential properties.
<b>Wetlands</b>	Less impact (1 to 2 acres).	More impact (3 to 5 acres).
<b>Property Acquisition</b>	Slightly fewer acres of R.O.W. required.	Slightly more acres of R.O.W. required.
<b>Ridership</b>	Will likely attract 100 to 200 more riders (not significant).	Will likely attract 100 to 200 fewer riders (not significant).

Conclusions are that from Colorado to Lincoln, the preferred alternative is the west side alignment because it is cheaper and, as long as user friendly access across I-25 is provided, there is not significant ridership difference between an alignment on the east side of I-25, compared to a west side alignment.

#### North Side Alignment Along I-225

Alignments for light rail along the north side of I-225 and in the median were examined. Findings from this analysis are:

**Table 4-5**

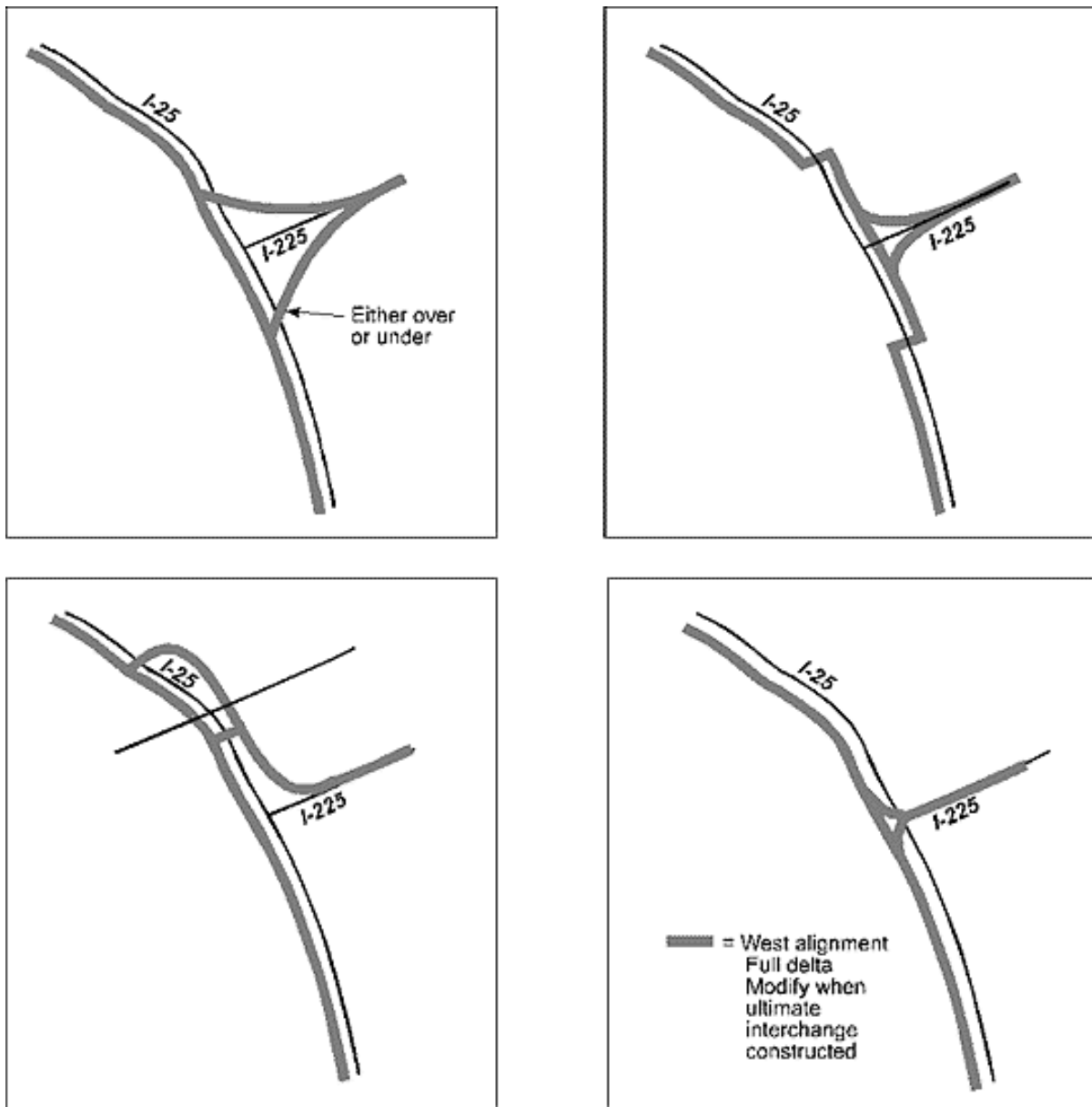
#### **Evaluation of Median Versus North Side Alignment Along I-225**

<b>Criteria</b>	<b>Median</b>	<b>North Side</b>
<b>Capital Cost</b>	No difference	No difference
<b>Parkland Impact</b>	Minimal	More
<b>Station Access</b>	More difficult	Better
<b>Right-of-Way Availability</b>	Yes	No

Conclusions are that along I-225, the technically preferred alternative is in the median due to right-of-way availability, although a north side alignment would also work.

#### Connections Between I-25 and I-225

Analysis was conducted of various ways to connect a LRT alignment along I-25 with one along I-225. These are illustrated on the following page:



The direction from the Southeast Corridor Policy Committee is to provide for a full delta connection, so that all movements could be served without requiring a transfer. This is designed to be consistent with an interim I-25/I-225 interchange (at the lowest possible cost). The assumption is that additional right-of-way would be needed and LRT would have to be reconstructed at the time the ultimate I-25/I-225 interchange is built. More detailed analysis of construction phasing will be done during the design phase.

### End-of-Line at Arapahoe Park-n-Ride

An end-of-line at the Arapahoe park-n-Ride was developed and evaluated. This is the end-of-line that is included in the Year 2015 Regional Transportation Plan. This was not recommended for the following reasons:

- The current difficulty in getting access to the Arapahoe park-n-Ride. This difficulty will be compounded in the future, as congestion increases, and may result in potential transit patrons choosing not to use transit.
- The congestion along I-25 between Lincoln and Arapahoe that will result. This congestion could be eased by having an end-of-line at Lincoln.
- The reduced likelihood of intercepting passengers from south of the DRCOG area (such as Castle Rock)

who are destined for employment centers in the south business park area. It is likely that if people are forced to drive as far north as the Arapahoe park-n-Ride, they would be less likely to choose transit, particularly if the destination is somewhere south of I-225.

- The growing commercial activity center and population area in the County Line Road area.

#### 4.4.1.4.2 Alternatives Advanced

The Light Rail Alternative advanced is described in Chapter Five of this report.

**Table 4-6**

#### **Other Alternatives Considered But Not Advanced**

<b>Alternative</b>	<b>Reason(s) Not Advanced</b>
Adding general purpose lanes	Ten additional lanes of I-25 and I-225 would be needed to satisfy the demand. The cost of this would be over \$1.0 billion; and there would be substantial impact to existing residences and businesses (569 residential relocations and 53 commercial structures relocated). This alternative would result in substantially increased traffic and congestion at both ends of the improvement, where there is no capacity to handle the increased traffic. This alternative is inconsistent with adopted regional policies for the Southeast Corridor.

**Table 4-6 (continued)**

#### **Other Alternatives Considered But Not Advanced**

<b>Alternative</b>	<b>Reason(s) Not Advanced</b>
Closing I-25 interchanges	The major investment (LRT) can be implemented without requiring closure of any interchanges. While I-25 operations would be improved somewhat, the neighborhood impacts of closing any of these interchanges is a significant off-setting issue. The City and County of Denver is currently completing a study of local street circulation in the area. The results of this study will be considered during the design and environmental process.
Double-decking I-25	Construction costs are substantial (\$1.6 billion); visual and air quality impacts are a concern.
Bus/HOV facility designated at 2+	This alternative is so attractive it "fills up" with carpoolers, so will need to be designated as 3+.
Fare Lane	This alternative has the same physical impacts as the Bus/HOV alternative.

#### 4.4.2 Evaluation Results

The following charts provide results of the detailed evaluation of the four alternatives described earlier in this chapter.

Table 4-7

## Evaluation of Detailed Alternatives : Cost and Constructability

Criteria	No Capacity Increase	Transportation Management	Bus/HOV	Light Rail
<b>Capital Cost</b>	Package A (No Build): Least Cost  Package B (Rebuild): \$350M	\$280M	\$756M (cost for barrier separated Bus/HOV). Buffer separated is slightly less expensive	\$445M (west alignment)  <i>An additional cost of \$9M is needed for a future spur to the Denver Union Terminal, to handle future capacity needs.</i>
<b>Operating Cost</b>  (Annual Cost)	Base	\$7.9M	\$12.2M	\$19.3M
<b>Total Annualized Cost</b>	Base	\$30.3M	\$71.5M	\$54.6M
<b>Constructability</b>	Package A: Minimal construction impact.  Package B: Major construction impact	Minimal construction impact	Major construction impact	Can be built without major construction impact to freeway system
<b>Financial Feasibility</b>	Package A: Financially feasible  Package B: \$40M less than 1995 escalated budget	Within corridor budget (financially feasible)	Approx. \$366M over 1995 escalated budget	Approx. \$55M over 1995 budget  (This is 14% over the budget.)
<b>Capital Cost of Total Strategy</b>	\$350M	\$280M	\$756M	\$510M (including LRT, highway and Transportation Management components)

Table 4-8

## Evaluation of Detailed Alternatives: Natural Resource Impacts

Criteria	No Capacity Increase	Transportation Management	Bus/HOV	Light Rail
<b>Wetlands</b>  ● Range of direct impact anticipated	Package A: No impact Package B: 1 to 2 acres impact	0.5 to 1 acre impact	4 to 6 acres impact	West side: 1 to 2 acre impact East side: 3 to 5 acres impact Buchtel: Same as Freeway alignment

<b>Section 4(f) Resources</b> <ul style="list-style-type: none"> <li>No. parks affected</li> <li>No. wildlife refuges affected</li> <li>No. historic properties affected</li> </ul>	Package A: No impact Package B: <ul style="list-style-type: none"> <li>Approx. 10 acres of direct park impact</li> <li>Indirect impacts to 4 parks</li> <li>No wildlife refuges impacted</li> <li>Two historic properties affected</li> </ul>	<ul style="list-style-type: none"> <li>Less than 0.5 acre of direct park impact</li> <li>Indirect impact to 1 park</li> <li>No wildlife refuges impacted</li> <li>No historic properties affected</li> </ul>	<ul style="list-style-type: none"> <li>Approx. 8 acres of direct park impact</li> <li>Indirect impact to 5 parks</li> <li>No wildlife refuges impacted</li> <li>Four historic properties affected</li> </ul>	<ul style="list-style-type: none"> <li>Approx. 6 acres of direct park impact if the Dayton interchange is included</li> <li>Indirect impact to 2 parks (at Dayton interchange area)</li> <li>No wildlife refuges impacted</li> <li>Two historic properties affected</li> <li>Buchtel: several more historic properties are impacted</li> </ul>
<b>Air Quality</b> <ul style="list-style-type: none"> <li>Corridor inventories (tons)</li> </ul> CO No <sub>x</sub> HC PM <sub>10</sub>	     119.24 19.27 14.20 0.80	     118.09 19.29 14.09 0.79	     117.23 19.47 14.07 0.80	     118.01 19.30 14.08 0.79
<b>Endangered Species</b> <ul style="list-style-type: none"> <li>No. of species in area</li> <li>Number of species likely affected</li> </ul>	Package A: No impact Package B: <ul style="list-style-type: none"> <li>11 species in area</li> <li>No species affected</li> </ul>	<ul style="list-style-type: none"> <li>11 species in area.</li> <li>No species likely affected</li> </ul>	<ul style="list-style-type: none"> <li>11 species in area</li> <li>No species likely affected</li> </ul>	<ul style="list-style-type: none"> <li>11 species in area</li> <li>No species likely affected</li> </ul>
<b>Hazardous Materials</b> <ul style="list-style-type: none"> <li>No. of known sites impacted</li> <li>Assessment of risk</li> </ul>	Package A: No impact Package B: <ul style="list-style-type: none"> <li>Sites impacted: Minimum of 8</li> <li>Most Risk</li> </ul>	<ul style="list-style-type: none"> <li>Sites impacted: none</li> <li>Minimal risk</li> </ul>	<ul style="list-style-type: none"> <li>Sites impacted: Minimum of 8</li> <li>Most risk</li> </ul>	<ul style="list-style-type: none"> <li>Sites impacted: Minimum of 3</li> <li>Moderate risk</li> </ul>

Table 4-9

## Evaluation of Detailed Alternatives: Community Impacts

Criteria	No Capacity Increase	Transportation Management	Bus/HOV	Light Rail
<b>Land Use</b> <ul style="list-style-type: none"> <li>Compatibility</li> </ul>	Not consistent with local plans	Supports or is compatible with local plans	Supports or is compatible with local plans	Supports or is compatible with local plans
<b>Economic Development Potential</b>	Package A: No economic development potential  Package B: No economic development potential	Some economic development potential at park-n-Rides	Some economic development potential at park-n-Rides	Most economic development potential in vicinity of stations
<b>Joint Development Potential</b>	Minimal potential	Minimal potential	Some potential at specific stations	Most potential at stations
<b>Likelihood of Safe Travel</b> (Risk of accidents)	Package A: Poor  Package B: Fair	Fair	Buffer: Good Barrier: Very good	Buchtel: Poor Freeway: Very good
<b>Provision of Public Services</b> (emergency service access)	Package A: Poor Package B: Fair	Fair	Very good	Fair
<b>Impact to Goods Movement</b>	Continued congestion	Continued congestion	Major investment will relieve some of the congestion in general travel lanes. Improved interchanges will also help conditions.	Major investment will relieve some of the congestion in general travel lanes. Improved interchanges will also help conditions.
<b>Right-of-Way</b> <ul style="list-style-type: none"> <li>Acres required</li> <li>Structures displaced</li> </ul>	Package A: No impact Package B: <ul style="list-style-type: none"> <li>Approx. 50 acres</li> <li>89 residential units displaced</li> <li>12 commercial structures</li> </ul>	<ul style="list-style-type: none"> <li>Approx. 55 acres</li> <li>50 residential structures displaced</li> <li>9 commercial structures displaced</li> </ul>	Termination at Broadway Station: <ul style="list-style-type: none"> <li>Approx. 136 acres</li> <li>429 residential units displaced</li> <li>42 commercial</li> </ul> Termination at 6th Avenue <ul style="list-style-type: none"> <li>Approx. 165 acres</li> <li>429 residential units displaced</li> <li>53 commercial</li> </ul>	West side: <ul style="list-style-type: none"> <li>Approx. 77 acres</li> <li>20 residential units displaced</li> <li>14 commercial structures displaced</li> </ul> East side: <ul style="list-style-type: none"> <li>Approx. 79 acres</li> <li>20 residential units displaced</li> <li>15 commercial structures displaced</li> </ul>

<b>Visual Impact</b>	Package A: No impact Package B: Minimal visual impact	<ul style="list-style-type: none"> <li>Minimal visual impact</li> </ul>	Greatest visual impact: facility comes closer to more homes	Moderate impact: facility will be most visible between Evans and Southmoor
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Table 4-9 (continued)

## Evaluation of Detailed Alternatives: Community Impacts

Criteria	No Capacity Increase	Transportation Management	Bus/HOV	Light Rail
<b>Neighborhood Disruption</b> <ul style="list-style-type: none"> <li>Homes w/in 300 feet of improved facility</li> <li>No. street closures</li> </ul>	Package A: No impact Package B: <ul style="list-style-type: none"> <li>650-730 homes</li> <li>Four road closures or relocations</li> </ul>	<ul style="list-style-type: none"> <li>345-385 homes</li> <li>No road closures</li> </ul>	<ul style="list-style-type: none"> <li>1188-1308 homes w/in 300 feet of facility *</li> <li>Seven road closures or relocations</li> </ul> <p><i>*These are on both sides of I-25 and I-225, since facility is being widened to both sides. This includes homes in the vicinity of stations.</i></p>	West side: <ul style="list-style-type: none"> <li>555 to 653 homes w/in 300 feet of facility, including stations</li> <li>No road closures</li> </ul> East side: <ul style="list-style-type: none"> <li>520-608 homes w/in 300 feet of facility, including stations</li> <li>No road closures</li> </ul> Buchtel: <ul style="list-style-type: none"> <li>30 additional homes</li> </ul>
<b>Noise/Vibration</b> <ul style="list-style-type: none"> <li>Number of homes within 300 feet of facility</li> <li>Number of stations</li> <li>Feet of additional transportation use</li> <li>Noise characteristics of vehicle</li> </ul>	<ul style="list-style-type: none"> <li>Package A: No impact</li> <li>Package B: Minimal noise / vibration impact. 650-730 homes w/in 300 feet of facility.</li> </ul>	<ul style="list-style-type: none"> <li>Minimal noise / vibration impact due primarily to highway improvements within the TM Alternative</li> <li>345 to 385 homes within 300 feet</li> </ul>	<ul style="list-style-type: none"> <li>1188-1308 homes within 300 feet of facility</li> <li>Increased local noise/vibration with 3 new park-n-Rides / stations</li> <li>Buffer-separated requires 50 feet and barrier-</li> </ul>	<ul style="list-style-type: none"> <li>West side: 555 to 653 homes within 300 feet of facility</li> <li>East side: 520 to 608 homes within 300 feet of facility</li> <li>Buchtel: 30 additional homes within 300 feet of facility</li> <li>Increased local noise /</li> </ul>

			separated requires 58 feet of additional travel-way space (in median) <ul style="list-style-type: none"> <li>The pass-by noise level of a transit bus (at 50 feet) is 84 to 88 dBA (SEL)</li> </ul>	vibration with 13 new stations, many with park-n-Rides <ul style="list-style-type: none"> <li>Buchtel includes several at-grade roadway crossings that will increase local noise due to gate bells and train horn</li> <li>LRT requires an additional 30 feet of travel-way space (on east or west side)</li> <li>The pass-by noise level of LRT at 50 feet is 82 dBA (SEL)</li> </ul>
<b>Environmental Justice</b> (Impacts to Minority or Low Income Communities) <ul style="list-style-type: none"> <li>Lineal miles bisecting such communities.</li> <li>Homes acquired in such communities</li> <li>Miles of facility along such communities</li> </ul>	<ul style="list-style-type: none"> <li>Zero miles bisecting</li> <li>No homes acquired in low-income or minority areas</li> <li>2.1 miles of facility is along low income or minority areas (10.6% of total)</li> </ul>	<ul style="list-style-type: none"> <li>Zero miles bisecting</li> <li>No homes acquired in low-income or minority areas</li> <li>Zero miles adjacent to low income or minority areas</li> </ul>	<ul style="list-style-type: none"> <li>Zero miles bisecting</li> <li>No homes acquired in low-income or minority areas</li> <li>2.7 miles of facility is along low income or minority areas (13.6% of total)</li> </ul>	<ul style="list-style-type: none"> <li>Zero miles bisecting</li> <li>No homes acquired in low-income or minority areas.</li> <li>0.6 miles is along low income or minority areas (3.4% of total)</li> </ul>

Table 4-10

## Evaluation of Detailed Alternatives: Effectiveness/Benefits (Year 2020)

Criteria	No Capacity Increase	Transportation Management	Bus/HOV	Light Rail
Daily Users of Investment (Year 2020)	N/A	N/A  N/A	2+: 54,100  3+: 23,300	With parking costs in SEBP*: 30,300 No parking costs in SEBP*: 29,250

<b>Users per Hour, Peak Direction (Year 2020)</b>	N/A	N/A	2+: 6,000 3+: 3,200	2,500
<b>Maximum Capacity (Peak Hour, Peak Direction)</b>	N/A	N/A	Approx. 11,450 (A general purpose lane carries 2,800 people.)	Approx. 13,500 (A general purpose lane carries 2,800 people.)
<b>Change in Daily Linked Regional Transit Trips</b>	Base	+3,000 over Base	+2,500 over Base	+15,700 over Base
<b>Change in Daily Vehicle Miles of Travel (Regional)</b>	Base	-70,000	-243,000	-222,000
<b>Change in Daily Vehicle Miles of Travel (Corridor)</b>	Base	-20,000	+120,000	-20,000
<b>Change in Daily Person-Hours of Delay (Regionally)</b>	Base	8,000 hours of delay reduced	41,000 hours of delay reduced	24,000 hours of delay reduced
<b>Daily Transit Ridership</b>	6,400	7,600	10,600	29,250 to 30,300
<b>Corridor Congestion</b>	Most congestion	No change from base	Slight improvement	Slight improvement
<b>Travel Times - Peak</b> (from Lincoln Avenue to CBD) (from Colorado Blvd. to 16th and California)	Highway: 68 minutes Transit: 66 minutes Highway: 27 minutes Transit: 26 minutes	Highway: 65 minutes Transit: 64 minutes Highway: 27 minutes Transit: 26 minutes	Highway: 65 minutes Carpool: 38 minutes Transit: 37 minutes Highway: 27 minutes Carpool: 21 minutes Transit: 20 minutes	Highway: 66 minutes Transit: 35 minutes Highway: 26 minutes Transit: 18 minutes
<b>Travel Time Reliability</b> (Based on degree of exclusivity, amount of conflicting traffic, risk of accidents)	Package A: Poor Package B: Poor	Fair	Buffer: Good Barrier: Very good (No at-grade crossings) Not as reliable as LRT: still affected by incidents and weather.	Freeway: Best (No at-grade crossings) Most reliable: not subject to incidents; not affected by weather.

*\*Southeast Business Park: includes Denver Technological Center, Greenwood Plaza, Meridian, Inverness, and other business areas in the general area.*

**Table 4-11**

### Evaluation of Detailed Alternatives: Regional Public Sector Cost-Effectiveness Measures

Criteria	No Capacity Increase	Transportation Management	Bus/HOV	Light Rail
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<b>Annual Capital and Operating Cost Per User</b>	Base	\$15.65	2+: \$4.50 3+: \$11.15	No parking costs in SEBP*: \$6.20  With parking costs in SEBP*: \$5.95
<b>Annualized Cost per New User (without considering the cost of delay saved)</b>	Base	\$40.85	2+: \$26.50 3+: >\$26.50	\$11.50
<b>Annualized Cost per New User (including the cost of delay saved)</b>	Base	Base	2+: \$17.59 3+: >\$17.59	\$0.47 **
<b>Annualized Cost per Vehicle Mile of Travel Reduced</b>	Base	\$1.25	2+: \$0.85 3+: >\$0.85	\$0.70
<b>Annualized Cost per Person-Hour of Delay Reduced</b>	Base	\$14.50	2+: \$7.05 3+: >\$7.05	\$9.00











\*Southeast Business Park: includes Denver Technological Center, Greenwood Plaza, Meridian, Inverness, and other business areas in the general area.












































































\*\*This cost is based on delay saved from an enhanced Transportation Management alternative (costed at \$280 million) which is more costly than is typical. If a cost of \$100 million is assumed for a Transportation Management alternative, this cost per new user is \$4.16.






Note: All cost-effectiveness measures are based on cost and ridership for the major investment only.

**Table 4-12**

### Comparative Summary of Evaluation Results

	Alternative				
	No Capacity Increase			Bus/HOV	
Criteria	No Build	Rebuild	Transportation Management	Facility (3 +)	Light Rail Transit
<b>Community Impacts</b>					
• ROW required (displacements)					
• Neighborhood impacts					

<ul style="list-style-type: none"> <li>Economic development potential</li> </ul>					
<b>Effectiveness/Benefits</b>					
<ul style="list-style-type: none"> <li>Daily transit ridership</li> </ul>					
<ul style="list-style-type: none"> <li>Total daily person trips</li> </ul>					
<ul style="list-style-type: none"> <li>Maximum person-carrying capacity</li> </ul>					
<ul style="list-style-type: none"> <li>Regional VMT</li> </ul>					
<ul style="list-style-type: none"> <li>Travel Time</li> </ul>					
<b>Costs</b>					
<ul style="list-style-type: none"> <li>Capital Cost</li> </ul>					
<ul style="list-style-type: none"> <li>Operating/maintenance cost</li> </ul>					
<ul style="list-style-type: none"> <li>Financial feasibility</li> </ul>					
<ul style="list-style-type: none"> <li>Cost-effectiveness</li> </ul>					
<b>Natural Resource Impacts</b>					
<ul style="list-style-type: none"> <li>Wetlands</li> </ul>					
<ul style="list-style-type: none"> <li>Parks</li> </ul>					
<ul style="list-style-type: none"> <li>Historic properties</li> </ul>					
<ul style="list-style-type: none"> <li>Endangered species</li> </ul>					
<ul style="list-style-type: none"> <li>Hazardous materials</li> </ul>					

<b>Legend:</b>	<i>Worst</i>		<i>Moderate</i>		<i>Best</i>
					

### 4.4.3 Summary of Findings of Evaluation

This section summarizes the main findings of the evaluation process, by type of evaluation criteria.

#### 4.4.3.1 Effectiveness Findings

The build alternative with the most total usage on the major investment is the Bus/HOV alternative with a designation of two or more people per vehicle. This alternative carries just over 54,000 people per day, including 43,560 in carpools and 10,550 in buses. The Light Rail alternative is projected to carry between 29,000 and 30,000 people per day.

The usage on the Bus/HOV facility is projected to be high enough that the level of service drops so that there is no longer a time advantage to using this facility. Because of this, its designation will need to be changed to three or more people per day. At this designation, projected usage will drop to 23,300 people per day.

Another interesting statistic related to the Bus/HOV alternative is that of the 43,560 people projected to use the facility in carpools, only 1,560 of those people are new users who are attracted to the facility. The Light Rail alternative also includes 42,000 people in carpools who are using the general purpose lanes.

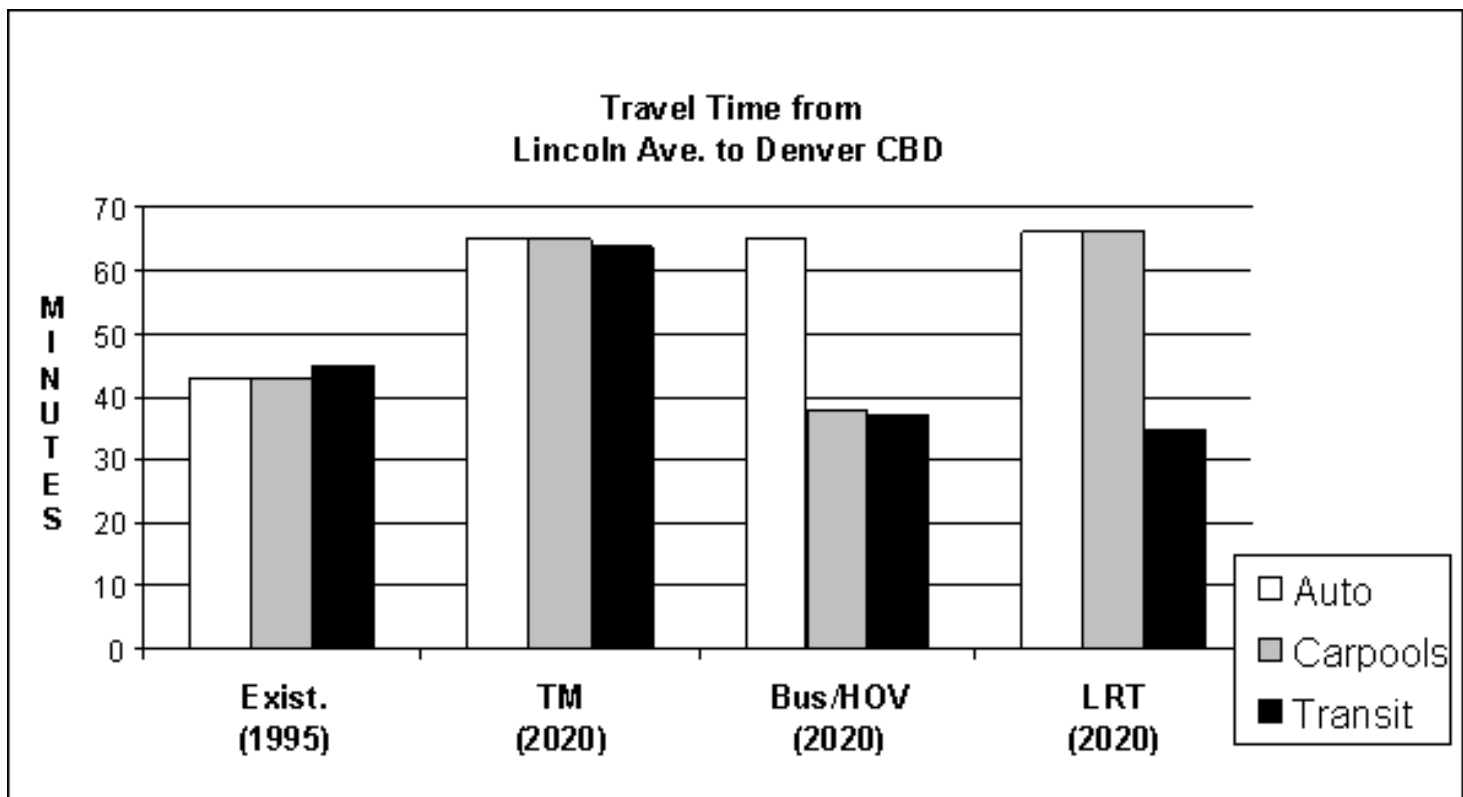
The Light Rail alternative has more potential carrying capacity than the Bus/HOV alternative; it also reduces vehicle miles traveled.

Adding parking charges at private parking lots in the south business area increases overall LRT corridor ridership by four percent. Ridership to/from the southern stations increases by seven to 15 percent.

Both the Bus/HOV Lane alternative and the Light Rail alternative provide a clear travel time advantage when compared to the general purpose lanes:

- From Lincoln Avenue to the Denver CBD, general highway users will need 66 minutes of travel time in the peak period. Users of the Bus/HOV Lanes will need 38 minutes (carpools) and 39 minutes (bus riders). Users of the Light Rail alternative will need approximately 35 minutes.
- Transit travel times will be improved. Transit travel time in 1995 is 43 minutes from Lincoln Avenue to the Denver CBD. In the Year 2020 without a major investment, travel time would be 66 minutes; with implementation of Light Rail, it will be 35 minutes and with the Bus/HOV Lane it will be 37 minutes.

(It should be noted that these travel times do not include any transfer times).



Thus, implementation of either of the major investments will provide a clear travel time advantage in the Year 2020.

Analysis was also conducted of the effect of the major investment on highway congestion. This is presented in Table 4-13 and illustrated on Figure 4-8. Generally, implementation of the major investment will result in either no benefit or only a minor benefit to congestion in the general purpose highway lanes.

**Table 4-13**

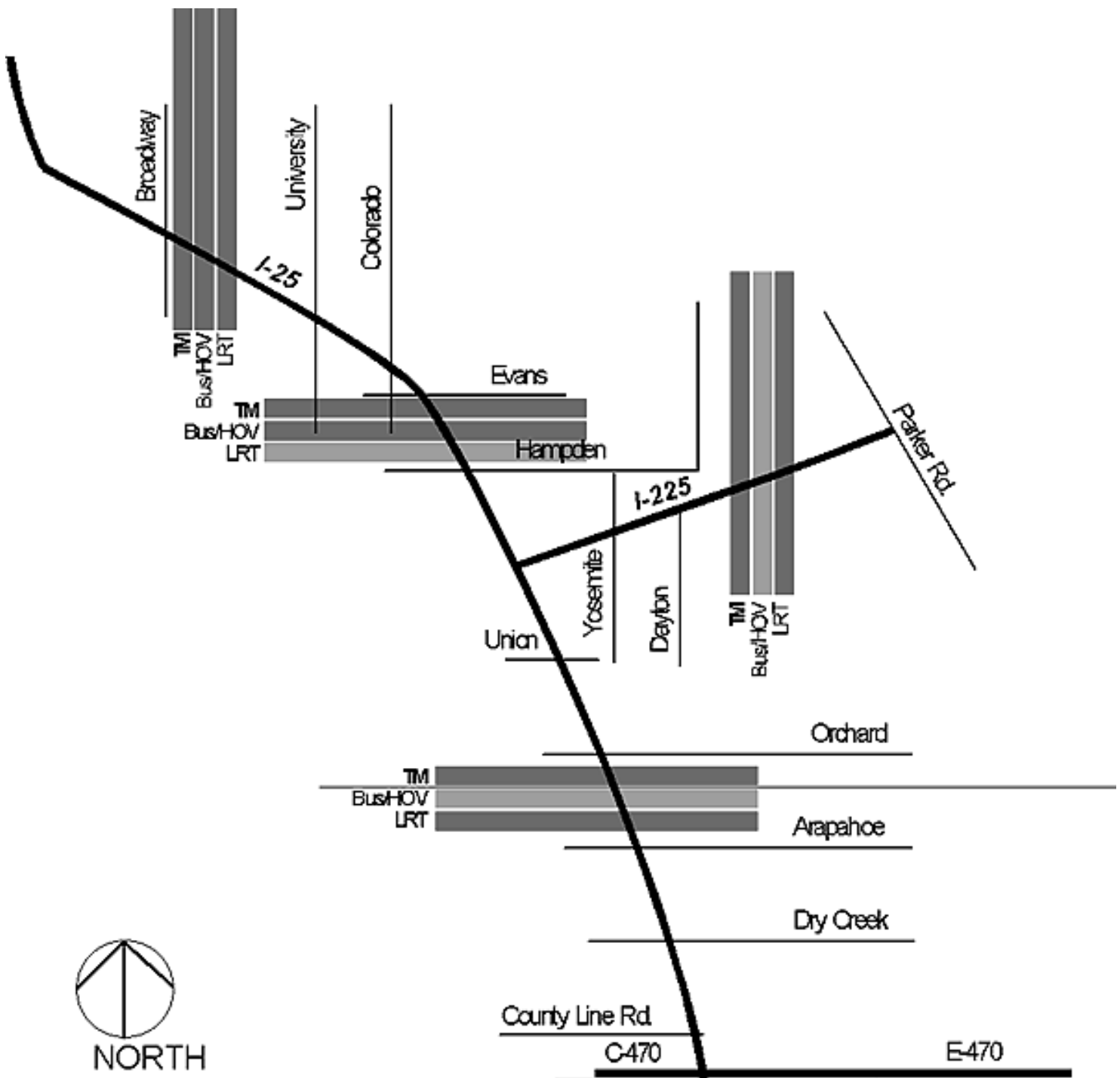
**Future Congestion on Corridor Roadways  
(With and Without a Major Investment)**

Location	No Capacity Increase	Transportation Management	Bus/HOV	Light Rail
East of Broadway	0.85 (1.03)	0.86 (1.03)	0.81 (1.00)	0.86 (1.04)
North of Hampden	0.83 (1.18)	0.84 (1.18)	0.78 (1.14)	0.83 (0.99)
North of I-225	0.94 (1.14)	0.83 (1.01)	0.77 (0.89)	0.84 (1.00)
North of Arapahoe	0.89 (1.04)	0.91 (1.06)	0.83 (0.95)	0.92 (1.06)
North of County Line	0.87 (0.95)	0.88 (0.95)	0.75 (0.82)	0.88 (0.96)
North of Lincoln	0.78 (0.96)	0.77 (0.95)	0.79 (0.96)	0.78 (0.96)
On I-225, at Yosemite	1.04 (1.08)	1.05 (1.08)	0.80 (0.96)	0.92 (1.12)

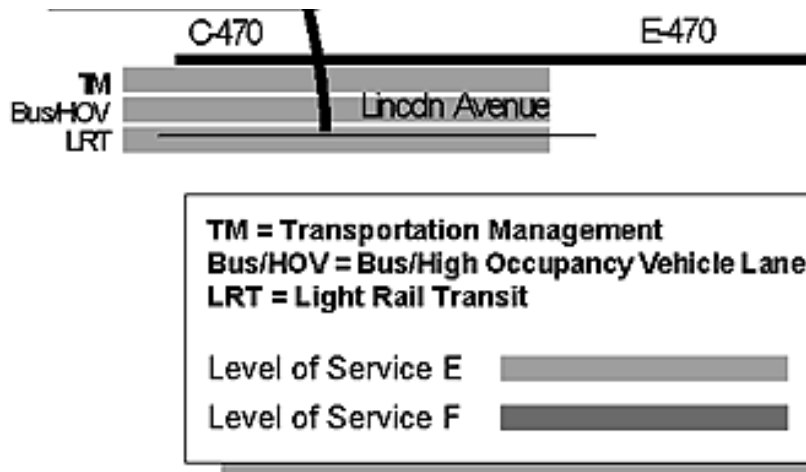
Legend: AM (PM)

1. Numbers represented are volume to capacity ratios on the existing roadway lanes.
2. Bus/HOV calculations are for the 2+ designation. The 3+ designation would result in higher ratios.
3. Ratios at 1.00 or higher are classified as level of service F (severe congestion).
4. Corridor roadways include I-25, I-225 and other arterials within a half-mile on either side of I-25 and I-225.

figure 4-8



NORTH



This analysis, however, does not include the benefit provided as a result of the addition of outside shoulders in areas with no shoulder now. Analysis that has been done of the effect to highway capacity of adding shoulders is that:

- Accidents are significantly reduced (adding shoulders allows 90 percent of errant vehicles to recover).
- Emergency vehicle response time is improved.
- Overall, congestion related to incidents is significantly decreased.
- Traffic flow rates are increased because drivers are less likely to slow down or leave large headways due to reduced "shy" distance.

Existing and future traffic volumes are shown on Figure 4-9.

#### 4.4.3.2 Costs and Affordability Findings

The most costly alternative is the Bus/HOV Lane alternative, costed at \$756 million. This alternative requires the concurrent expenditure of \$120 million for replacement of the Broadway/Santa Fe viaduct. While this was considered off-budget (not within the \$390 million budget for the Southeast Corridor), unavailability of funds for this construction could delay implementation of this alternative. The Light Rail alternative is significantly less expensive and could proceed regardless of viaduct reconstruction funding.

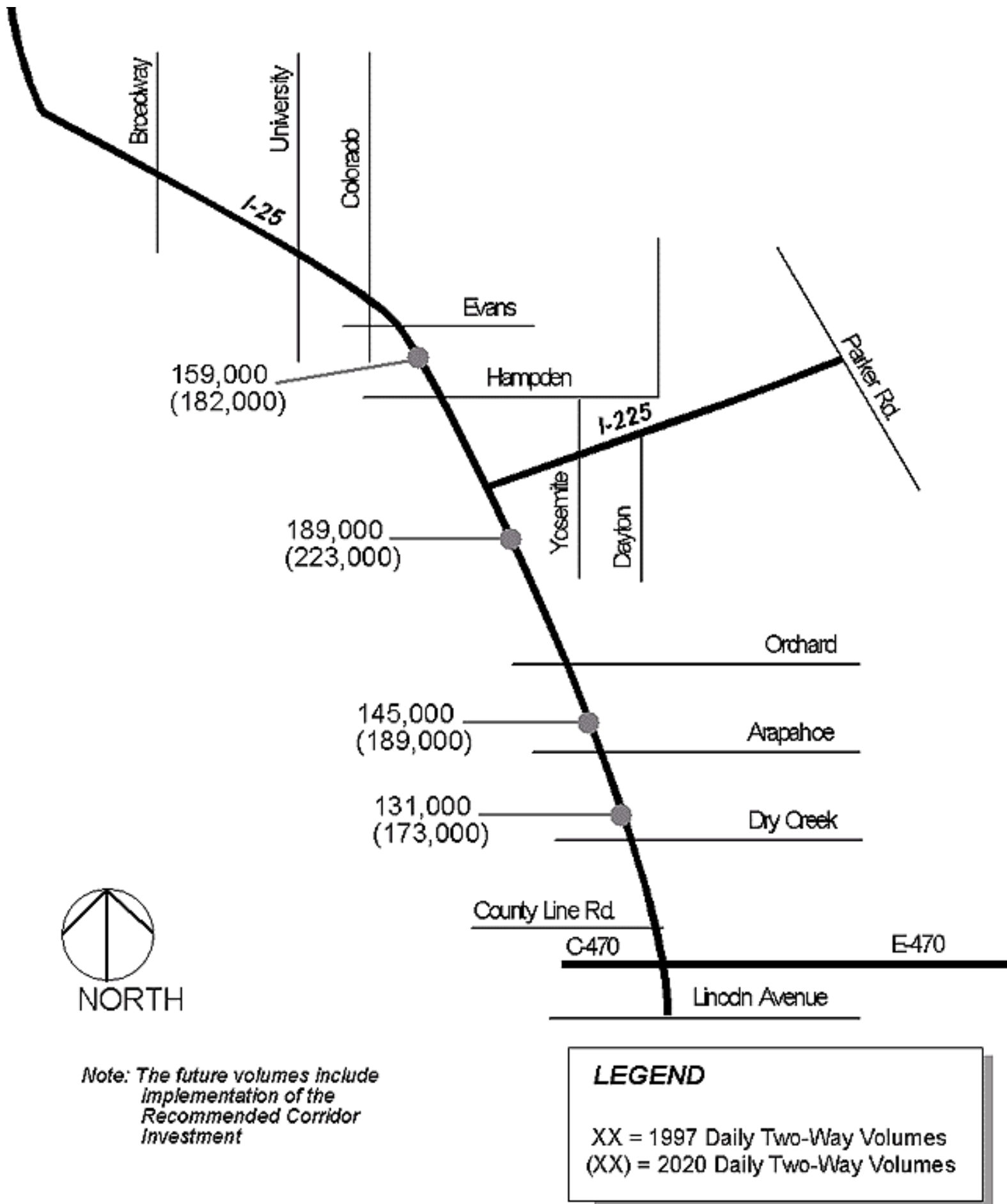
Operating and maintenance costs are higher for the Light Rail alternative (\$19 million) than for the Bus/HOV Lane alternative (\$12 million).

#### 4.4.3.3 Cost-Effectiveness

On a cost-per-user basis, including annualized capital and operating costs, the Bus/HOV Lane is the least expensive at a 2+ designation (\$4.50) and the most expensive at a 3+ designation (\$11.15). It is also the most expensive cost per new user (\$26.50) and more costly per each mile of reduction in travel.

The Light Rail alternative ranges from \$5.95 to \$6.20 cost per user, depending on whether or not parking charges are assumed in the southeast business park area. The Light Rail alternative costs \$11.50 for each new user without the cost of delay included. If the cost of delay saved is included, the cost per new user drops to \$4.16. The Light Rail alternative costs only \$0.70 for each mile of travel reduced.

figure 4-9



#### 4.4.3.4 Community and Natural Resource Impacts

The most significant differences between the Bus/HOV Lane alternative and the Light Rail alternative were in the community and natural resource area. The Bus/HOV alternative was found to have significantly more impacts than the Light Rail alternative in the following areas:

- More acres of right-of-way needed
- More residential units displaced
- More commercial structures displaced
- More neighborhood impacts anticipated
- More noise and vibration impacts anticipated
- More wetland impact
- More parks impacted
- More historic properties impacted
- More hazardous sites potentially impacted

In addition, the Bus/HOV Lane alternative is less compatible with future land use and economic development.

This general finding is consistent with opinions expressed at corridor public meetings and in numerous polls taken. Members of the general public and representatives of most businesses are supportive of the implementation of Light Rail Transit in the Southeast Corridor.

#### 4.4.4 Final Analysis Findings

Based on the results of the analysis described in Section 4.4.2 and 4.4.3, the following alternatives were not recommended:

- Transportation Management alternative was not recommended because it does not address the needs of the corridor.
- The Bus/HOV alternative was not recommended because its capital costs are over \$200 million more than the Light Rail transit alternative and it results in physical impacts that are over 20 times those of the Light Rail Transit alternative (using residential relocations as an example).
- The Fare Lane alternative was not recommended because its capital costs are even higher than the Bus/HOV lane alternative (due to capital costs for tolling equipment) and it would have the same physical impacts.

## Chapter Five: Recommended Corridor Investment

The Southeast Corridor Policy Committee has endorsed a recommendation for Light Rail Transit within the freeway right-of-way. The reasons for the recommendation of Light Rail Transit are:

- It has substantially fewer impacts to existing residences and businesses in the corridor and to natural resources, such as wetlands, parks, and historic properties;
- Its capital costs are as much as \$200 million less than the Bus/HOV alternative.
- It has the greatest potential carrying capacity.
- It has the best travel time.
- It requires the lowest investment per user.
- It has stronger potential for joint development.
- It is reliable and safe.
- It has community support.

The reasons for the recommendation of the freeway alignment (compared to the Buchtel alignment) are:

- It has higher operating speeds and greater reliability;
- It has improved safety because there are no at-grade crossings;
- From a neighborhood perspective, the location along the freeway is generally more compatible with neighborhood character [providing for consolidation of transportation uses (highway and transit) within an existing transportation corridor];
- From Denver University's perspective, vacation of the Buchtel right-of-way allows for a reconfiguration of circulation which is compatible with their redevelopment plans; and
- It results in minimal impact to traffic flow on adjacent streets.

The reasons for the recommendation of the western alignment along I-25 are:

- It is less expensive because no crossings of I-25 are required;
- It is within walking distance of slightly more homes and businesses, likely resulting in 100 to 200 more riders a day;
- It requires slightly less right-of-way; and
- It has less of an impact on wetland resources.

### 5.1 Rail Component

#### Alignment Description

The specific alignment for Light Rail Transit is illustrated generally on Figure 5-1. The 19.7-mile alignment (with 4.5 miles along I-225 and 15.2 miles along I-25) originates at the existing Broadway LRT station. It would then continue in an easterly direction adjacent to I-25, with short tunnel sections to get under existing interchange ramps. Initially, this would be done without replacing the bridges, since virtually all of the bridges have sufficient life to last for the next 20 years. This will be done by removing the wing walls and excavating under the bridge back to the vertical abutment that supports the bridges. Over time, as the bridges are replaced, they will be designed to cross over the new LRT tracks.

Through the Broadway to University segment, the LRT tracks will be placed at the same level as I-25, with Buchtel Boulevard remaining in its elevated position above I-25. At Colorado Boulevard, the alignment would use the Buchtel right-of-way until just north of Evans. The alignment would then continue along the western edge of I-25 and terminate just north of Lincoln Avenue.

The I-225 spur will originate just west of the current I-25/I-225 interchange. At this point, LRT will be in a short tunnel to traverse under the interchange. The tracks will then continue east in the median of I-225, with a termination point just west of Parker Road.

Typical sections are shown on Figure 5-2. The system will be double-tracked, with trains running in both directions throughout the day. Headways will be 7½ minutes in the peak period and 15 minutes in the off-peak period. Maximum speed between stations is 55 miles per hour. Average speed (not including dwell time at stations) is 48 miles per hour.

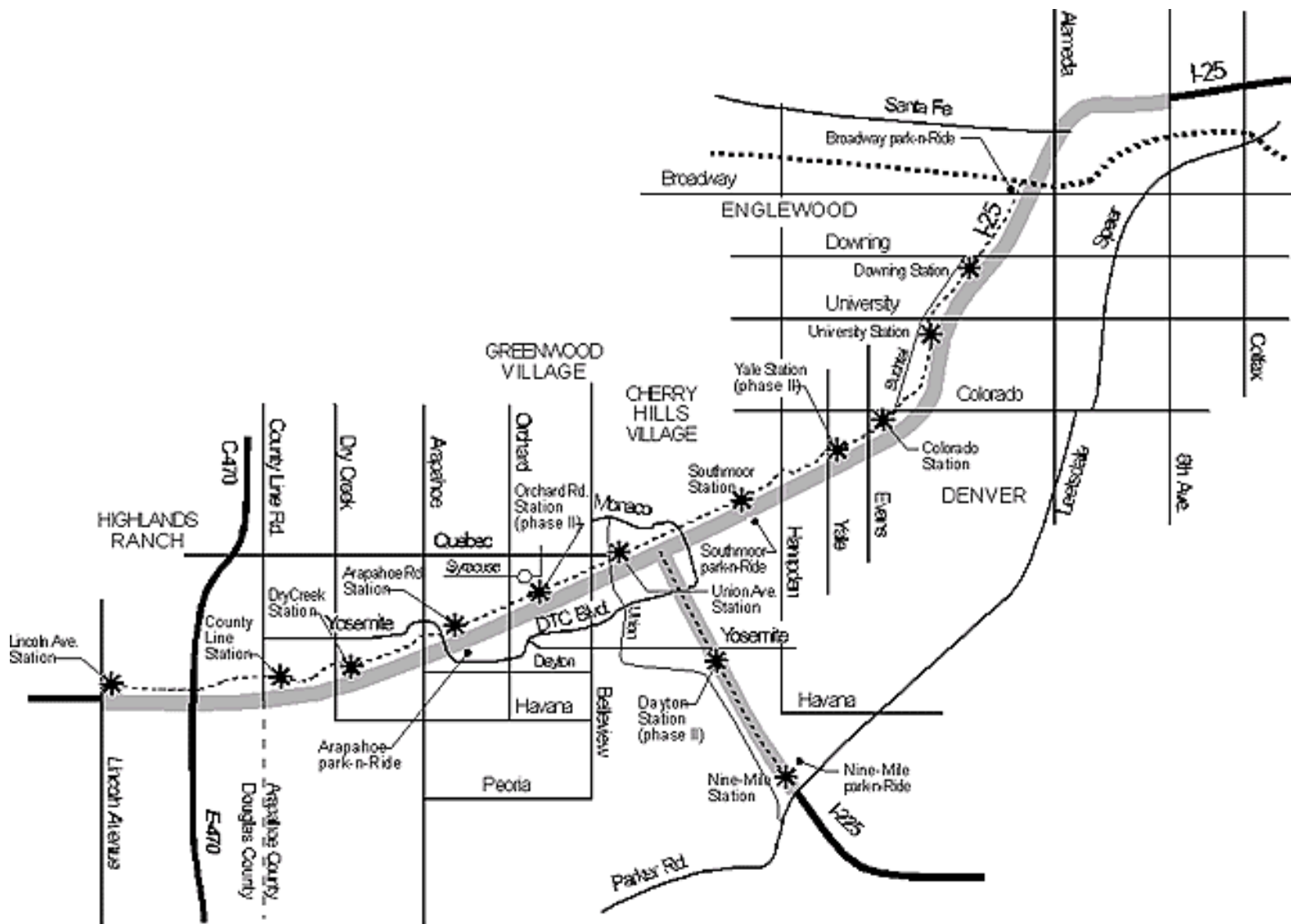
The LRT operating plan assumes peak period service levels in the Southeast Corridor that is divisible by 7.5 minutes. Table 5-1 presents the rail lines and corresponding service levels. In the Southeast Corridor, the LRT peak period operating plan provides 16 trains per hour per direction between I-25/Broadway and Arapahoe, 8 trains per hour per direction from Arapahoe to Lincoln, and 16 trains per hour per direction along I-225.

**Table 5-1**

**LRT Operating Plan**

<b>Rail Line</b>	<b>Peak Period</b>	<b>Off-Peak Period</b>
Lincoln to 30th/Downing	15 minutes	30 minutes
Lincoln to 18th/Stout	15 minutes	30 minutes
Parker to I-25/Broadway	7.5 minutes	15 minutes
Parker to Arapahoe	7.5 minutes	15 minutes

figure 5-1



- Study Area
- Central & Southwest LRT Corridor
- Southeast LRT Corridor
- LRT Stations

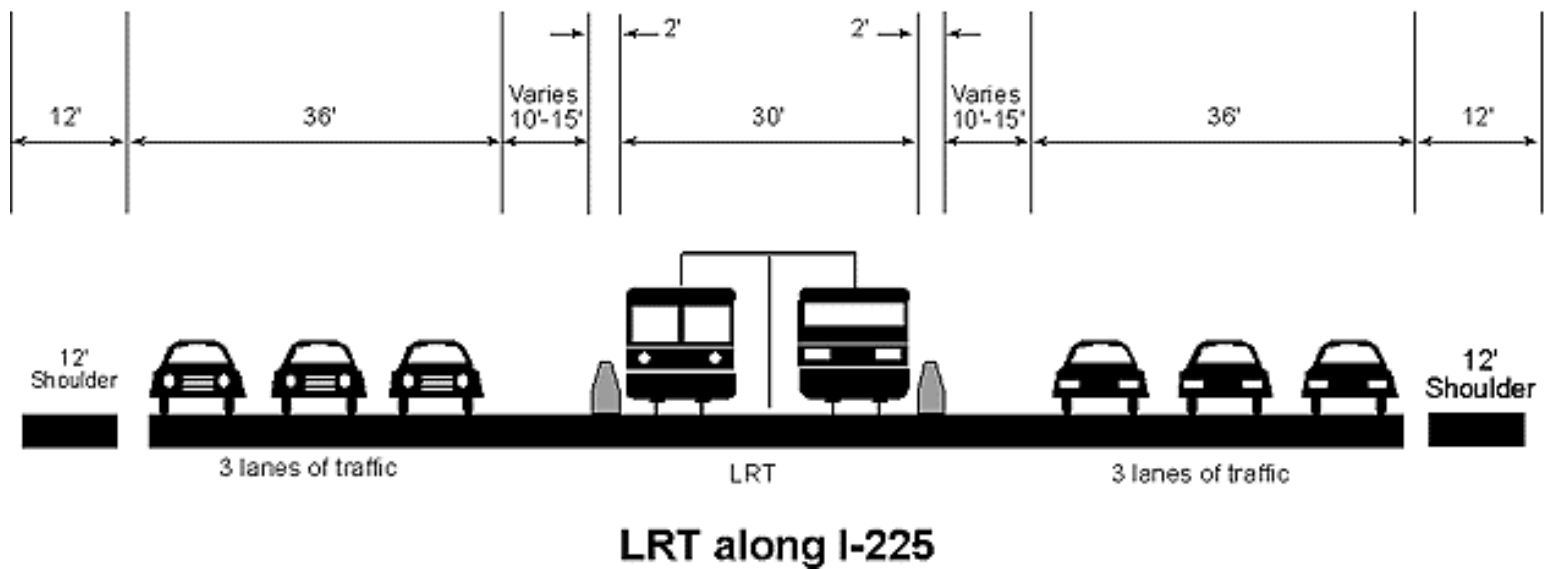
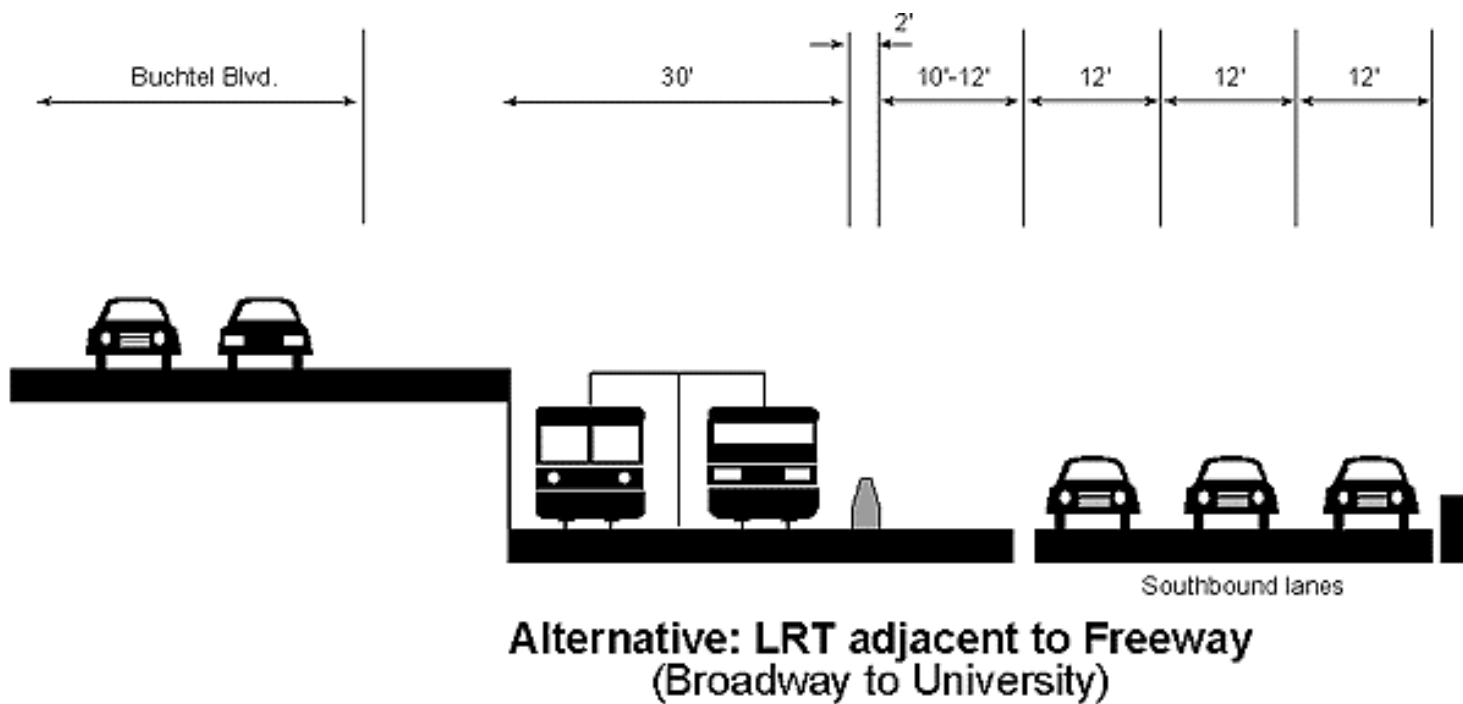
Note: Locations for stations are schematic. These will be finalized during the design process.



#### Highway Elements:

1. Add outside shoulders: Broadway to Evans, and Parker to I-25 (on I-225). Add inside shoulders where feasible: University to Colorado.
2. Minor interchange improvements at University, Colorado, Evans, I-225/I-25, Bellevue, Dry Creek, and County Line Road.
3. Add auxiliary lanes on I-25: Arapahoe to Orchard northbound, ramps from C-470 to County Line Road.
4. Upgrade storm drain outfall.
5. Repave with concrete: Broadway to Evans.

figure 5-2



Daily ridership is estimated to vary between 29,000 and 30,000. Over half of this ridership (approximately 16,000) is estimated to be new riders. Figure 5-3 illustrates ridership at each of the stations.

The alignment will be fully grade separated, with locations for LRT as indicated:

- Broadway crossing (LRT will be under)
- Downing crossing (under)
- University Boulevard (under)
- Colorado Boulevard (under)
- Evans Avenue (under)

- Yale Avenue (over)
- Hampden Avenue (under)
- Union Avenue (under)
- Belleview (over)
- Orchard Road (over)
- Arapahoe Road (over)
- Dry Creek Road (over)
- County Line Road (over)
- C-470 (under ramps and over C-470)

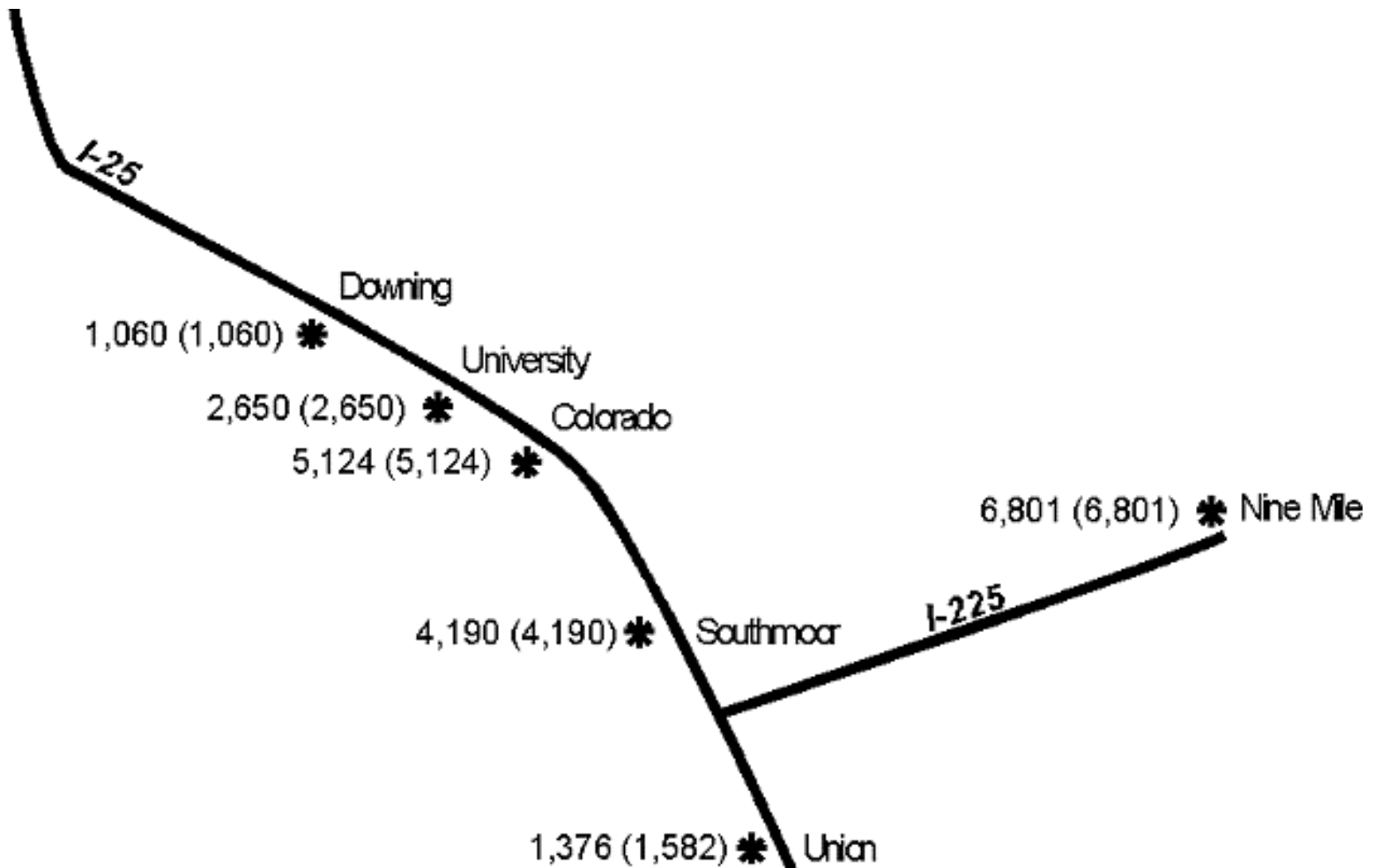
Visual simulations of the alignment were prepared in two locations (at Louisiana and at Union) to assist with illustrating the plans to the public. These are shown in Figures 5-4 and 5-5.

The portion of the alignment south of County Line Road, west of I-25, is not currently within the RTD District. The assumption of this MIS is that prior to construction, this portion of the alignment will be included in the RTD District.

### Conceptual Station Locations

Figure 5-1 also indicates conceptual locations for stations. These exact locations may change during the subsequent design and environmental process. These are listed in Table 5-2.

figure 5-3



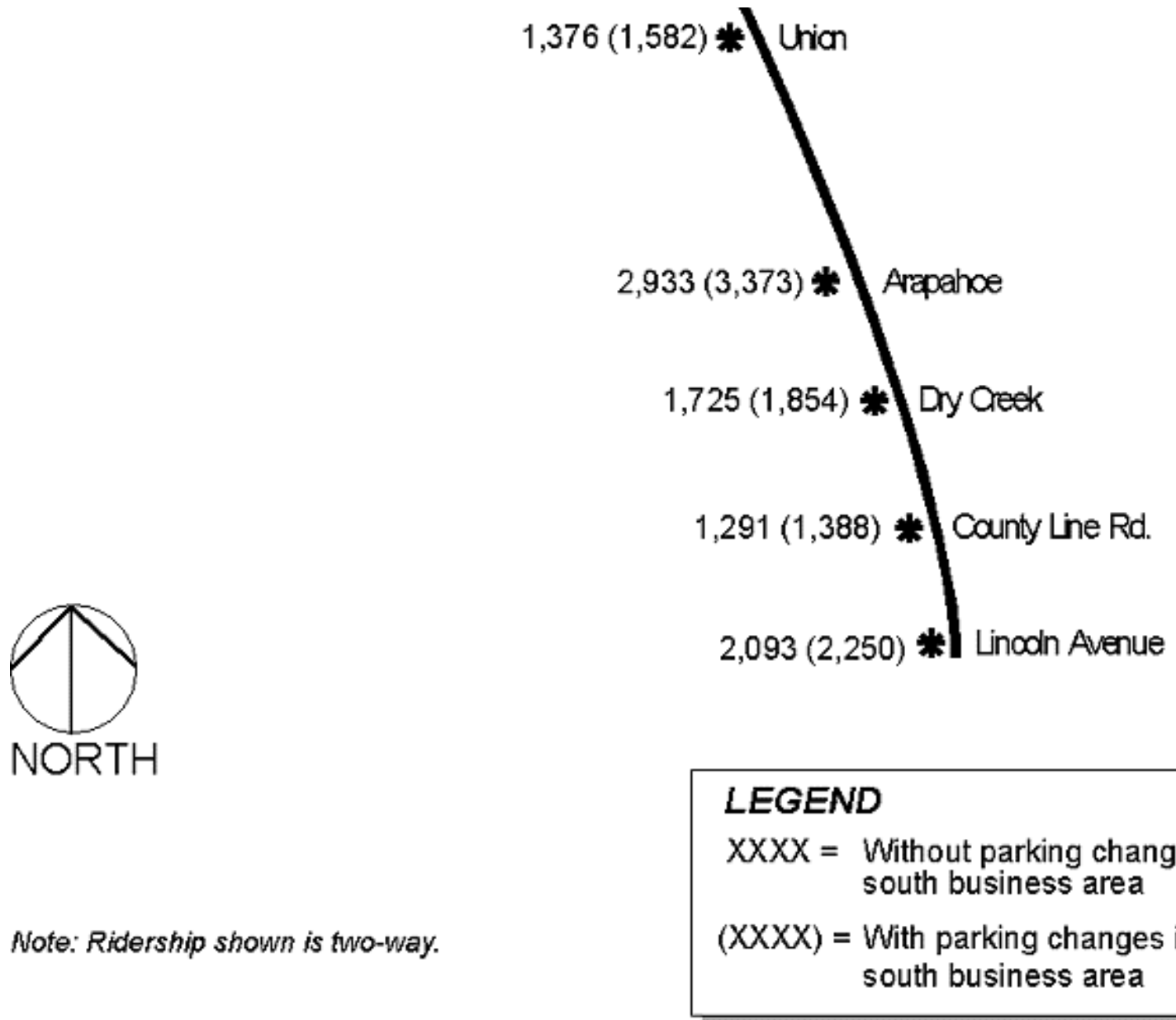


figure 5-4



figure 5-5



Table 5-2

LRT Stations

Station	Buses	Parking	Total # Spaces	Kiss-n-Ride	Walk	Phase I
Broadway	X	X	See note	X	X	--

Downing	X	N	-	X	X	yes
University	X	X	400	X	X	yes
Colorado	X	X	500 **	X	X	yes
Yale	X	N	-	N	X	no
Southmoor	X	X	665 total (465 existing)	X	X	yes
Dayton/Galleria	X	X	-	X	X	no
Parker/Nine Mile	X	X	600 **	X	X	yes
Union	X	N	-	X	X	yes
Orchard	X	N	-	X	X	no
Arapahoe P&R	X	X	458 total (358 existing)	X	X	yes
Dry Creek	X	X	* (see note)	X	X	yes
County Line	X	X	300	X	X	yes
Lincoln Ave.	X	X	600	X	X	yes

\* Assumed to be shared (joint development) parking.

\*\* Assumed to be structured parking.

*Note: 1 Additional capacity will be provided at the Broadway station by RTD. Total capacity will be 1,116 spaces (177 are existing).*

*2. At the Dry Creek Station, the projection on parking spaces needed is 100.*

Parking provided is assumed to be surface at all locations except for Colorado and Nine Mile. In these locations, parking garages are assumed. The Broadway Station will be provided with additional parking capacity by RTD, as an enhancement to the Central Corridor Light Rail project. Costs for this are not included as a part of the Southeast Corridor MIS.

Station locations have been defined in this study primarily to develop a conceptual cost estimate. Additional studies of alternative station locations will be conducted during the subsequent design and environmental process; impacts of these will be defined and mitigation measures identified.

Neighborhood concerns have been expressed about the University area station located east of University. The Union Avenue bus drop-off area located east of I-25 also has problems accommodating bus drop-off needs. These are two examples of stations where alternate sites will be examined during the subsequent design and environmental process and mitigation for impacts will be fully defined.

Cost assumptions in the vicinity of stations addressed primarily corridor improvements. There may be additional

costs for improvements to arterial streets associated with station impacts.

## Bus Service Changes

Bus routes in the Southeast Corridor would be modified to serve the LRT stations along the alignment. These are illustrated on Figure 5-6. Circulator service will be added in the south business park area, providing frequent (every five minutes) service in peak periods, to distribute passengers from the LRT station to their destination.

## Capital Cost

The capital cost for the recommended LRT investment is estimated at \$445 million.

## 5.2 Highway Components

Figure 5-7 illustrates the recommendations for highway improvements. These are described in Table 5-3.

**Table 5-3**

### Highway Elements Recommended

Type of Improvement	Location	Description	Cost
Add outside shoulders; replace asphalt with concrete pavement; add inside shoulders where feasible; build retaining walls on the south side to accommodate traffic detours during construction and to accommodate transit envelope.	Broadway to Evans	Reconstruct I-25 to add a full width outside shoulder, to add area to accommodate traffic during construction and to repave with concrete. The ultimate section between Colorado and Evans will be able to accommodate acceleration and deceleration lanes when the Steele bridge is replaced.	\$24.0M
Add outside shoulders.	I-25 to Parker (on I-225)	Add paved full width outside shoulders.	\$2.3M
Improve interchanges	University/I-25	Reconstruct southern ramps to partial diamond.	\$2.3M
	Colorado/I-25	Signing, striping and signal upgrades; realign ramp.	\$0.4M
	Evans/I-25	Signing, striping and signal upgrades.	\$0.4M
	I-25/I-225 (Phase I)	Braid Belleview northbound on-ramps; extend westbound to southbound gore point north on I-25 to preclude existing weave; construct westbound off-ramp to DTC Boulevard from I-225; construct eastbound on-ramp from DTC Boulevard to I-225.	\$11.3M

	Bellevue/I-25	Signing, striping and signal upgrades.	\$0.4M
	Dry Creek/I-25	Signing, striping and signal upgrades.	\$0.4M

figure 5-6

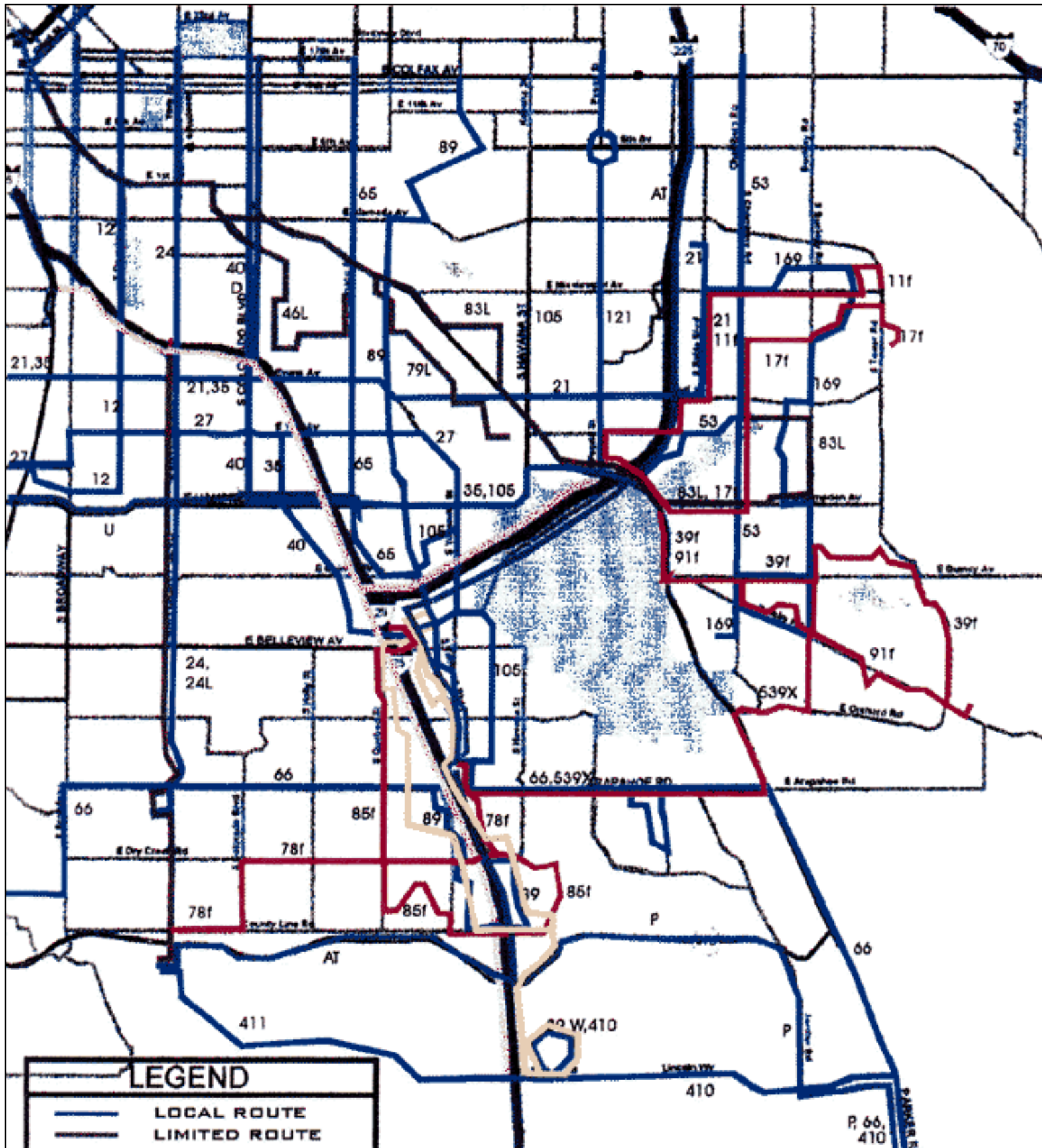
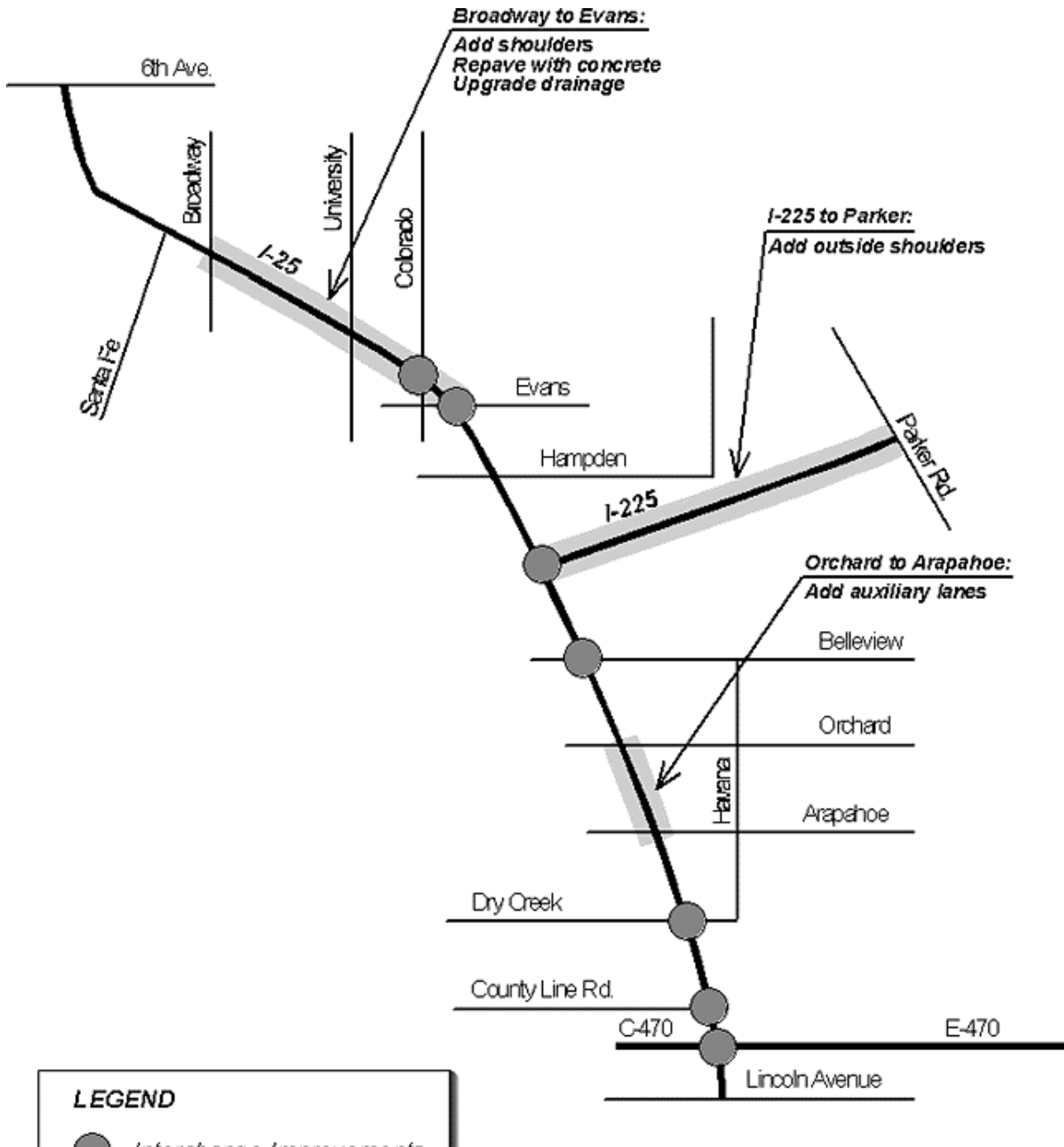




figure 5-7



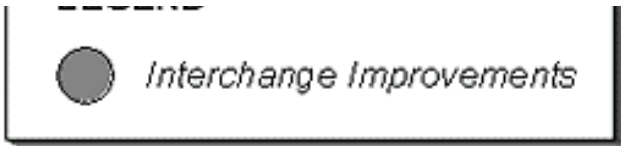


Table 5-3 (continued)

**Highway Elements Recommended**

Type of Improvement	Location	Description	Cost
	County Line Road/I-25	Signing, striping and signal upgrades to interchange and to County Line Road to access station.	\$1.0M
	C-470 to County Line	Create wider merge lanes (to full width); lengthen merge distance on northbound C-470, ending at County Line Road.	\$2.0M
Add auxiliary lanes	Arapahoe to Orchard	Add full width auxiliary lane on I-25 northbound from Arapahoe to Orchard.	\$2.0M
Upgrade drainage	Broadway to Evans	Retrofit the current outfall system which conveys drainage from Evans to Arizona Avenue to address the drainage problem between Broadway and Evans.	\$10.0M
<b>Total</b>			<b>\$57.0M</b>

The two viaducts in the Southeast Corridor which will need to be replaced within the 20-year planning horizon are the Broadway/Santa Fe viaduct and the Evans Avenue viaduct. These viaducts are proposed to be funded with other funds. The cost of these viaducts (approximately \$123 million) is not included as a part of the Major Investment Study recommendation.

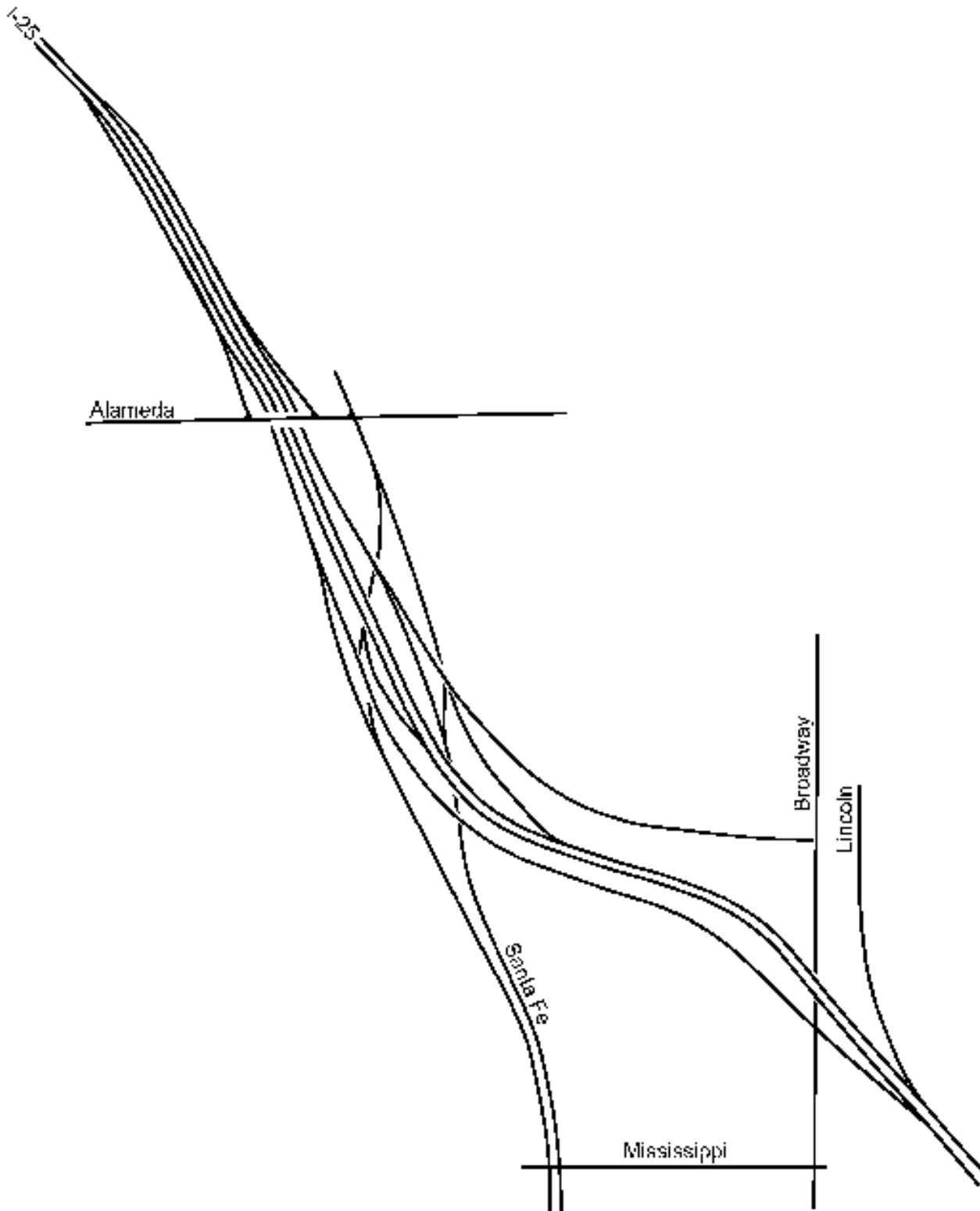
Reconstruction of the I-25 viaduct from Broadway to Alameda will include total replacement. The new viaduct will be immediately north of its present location which will enable the construction while providing traffic to utilize the existing structure.

The distance between the Alameda and Broadway interchange is approximately one mile. This is a preferred minimum spacing for highway interchanges in urban areas. Within this distance, in addition to the two major local access interchanges mentioned, lies the major directional interchange at Santa Fe (resulting in half-mile spacing). In order to accommodate this scenario the interchanges and their associated movements and connections to I-25 must be considered as a single system to meet all geometric and operational requirements while maintaining as many movements as possible. Proposed enhancements include:

- A half diamond at Alameda providing southbound off movements and northbound on movements.
- At the Santa Fe interchange, the predominant movements (i.e., southbound I-25 to Santa Fe, southbound Santa Fe to southbound I-25, northbound I-25 to northbound Santa Fe and northbound Santa Fe to

northbound I-25) are provided with directional ramps. The other four minor movements are provided by the arterial street network, including Alameda, Broadway, and Mississippi. In addition, the ramps between Santa Fe and Broadway are braided.

- A directional northbound I-25 off-ramp has been included to exit directly to Lincoln Avenue.
- The southbound I-25 on-ramp from Broadway is proposed to operate similarly to its existing configuration.
- Santa Fe and Kalamath have been combined north of Alameda to accommodate one grade separated crossing of the mainline railroad tracks and to achieve proper signal spacing along Alameda.



## Alameda/Santa Fe/Broadway Interchange Proposed Improvements

### 5.3 Pedestrian and Bicycle System Improvements

In order to minimize the barrier effect that I-25 and I-225 have related to pedestrian and bicycle circulation in the study area, the recommendation includes pedestrian cross-overs (overpasses or underpasses) in five locations:

- Southmoor station
- Union station
- Arapahoe station
- Dry Creek station (or Dahlia)
- Nine Mile station (along I-225)

These pedestrian cross-overs will be as "pedestrian friendly" as possible.

### 5.4 Intelligent Transportation System Improvements

Improvements which have been included within the general category of Intelligent Transportation System (ITS) Elements include upgrading ramp metering equipment, implementation of real-time, multi-modal transportation information, expansion of traffic signal coordination (per DRCOG's adopted Traffic Signal System Improvement Program) and providing transit enhancements.

These improvements are in addition to those currently in place along the corridor, including continuation of the Mile High Courtesy Patrol, continuation of the programs provided by the Traffic Operations Center, continuation of ramp metering already in place, and continuation of RTD's computerized bus position program.

### 5.5 Land Use Recommendations

Land use elements recommended include formulating policies to promote transit supportive redevelopment at appropriate park-n-Rides; policies to promote improved transit-oriented design; and policies to promote joint development, joint use or shared parking. These policies are the responsibility of the local jurisdictions along the Southeast Corridor.

### 5.6 Transportation Demand Management Recommendations

Transportation Demand Management elements recommended include continuation of the programs currently provided by the Downtown, Southeast, and South Colorado Boulevard/Cherry Creek Transportation Management Organizations (TMOs).

### 5.7 Joint Developmen

Assumptions have been made that some of the planned LRT stations will include joint development. Opportunities for joint development (or private funding) include:

- Donation of all or a part of the right-of-way; or

- Contribution to cover construction of parking, lighting, pedestrian enhancements, or other station costs.

Stations where joint development seems most appropriate are:

- Broadway
- Colorado Center
- Union
- Arapahoe
- Dry Creek
- County Line \*
- Lincoln

*\* Since this station is not currently in the RTD District, the funding assumption is that a portion of the costs for this station would be borne by the private sector and the station would be located in the District. The District boundaries may change in the future.*

The costs defined in Table 5-4 on the next page include assumptions that the following right-of-way costs are joint development costs:

Broadway: All of the right-of-way cost.

Colorado Boulevard: One-half of the right-of-way cost.

County Line Road: One-half of the right-of-way cost.

Lincoln: One-half of the right-of-way cost.

Since the estimate of construction cost for the recommended corridor investment exceeds the budget identified in the Year 2015 Plan, opportunities for additional funding will be sought.

Options include:

- Public referenda, such as the "Guide the Ride" proposal which will be on a ballot in November 1997; and
- Increased joint development funding. The assumptions thus far are that a portion of the right-of-way needed for four stations would be donated. Potential for increasing this contribution includes:
  - Increasing the number of stations that assume some private contribution; and/or
  - Obtaining commitments for participation in specific station elements such as pedestrian cross-overs, parking, lighting, landscaping, access improvements or others.
- Earmarked federal funds from the next Intermodal Surface Transportation and Efficiency Act; and
- State Funds.

These additional funding opportunities will continue to be explored during the next phases of the project.

## 5.8 Preliminary Opinion of Probable Cost

The preliminary opinion of probable construction cost for these improvements, based on conceptual level drawings and unit costs (in 1995 dollars) as defined in the joint three-corridor "Guidance Manual" are listed in Table 5-4.

**Table 5-4**  
**Preliminary Opinion of Probable Costs for**  
**Recommended Corridor Investment**

<b>Capital Cost</b>	<b>Millions of 1995 Dollars</b>
<b>Light Rail</b>	
Right-of-Way	\$38.63
Removals and earthwork	\$2.90
Streets, bridges, retaining walls	\$106.23
Trackwork, signals, system costs	\$56.69
Stations	\$21.92
Maintenance facility	\$8.10
Vehicles	\$53.55
Design Features (1)	\$39.88
Mobilization/contingencies, other costs	\$116.53
<b>Total Light Rail</b>	<b>\$444.43</b>
<b>Highway</b>	
Broadway to Evans reconstruction	\$24.00
Add outside shoulders on I-225	\$2.30
Improve 8 interchanges	\$18.20
Add auxiliary lanes	\$2.00
Upgrade drainage	\$10.00
<b>Total Highway</b>	<b>\$57.00</b>

<b>Transportation Management</b>	
Pedestrian crossing of I-25 at Dry Creek (cost for other pedestrian crossings is included in costs for Light Rail)	\$3.36
Intelligent Transportation System elements	\$5.70
Total Transportation Management	\$8.00
<b>Total Capital Cost</b>	<b>\$510.00</b>

Table 5-4 (continued)

**Preliminary Opinion of Probable Costs for  
Recommended Corridor Investment**

<b>Capital Cost</b>	<b>Millions of 1995 Dollars</b>
<b>Total Annual Operating and Maintenance Cost</b>	<b>\$21.21</b>
LRT Operations Cost Bus Operations Savings (included in \$19.3 million)	\$19.3
Highway Operations Cost (includes savings associated with highway reconstruction in Broadway to Evans segment)	\$0.007
TM Operations Cost	\$1.9

*(1) Includes drainage, utility relocation, noise and environmental mitigation, signing and striping, traffic control, urban design/landscaping.*

## 5.9 Future Corridor Needs

The I-25 corridor is projected to continue to carry increasingly large volumes of people in the future. The most difficult task which confronted the policy makers who were involved in the Southeast Corridor MIS was to recommend a multi-modal transportation solution which was also fiscally constrained. There are additional needs in this corridor that can only be addressed if additional financial resources for construction and operation are made available.

## Chapter Six: Implementation

### 6.1 Next Steps

Once approved and incorporated into the Regional Transportation Plan by the Denver Regional Council of Governments Board of Directors, the recommended corridor investment would be eligible for federal funding to accomplish federally required environmental review, preliminary engineering, design, and construction. Implementing agencies must secure approval of their policy bodies to undertake the recommendations. Federal funding sought by the implementing agencies must be programmed in the Transportation Improvement Program.

The Southeast Corridor MIS was conducted as a precursor to National Environmental Policy Act (NEPA) documentation, as allowed for under federal guidance. Accordingly, all components in the recommended corridor investment will be analyzed in an upcoming NEPA document, which will address how any adverse environmental impacts will be mitigated. Fundamental to the NEPA process are proactive public involvement activities. Mitigation measures will be reflected in the project's design and ultimately the construction of the major investment.

Final design and right-of-way acquisition for component elements of the recommended corridor investment will occur as the environmental process and project funding allow.

### 6.2 Phasing/Sequencing

The first projects that will be under construction in the Southeast Corridor are those for which construction funds have been programmed:

- Replacement of the Yale bridge over I-25; and
- Reconstruction of the I-225/Parker Interchange

The remaining improvements will be dependent on availability of funding, funding restrictions and maintaining the integrity of the existing facility.

Funding availability will significantly influence how quickly the project can be built. The ultimate goal will be to phase construction of logical segments of LRT completion. Advanced highway-related work within the Broadway to Evans section is a logical early construction phase for the corridor. This would include reconstruction of the freeway section with concrete pavement and standard width outside shoulders. Retaining walls would need to be constructed with adequate setbacks to accommodate the LRT envelope. Completion of this freeway section would permit construction of LRT to at least Evans.

Funding restrictions will also need to be evaluated for optimizing corridor construction. An example of restricted funds would be those that can only be used for bridge reconstruction.

Regional priorities should consider future bridge repairs within the corridor where these special funding projects could incorporate as much of the ultimate corridor improvements as possible. The use of these types of special funds would offset costs that would otherwise need to be absorbed as part of the funding needed to construct the LRT.

Projects that maintain the integrity of the existing system can also incorporate components of the ultimate LRT improvements. The addition of the auxiliary lanes, shoulders along I-225 and improvements to the I-25/I-225 interchange, can be constructed as these types of funds become available.