U.S. Department of Transportation

The Effects of Land Use and Travel Demand Management Strategies on Commuting Behavior

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TMIP

Travel Model Improvement Program

Department of Transportation
Federal Highway Administration
Federal Transit Administration
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Travel Model Improvement Program

The Department of Transportation, in cooperation with the Environmental Protection Agency and the Department of Energy, has embarked on a research program to respond to the requirements of the Clean Air Act Amendments of 1990 and the Intermodal Surface Transportation Efficiency Act of 1991. This program addresses the linkage of transportation to air quality, energy, economic growth, land use and the overall quality of life. The program addresses both analytic tools and the integration of these tools into the planning process to better support decision makers. The program has the following objectives:

1. To increase the ability of existing travel forecasting procedures to respond to emerging issues including; environmental concerns, growth management, and lifestyle along with traditional transportation issues,

2. To redesign the travel forecasting process to reflect changes in behavior, to respond to greater information needs placed on the forecasting process and to take advantage of changes in data collection technology, and

3. To integrate the forecasting techniques into the decision making process, providing better understanding of the effects of transportation improvements and allowing decisionmakers in state governments, local governments, transit operators, metropolitan planning organizations and environmental agencies the capability of making improved transportation decisions.

This program was funded through the Travel Model Improvement Program.

Further information about the Travel Model Improvement Program may be obtained by writing to:

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The Effects of Land Use and Travel Demand Management Strategies on Commuting Behavior

Final Report
November 1994

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Preface

This report presents the analytical results of a larger project undertaken for the Federal Highway Administration by Cambridge Systematics, Inc. investigating the "Effects of Land Use and Demand Management on Traffic Congestion and Transportation Efficiency." Prior tasks examined the literature that was available on this subject and explored the utility of either using or augmenting existing databases. In support of this previous work, JHK and Associates, Inc., assessed the potential of using the employment site dataset developed as part of NCHRP Project 3-38(2), "Travel Characteristics of Large-Scale Suburban Activity Centers." It was determined, though, that the site characteristics contained in this NCHRP dataset were not sufficient to support investigation of the interactive effects of land use and travel demand management policies on an employee's commuting behavior.

The work reported herein represents an ambitious program of data collection and analysis with respect to employment sites located in the Los Angeles metropolitan area. Activities were carefully designed so that the most interesting land use and urban design variables could be tested to determine their influence on travel behavior. Data analysis was carried out by Cambridge Systematics, including preparation of this report. Primary contributors included Arlee Reno, Susan Moses, John Suhrbier, Eric Paquette, Anne Martin, Krista Rhoades, and Yoram Shiftan. An initial phase of the project was performed by Sam Seskin.

The data collection design portion of the work was performed by Elizabeth Deakin of the University of California at Berkeley and the firm of Deakin, Harvey, Skabardonis, with advice from other team members and FHWA. The actual data collection was conducted by graduate students from UCLA, under the supervision of Ms. Deakin. Site information, a comprehensive set of Regulation XV data, advice on site selection, and review of the technical results was provided by Professor Genevieve Giuliano of the University of Southern California's School of Urban and Regional Planning, serving as a consultant to Cambridge Systematics, Inc. Data was gathered for the employment site itself, for its immediate surroundings, and for the general environs. All project work was carried out under the overall direction of Fred Ducca of the Federal Highway Administration.

Copies of the compiled "Los Angeles Land Use/TDM" dataset, Accession No. PB95-500427 can be obtained either from the U.S. Department of Commerce, National Technical Information Service, Springfield, VA 22161; or by contacting:

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1.0 Introduction

1.1 Overview

There is considerable current interest in the effects of urban design and land use characteristics on the transportation choices made by commuters. The underlying assumption is that these employment site characteristics have an important influence on a person's willingness to commute by transit, ridesharing, bicycling, or walking – modes other than driving alone. Further, the selection of transportation demand management (TDM) strategies that an employer may choose to implement should be a function of surrounding site characteristics, and that the combination of site characteristics and TDM strategies can have a positive interactive effect in influencing an employee's choice of commute travel mode. While the effectiveness of travel demand management strategies, implemented both individually and in combination, has been investigated, relatively little empirical work has been done to evaluate the interactive effects of land use and TDM strategies on commuting behavior.

For this project, an integrated database of land use characteristics and travel demand management strategies was developed for a sample of specific employment locations in the Los Angeles urban area. The integrated database was constructed by adding land use and site information, developed through field observation, to the "Regulation XV" dataset of the South Coast Air Quality Management District (SCAQMD). The SCAQMD dataset includes information about aggregate employee travel characteristics, and the incentive programs offered by employers. This integrated database was then analyzed to explore the interactions that may exist between travel demand management programs, land use, urban design characteristics, and employee mode of travel. The primary objective was to develop conclusions about the combined impacts of land use and travel demand management strategies on employee travel behavior.

Information was collected regarding the land use and urban design characteristics of a work site, the set of transportation incentives provided to the employees by the employer at that site, and the mode of travel by employees both before and after implementation of the transportation incentives for the trip between home and work. Data were collected and analyzed for individual employment sites. Data were not available regarding the characteristics or travel behavior of individual employees at a given work site, only the aggregate distribution of modal shares. Information was not available in the dataset about the residential end of the work trip. Similarly, data on midday travel, trip chaining, or other related topics were not available.

The second section of this report describes the methodological approach utilized, including the specific data collection and analysis procedures. Findings of the statistical analyses are presented in the third section. The effects of various travel demand management strategies were examined both individually and in combination with land use characteristics. General conclusions are presented in the final section. The overall finding is that an interaction effect does indeed exist. The effectiveness of programs of travel demand management measures is increased at those locations where supportive land use and urban design characteristics also exist.

The results presented here represent an initial or preliminary analysis of an extensive dataset; considerable additional analysis is possible and is encouraged. The integrated employment site, land use/transportation database represents a valuable product by itself. Previously existing datasets do not include descriptions of both land use and travel demand management programs for individual employment sites.

1.2 Background

An examination of trends in travel behavior shows increases in the number of workers per household, licensed drivers per household, vehicles per household, vehicle trips, and average trip length. Both employment and housing are growing at faster rates in suburban than at central city locations, with the majority of employment growth now occurring at suburban employment centers. Auto occupancies are declining and the percentage of single-occupant commuting is increasing. Overall, vehicle miles of travel, in most areas, are growing at a higher rate than either employment or population. The result of these trends is an increasing level of traffic congestion in urban and suburban areas across the country, particularly during peak commute periods. Congestion often exists in newly developing suburbs and semi-rural areas, as well as in central business districts and older residential neighborhoods.

A response to these increasing levels of congestion has been a desire to increase the effectiveness with which existing transportation resources are utilized. While this response has included both the expansion of highway capacity and increasingly sophisticated systems of traffic engineering and control, a variety of transportation demand management measures also have been implemented throughout the country. TDM programs typically include a variety of employer provided incentives aimed at inducing commuters to rideshare, use public transportation, walk or bicycle to work. TDM incentives include ridesharing and transit subsidies, preferential parking for rideshare vehicles, rideshare matching services, facilities for bicyclists (e.g., bike storage, showers and lockers), award programs, and a variety of other miscellaneous strategies.

Over the past two years, experience with transportation demand management (TDM) measures has grown rapidly. For example, it has been found that transit works best in areas with moderate to high densities at both the work and the home end of the trip; ridesharing is most effective for long trips destined for large centers where "matches" can be easily found.

The importance of land use policies and patterns as determinants of travel conditions and choices has increasingly been hypothesized in the last few years, and efforts to avoid and manage traffic problems through more forceful land use planning have received attention. It is believed that the effectiveness of a particular transportation demand measure depends, in large part, on its application in a supportive environment. For example, commute alternative programs are most successful in settings having a mix of uses to which midday trips easily can be made on foot. Where supportive conditions are absent, or when conditions tend to cancel out (as when ridesharing is "encouraged" but convenient free parking is guaranteed), efforts at demand management generally are far less successful.

Project-level planning and zoning controls are one way of affecting transportation through the land development process; measures include exactions and impact fees to help pay for transportation improvements, and conditional approvals requiring on-site traffic mitigation programs.

With respect to urban design, a better matching of transportation to the specific land uses it serves often is advocated. Design objectives aim for environments in which buildings are clustered and uses are mixed; a balance of housing, jobs, and services is available; and the streets, sidewalks, transit stops, and bike facilities are designed to be transit-oriented and pedestrian-friendly. At the regional or large-area level, policies such as urban limit lines, infill incentives, level of service requirements, and control of activities at the rural fringe are considered as means of channeling growth to areas best able to accommodate it, pacing growth to reflect infrastructure availability, and providing incentives to manage travel demand, simultaneously protecting valuable farmland and open space.

An important issue that has arisen is how best to design transportation strategies so that these transportation actions are fully reflective of an area's land use characteristics, and therefore have maximum impact in controlling congestion. Analogously, the urban design characteristics of an employment site can be adjusted so that they are more fully supportive of the particular transportation demand management strategies to be utilized at that particular location than otherwise might be the case. It is argued that by matching carefully conceived packages of transportation demand management programs with land use plans and actions, greater transportation benefits should accrue, such as reduced congestion and improved air quality. Since relatively little work has been done that explicitly sorts out the respective contributions of transportation measures and land use controls, or that identifies and quantifies the synergistic effects of joint land use and transportation actions, this project was undertaken to develop this specific kind of quantitative information.

The underlying hypothesis of this project, therefore, is that land use and urban design characteristics of work sites affect employee work trip mode choices. Furthermore, these land use and urban design characteristics may interact with various employer-based transportation demand management (TDM) strategies to alter commuter work trip mode choice. That is, similar TDM's may cause different changes in mode choice as a result of the mix of land use and urban design characteristics present at different work sites. In order to test these hypotheses, it is necessary to define and quantify the specific aspects of land use and urban design which may actually influence mode choice.

It is further hypothesized that the general quality, ambiance, or environment of a work site, rather than any individual characteristic, helps determine mode choice. It is not necessarily an individual land use or urban design characteristic that influences mode choice, rather it is their **combination** which create a work site environment. For instance, the presence of a vacant lot may not by itself cause a person to choose a different work trip mode of travel. However, that vacant lot may influence a commuter's perception of the overall safety of the work site, with mode choice being affected more by overall safety considerations than by any one particular land use characteristic. In this example, the commuter's perceived safety is an influential site characteristic in determining mode choice, while the presence of a vacant lot (in combination with other individual land use and urban design characteristics) influences the perception of safety. Acknowledgement of this relationship is essential to defining the factors which contribute to mode choice.

2.0 Approach

2.1 Overview

The underlying objective of the analytical portion of this project was to statistically analyze employee commuter behavior at individual employment sites to determine any differences that may exist that are a function of both the particular transportation demand management incentives and the particular land use and urban design characteristics that exist at that site. As indicated in Figure 2.1, the first step involved the definition of the particular variables to be tested.

Assembly of a dataset containing information on the desired variables then constituted the second, and difficult, step of the analysis process. It was determined that no existing dataset contained the desired information on both TDM and land use. Consequently, it eventually was decided to build upon the results of earlier analyses of the data developed for the Southern California Regulation XV Employee Trip Reduction Ordinance that had been conducted by Giuliano, Hwang, and Wachs, (1992),[1] which are primarily oriented to travel demand management (TDM) variables. For a subset of the sites contained in the dataset developed by Giuliano et al, detailed land use and urban design data were collected. The data on urban design and land use were then analyzed in conjunction with the transportation demand management measures that existed at that employment site to determine their respective influence on the choice of travel mode for commuting. The site specific land use/TDM dataset is far more detailed than any data on employment sites and commuter travel patterns previously developed or evaluated. The following subsections describe the analytical methodologies utilized, addressing each of the steps identified in Figure 2.1.

2.2 Selection of Variables to be Analyzed

Work trip mode choice is affected by many factors. Giuliano, Hwang, and Wachs (1992), in their analyses of the Southern California Regulation XV data, classified the factors known to influence commuters' choice of modes into three broad categories: employee characteristics, intraorganizational characteristics of the work place, and environmental factors (Figure 2.2). Employee characteristics were defined as including factors such as workers'

1/ Giuliano G., Hwang K., and Wachs M., "Employee Trip Reduction in Southern California: First Year Results," June 1992

Figure 2.1 Overall Approach to Data Collection and Analysis

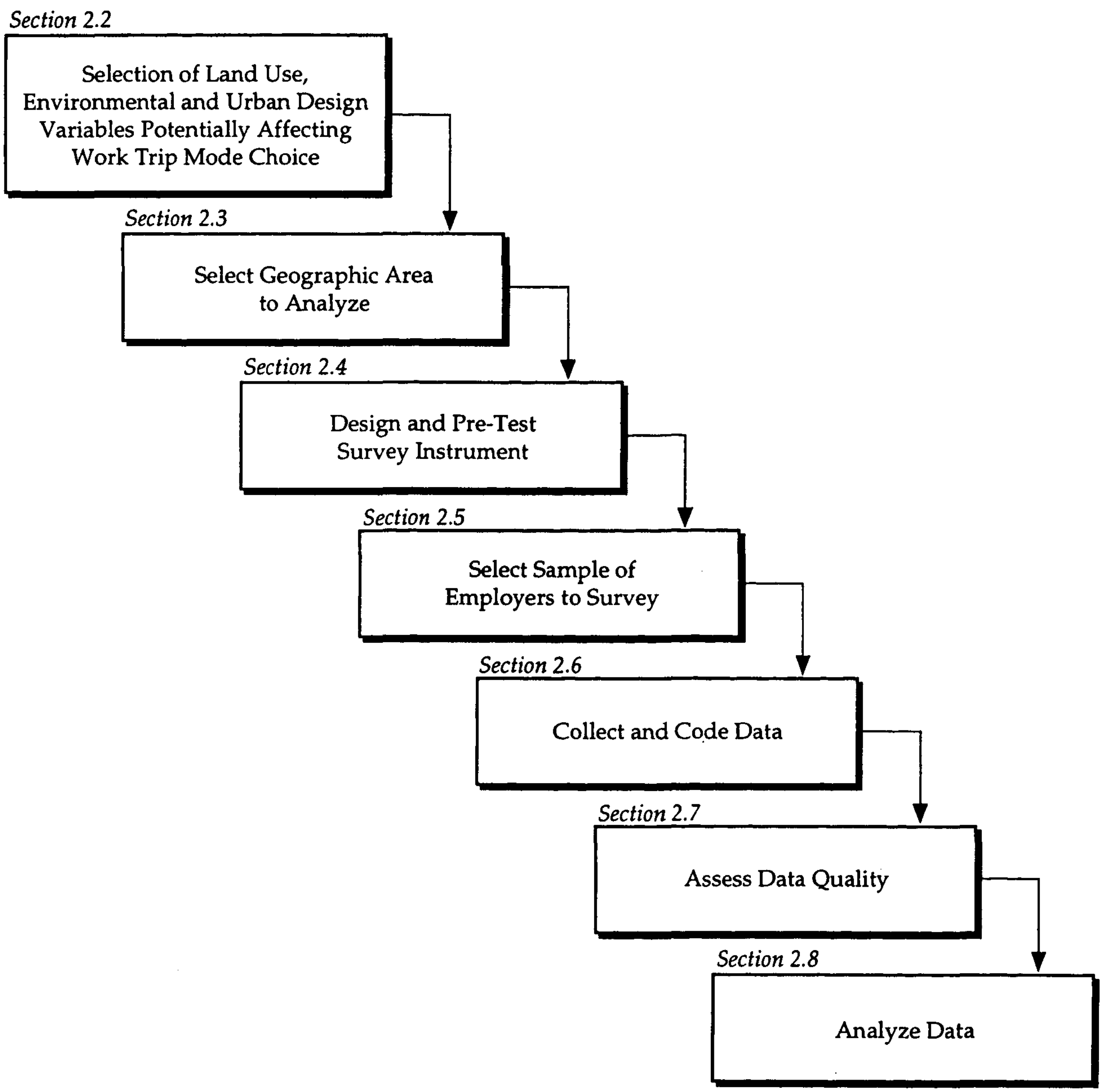
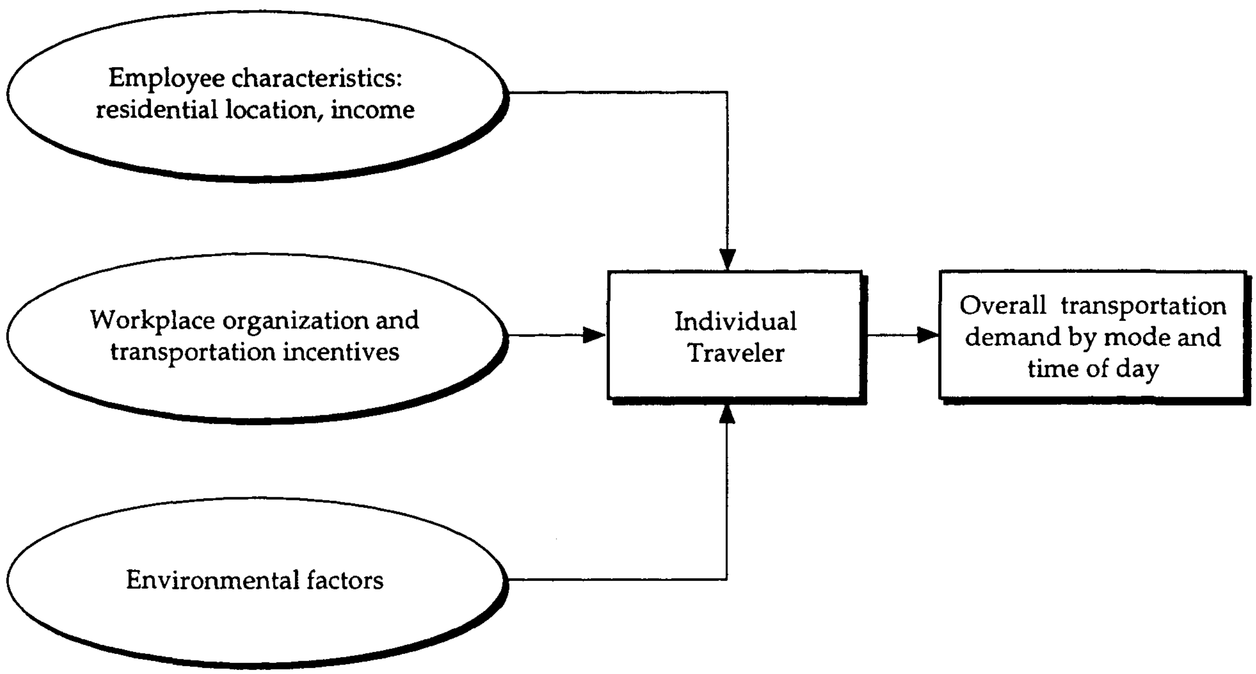


Figure 2.2 Factors Influencing Work Trip Mode Choice



commute distances, incomes, and levels of automobile ownership. Similarly, organizational characteristics defined include factors such as the need in certain industries for all workers to be at work simultaneously, and the degree to which certain jobs require traveling (i.e., sales).

Environmental factors, as defined by Giuliano et al., include transportation supply characteristics, such as the availability of alternative modes and mode attributes (e.g., travel time and cost, parking availability, and congestion); factors that have been shown through prior research to have a strong influence upon commuters' choice of modes. The approach in this project was to build upon the Giuliano et al classification by expanding upon the definition of 'environmental factors' to also incorporate a range of land use and urban design variables.

Land use encompasses factors relating to the spatial pattern of urban development, as well as the distribution of different activities within an urban area. Land use factors hypothesized to influence commuters' choice of modes included accessibility to services, particularly the mix and intensity of services within walking distance of the work place, and employment density. It was hypothesized that increasing the mix and intensity of services within a convenient walking distance encourages the use of alternative modes (e.g., transit, ridesharing, biking, walking) by increasing the feasibility and desirability of making midday trips without using a personal vehicle. Although employment density was not hypothesized to affect commuters' choice of modes directly, it was included because of its strong relationship with the level of transportation services provided, the range and intensity of other services provided, and urban form characteristics.

Urban design relates to the physical characteristics of specific sites. These characteristics include architecture, streetscape, and site layout, and can influence the way people perceive urban environments and, in turn, the way urban environments make people feel. Urban design features hypothesized to affect commuters' choice of travel modes included characteristics that would enhance the aesthetic appearance of the work place, and those features contributing to feelings of comfort and safety. It was hypothesized that these factors encourage the use of alternative modes for the work trip in two ways: 1) by increasing the desirability of using an alternative mode for the work trip itself; and 2) by increasing the desirability of fulfilling midday trip needs without the use of a personal vehicle.

2.3 The Southern California Regulation XV Database

Extensive data on travel demand management measures and employee travel to work sites had been collected in association with the South Coast Air Quality Management District's (SCAQMD) Regulation XV Trip Reduction program. After examining the use of other potential datasets and data collection opportunities, a decision was made to focus data collection efforts upon augmenting the existing Southern California dataset with the desired information on land use and urban design characteristics.[2]

Under the SCAQMD's Regulation XV program, employers having 100 or more employees at any work site within the Los Angeles Metropolitan area are required to develop and implement a trip reduction program aimed at obtaining a specified Average Vehicle Ridership (AVR) target. AVR is defined as the ratio of the number of employees arriving between 6:00 a.m. and 10:00 a.m., to the number of motor vehicles used by the employees. Regulation XV does not require employers to meet their AVR targets, but employers can be fined for not implementing the trip reduction programs.

The Regulation XV trip reduction ordinance was enacted by the South Coast Air Quality Management District in 1988 with implementation phased in over a period of years. Employers having 500 or more employees were to submit plans during the first year. Participation by employers of 200 or more was scheduled for 1989, and employers of 100 or more were phased in during 1990 and later years. In January 1994, the SCAQMD decided in the form of Rule 1501 to undertake a review of implementation experience with Regulation XV. The intent of the review is to identify options that could both reduce implementation costs to individual employers and increase effectiveness in terms of the magnitude of emission reductions that are being achieved.

As a part of the Regulation XV program, information was collected for each work site. Data included work site characteristics, time series data describing initial and follow-up trip reduction measures implemented, mode share, and AVR information. Data pertaining to individual employees, however, was not included. The resulting information was incorporated into a database as part of the investigation completed by Giuliano, Hwang, and Wachs [1992] of the results of the first year of the Regulation XV program. Two basic criteria were used for inclusion of a work site in the database: 1) the site had to have

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2/ The SCAQMD Regulation XV dataset included travel demand management variables and employee travel behavior, but no land use variables at the employment site. Thus, additional data collection was necessary to add site-specific land use variables.

An alternative dataset considered was one that included land use variables and employee travel behavior information at a national sample of employment sites having over five million square feet of existing floor space. Developed by JHK and Associates, Inc. as part of NCHRP Project 3-38(2), "Travel Characteristics of Large-Scale Suburban Activity Centers," this dataset had the disadvantage of lacking information on the specific travel demand management information that existed at each employment site.

An exploration of the feasibility of adding travel demand management variables to the NCHRP dataset indicated that it was very difficult for people to either remember or estimate what kind of travel demand management actions or programs had been in effect at the time the data on travel behavior was collected. For the Regulation XV database, not only was it judged to be easier to assume that overall site variables had not changed since the travel data was collected, but the travel data was more recent and included different years of travel behavior and travel demand program information for each site. Since the South Coast data promised more opportunities and fewer difficulties, a decision was made by FHWA and the project team that available resources would be best devoted to enhancement of the South Coast dataset by adding the land use variables to the already existing travel demand management and travel behavior information.

submitted and received approval for first and second year trip reduction plans as of August 1991; and 2) data for the site had to pass certain tests for logic and consistency. The resulting dataset covered 1,110 work sites, or 27 percent of the 4,032 total sites that had received approval for their plans as of August 1991.

Many employers and especially larger employers in Los Angeles County, already had implemented a variety of TDM measures prior to enactment of the Regulation XV ordinance by the SCAQMD. Since all TDMs are not, therefore, a direct result of Regulation XV, the estimates of effectiveness derived from the SCAQMD database will be an underestimate, all else being equal, of actual impacts if true before and after data were available.

2.4 Survey Instrument Design

The primary aim in designing the survey instrument was to identify urban design and land use variables that would provide a comprehensive picture of the work site and its environs. A secondary aim, though, was to supplement some of the data already contained in the Regulation XV dataset, particularly information on parking and transit accessibility. Given the desire to test hypotheses about the relationship between urban design variables and work trip mode share, a particular emphasis in designing the survey instrument was placed upon identifying variables that would describe the 'friendliness' of the area to specific modes, particularly walking, bicycling, transit, and car and van pools. Another emphasis was upon defining measures of accessibility to services, including both the mix and intensity of services within walking distance of the site.

To meet these data collection objectives, a survey instrument was designed to gather information at three distinct levels. The first level of information focused upon the general environs of each work site ranging from one-half square mile to two square miles from the work site area. Data collection at this level was focused upon understanding the 'friendliness' of the area to specific commute alternatives. Specific data elements defined for collection at this level were grouped into two categories: land use and street characteristics, as shown in Table 2.1.

The second level of data collection involved the area within one-quarter mile of the work place. Information gathered at this more detailed level was designed to provide an understanding of the feasibility and desirability of satisfying midday trip needs by walking. Data items collected described the accessibility of the site to services and the quality of the travel paths between the work place and services. Although some information collected at this level covered topics similar to those addressed within the site environs, such as land use and street characteristics, the information collected at this level was much more detailed. Examples of specific data elements collected at this level are shown in Table 2.2.

Table 2.1 Data Elements – General Environs of the Site

Land Use	Street Characteristics
• Land use mix	• Identification of the main streets
• Predominant single land use	• Traffic levels
• Special features or notable sites	• Presence of sidewalks
• Building types	• Landscape quality

Table 2.2 Data Elements – Site Area (One-quarter mile radius)

Land Use

Land Use Mix

- Horizontal
- Vertical

Presence of Specific Land Use Types

- Residential
- Office
- Retail
- Heavy industrial
- Light industrial
- Auto-related
- Institutional
- Open space
- Parking (off-street)
- Personal services
- Business services

Services

Presence, Frequency, and Distance to Specific Services

- Restaurants/coffee shops
- Groceries
- Banks/ATM machines
- Parks/open space
- Child care
- Dry cleaning/laundry
- Drug stores
- Entertainment: movies,videos, etc.
- Haircuts
- Health club/exercise/dance
- Copies
- Post office
- Travel agent
- Parking lot
- Parking structure

Street Characteristics

- Street type
- Median
- On-street parking
- Level of traffic
- Street layout
- Mix of Traffic
- Noise level

Streetwall Characteristics

- Building set-back
- Quality of streetwall
- Adjacent uses
- Signage
  - Parcel use
  - Unrelated to use (e.g., billboards, graffiti)

Sidewalk Characteristics

- Presence of sidewalk
- Pavement type
- Level of maintenance
- Sidewalk zones
  - Tree/shrub planting strip
  - Arcades/awnings
  - Street furniture

Pedestrian Characteristics

- Types of pedestrians
- Extent of pedestrian activity

Landscaping Characteristics

- Presence of trees
- Tree size and spacing
- Shade effect

The third scale of data collection was the work site itself. Data gathered at this level focused upon understanding the general ambiance of the site and its immediate surroundings. The intent of work-site data collection was to understand the environment that employees would encounter both in arriving at a particular work site and in choosing to spend their lunch hour within the immediate vicinity of the site. A summary of the data items collected for the work site is shown in Table 2.3.

A copy of the final survey instrument used for field data collection is provided as Appendix A to this report. Given the volume and complexity of the data to be collected, an extensive instruction sheet was prepared for use by field staff along with the survey instrument. A briefing also was held to instruct field staff. Both the instructions and survey form were refined based upon a pretest that was conducted at several sites. A copy of the the instructions provided to the field staff is provided as Appendix B.

2.5 Sample of Employment Sites Surveyed

The full Regulation XV database covers the entire South Coast AQMD regulatory area, a 13,000-square mile region encompassing Los Angeles County, Riverside County, Orange County and the non-desert portions of San Bernardino County. Given the extent of urban design data desired as well as the need for on-site data collection, collecting on-site data from firms across such a large area would have been prohibitively time consuming. Consequently, it was necessary to focus the data collection efforts on a sample of the 1,110 sites in the Regulation XV database. To determine the desired sampling approach, the 1,110 sites were examined to determine the range in those factors thought to most strongly affect urban form: location, land use, scale, and employment density.

The 1,110 sites were grouped by zip code and mapped by location to determine the extent of geographic clustering. After the sites were mapped, the clusters and isolated sites were analyzed to determine representation along the other factors, including types of land uses, scale, and employment density.

The majority of the 1,110 sites, approximately 68 percent, contained in the Regulation XV database are located within Los Angeles County. Twenty-one percent of the sites are located within Orange County, and the remaining sites are fairly evenly divided between San Bernardino and Riverside Counties.

Mapping of sites illustrated that there was substantial geographic clustering. Major clustering occurred within downtown Los Angeles, Hollywood, and in the major employment centers in the corridors stretching from the downtown Los Angeles area to western Los Angeles, to Santa Monica, and to the Los Angeles International Airport. Other major clusters were found in Orange County, within the vicinity of Santa Ana and the Orange County Airport.

Table 2.3 Data Elements – Work Place Characteristics

Parcel and Block Characteristics

- Block form
- Block density
- Floor-to-area ratio (FAR)
- Parcel size
- Number of parcels in block
- Block dimensions

Transportation Characteristics

- On/Off-street parking
- Distance to bus stop
- Distance to rail transit
- Width of sidewalk at main entrance
- Typical sidewalk distance in area
- Number of cyclists

Building Characteristics

- Building size
- Architectural style
- Aesthetic appearance
- Building materials
- Building set-back
- Orientation
- Scale
- Building maintenance

Given both the distribution of sites geographically and the logistical implications of on-site data collection, the decision was made to focus the data collection efforts on the sites within Los Angeles County. Based upon the mapping of sites and the analysis of their representation of the range in land uses, scale and employment densities, a sample of 330 work sites was selected from the 761 work sites within Los Angeles County.

2.6 On-Site Data Collection

For the 330 selected employment sites, data collection was completed from March through July 1993. Data were collected by graduate students in urban planning, urban design, and related fields from UCLA. Since some of the data to be collected, such as pedestrian activity or traffic levels, were items that varied by time of day and day of the week, surveyors were instructed to observe this type of information during standard weekday business hours. This ensured that observations made were consistent with the environment that an employee would encounter during the standard work day. Data collection included completion of the survey form, diagrams, maps, and photographs of each site.

2.7 Data Quality Assessment

Three different means were utilized to evaluate the quality of the collected data. Coding of the data provided the opportunity to examine maps of the sites along with the data and surveyor comments provided on the survey form. Through the coding process, a small number of data elements were identified where there were clearly differences in interpretation among field staff or simply a lack of understanding of the information desired. Missing values for certain data elements also provided clues as to information that was not understood by the surveyors.

A second opportunity for assessing data quality was provided by independently sending two different teams of data collectors to collect the same information at five of the selected sites. With the exception of certain data elements that could be expected to vary with time and day of observation, such as level of traffic or pedestrian activity, the data collected by one team of data collectors under an 'ideal' scenario would have exactly replicated the results of the other. Although the size of the subsample, five, was too small to gauge data quality with any statistical significance, it did help identify particular data elements that could be of potential concern.

The final test of data quality was a series of logic tests undertaken to check specific variables, and the relationships between variables, for reasonableness and consistency. For example, tests were completed to determine the number of sites identified both as having several different land uses within the vicinity <u>and</u> as 'single use.' These types of tests, checking for multiple conditions that would not reasonably be expected to occur simultaneously, also helped to assess the quality of the data that had been collected.

Based upon these assessments of data quality, a small number of variables were identified as being of potential concern. Even though some variables were thought to be reasonably objective to measure, there were some cases where it was clear data collectors did not understand the particularly information desired. Examples of this first type of problem included items such as floor-to-area ratio (FAR), block and parcel size, number of bus lines, street type, and street set-back. For example, FAR values were missing in over 98 percent of the site observations.

Some data elements proved to be problematic simply because they proved to be more subjective to measure than originally expected. Among this group of variables were items such as land use grain, and presence of trees. Although the difficulty with some of these data elements, such as the presence of trees, was unexpected, it is possible that different data collectors set different thresholds for the frequency with which a characteristic needed to occur (e.g., number of trees) before they would indicate a characteristic was present at the site.

Certain data elements also proved to be more difficult to measure than anticipated, even though they are not inherently subjective or abstract concepts. Examples include the presence of certain services within walking distance of a site. Follow-up visits to sites indicated that, in some situations, landscaping obscured particular land uses. To thoroughly observe the presence of all services within walking distance in large suburban locations having extensive landscaping proved to require an extensive amount of time to completely walk within one-quarter mile of each building and site and examine the specific services offered. A quick review of signage and streetwall frontage proved insufficient for such site locations.

2.8 Data Analysis

Distribution of Site Characteristics

The first part of the data analysis involved an examination of the employer and transportation characteristics of the subsample of 330 sites used in the urban design survey. As tabulated in Tables 2.4, 2.5, and 2.6, the characteristics examined include the degree of variation in AVR, site attributes, trip reduction incentives, mode share, and change in mode share between implementation and one year following implementation. Table 2.4 identifies the percentage of sites by AVR, location, industry type, and size classifications. Table 2.5 tabulates the mix of trip reduction incentives utilized. Table 2.6 examines and compares AVR and mode share.

These tables also present a comparison of the 330 and 1,110 site databases, noting statistical significance (at the 0.95 level), to provide an indication of the difference between the 330-site subsample and the larger 1,110-site sample. However, just as the 1,110 work sites do not necessarily reflect a random sample of the employment sites subject to the Regulation XV ordinance, the 330 subsample was not intended to be fully representative of

Table 2.4 Distribution of AVR, Location, and Industry Characteristics

	Percent of Sites		Statistically Significant
	330 Subsample	1,110 Sample	
AVR Target			
1.3	0.3	2.7	Yes
1.5	97.0	93.4	Yes
1.54	0.0	0.1	No
1.63	0.0	0.1	No
1.75	2.7	3.7	No
Sub Areas			
(1) Los Angeles County Central	13.2	11.7	No
(2) Los Angeles County West	14.1	6.0	Yes
(3) Los Angeles County South	4.0	4.6	No
(4) Los Angeles County Southwest	16.0	8.1	Yes
(5) Los Angeles County East	12.6	5.4	Yes
(6) Los Angeles County Remote West	7.1	3.4	Yes
(7) Los Angeles County Remote Northeast	7.4	9.3	No
(8) San Fernando Valley	5.8	6.5	No
(9) Burbank,Glendale,Pasadena	6.1	7.9	No
(10) Long Beach	13.8	4.8	Yes
(11) San Bernardino County	0.0	5.9	Yes
(12) Riverside County	0.0	4.7	Yes
(13) Orange County North	0.0	13.0	Yes
(14) Orange County South	0.0	8.1	Yes
(15) Remote Area	0.0	0.5	Yes
Area			
L.A. Central (1)	13.2	11.7	No
L.A. County (2,3,4,5,7,9,10)	73.9	46.2	Yes
Suburb (6,8,11,12,13,14,15)	12.9	42.1	Yes
Industry (SIC Code)			
Ag/Fo/Fi/Mi	0.6	0.6	No
Construction	0.0	0.2	No
Manufacturing	30.5	36.3	Yes
Tran/Comm/Util	19.7	17.2	No
Whole/Retail	13.8	13.5	No
Fire	7.4	5.4	No
Services	23.7	22.6	No
Public Office	4.3	4.2	No
Business			
Manufacturing	30.5	36.3	Yes
Service/Service Related	49.2	45.7	No
Others	20.3	18.0	No

Table 2.5 Distribution of Employer Size and Trip Reduction Incentives

	Percent of Sites		Statistically
	330 Subsample	1,110 Sample	Significant
Size			
250 or less employees	27.4	28.6	No
251 or greater employees	72.6	71.4	No
Incentives			
Preferential Parking Area	71.6	67.7	No
Transit Subsidy	53.2	49.0	No
Guaranteed Ride Home	52.0	47.8	No
Prize Drawings	47.7	48.2	No
Bike Racks	41.0	43.0	No
Regional Commuter Management Agency Matching	40.7	36.9	No
Information Booths	36.1	31.9	No
Flexible Work Hours	34.3	31.7	No
Commuter Information Center	32.4	27.1	Yes
Other Marketing Elements	28.7	24.7	No
Carpool Subsidy	27.8	29.0	No
New Hire Orientation	27.8	25.8	No
Employer Based Matching Service	25.7	26.3	No
Compressed Work Week Program	25.1	21.4	No
Other Employee Benefit	24.2	23.7	No
Showers and Lockers	22.9	21.9	No
Other On-Site Services	19.9	16.2	No
Cafeteria/ATM/Postal/Fitness Center	19.6	19.2	No
Company Owned/Leased Vanpool	19.0	15.9	No
Walk Subsidy	18.7	18.6	No
Preferential Parking - Carpool	17.8	16.4	No
Bike Subsidy	17.1	17.7	No
Vanpool Subsidy	14.7	13.9	No
Auto Service	13.8	13.8	No
Special Interest Group	11.3	12.8	No
Recognition in Newsletter	10.4	12.9	No
Commuter Fairs	9.5	11.7	No
Telecommuting Program	8.9	8.8	No
Other Financial Subsidy	8.0	8.0	No
Additional Time Off With Pay	6.1	7.1	No
Rideshare Parking Subsidy	4.3	2.5	No
Introductory Transit Pass Subsidy	4.0	5.5	No
Vanpool Seat Subsidy	3.7	3.6	No
Other Facility Improvement	3.4	3.2	No
Passenger Loading Area	2.4	1.7	No
Preferential Parking - Vanpool	1.2	1.8	No
Other Parking Management	1.2	2.1	No
Transportation Allowance	1.2	0.5	No
Employee Parking Subsidy	0.9	0.7	No
Childcare Services	0.9	1.2	No

Table 2.6 Distribution of Transportation Mode Shares at Implementation and One Year Later

	At Implementation			One Year After Implementation		
	Mean			Mean		
	330 Subsample	1,110 Sample	Statistically Significant	330 Subsample	1,110 Sample	Statistically Significant
Average Vehicle Ridership	1.213	1.208	No	1.245	1.243	No
Drive Alone Share	0.762	0.766	No	0.714	0.714	No
Carpool Share	0.125	0.134	No	0.174	0.188	Yes
Vanpool Share	0.009	0.007	No	0.013	0.011	No
Bus Share	0.046	0.038	Yes	0.043	0.036	Yes
Other Mode Share	0.033	0.031	No	0.028	0.028	No
Telecommuting Share	0.005	0.004	No	0.003	0.003	No
Compressed Work Week Share	0.020	0.018	No	0.024	0.020	No

the characteristics of the full 1,100-site database. While there are differences between the two datasets, as noted below, the overall conclusion is that the 330 sample is approximately representative of the SCAQMD database as a whole.

As visible from Table 2.4, the 1.3 AVR target was under represented in terms of statistical significance and the 1.5 AVR target was statistically over-represented within the 330-site subsample. The AVR targets are based upon geographic location. The AQMD assigned low-density areas an AVR target of 1.3, while developed urban and suburban areas are targeted for 1.5 AVR and the Los Angeles CBD has an AVR target of 1.75. Several geographic areas within the Regulation XV Los Angeles metropolitan area differ in their representativeness within the two datasets. As discussed in Section 2.5, Sampling, the data collection effort was limited to locations within Los Angeles County. Therefore, San Bernardino, Riverside, and Orange Counties are not represented in the 330-site subsample, and sites including north, southwest, east, and remote west Los Angeles County and Long Beach are over-represented compared to the larger 1,110-site sample. As indicated in Table 2.4, manufacturing was the only type of industry with a significant variation between the two samples. Both the size of the work site, based upon number of employees, and trip reduction incentives for the 330-site subsample were representative of the 1,110-site sample.

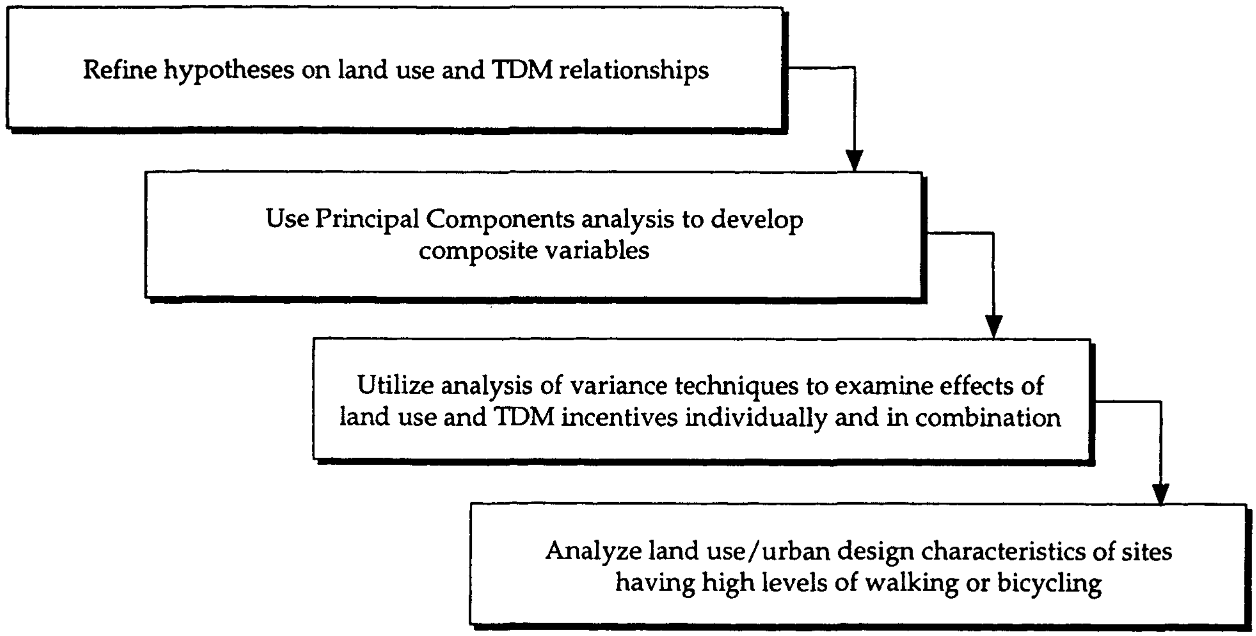
The comparison between the 1,110-site and the 330-site subsample presented in Table 2.6 identifies statistically significant differences for bus share at implementation of plan, and for carpool share and bus share one year later. Based upon the calculated means for mode share, the bus share is over-represented in the 330-site subsample for both implementation years. This difference presumably is due to the restriction of the data collection to Los Angeles County. Areas such as San Bernardino and Riverside Counties, that are contained in the larger 1,110-site sample, do not have comparable bus systems to those existing in Los Angeles County.

Overview of Analysis Methodology

The land use, urban design, and transportation incentive data collected for the 330 employment sites were analyzed using a combination of Principal Components analysis and standard analysis of variance statistical techniques. As shown in Figure 2.3, the first step in the analysis involved a refinement of the hypotheses concerning the effects of land use and urban design characteristics and TDM incentives on the commute trip mode choice. Principal Components analysis was then used to identify groups of land use variables having similar impacts. The intent was to derive a small number of composite variables that could be used to capture the overall characteristics of a site.

Standard analysis of variance techniques were used next to examine the effects of groups of land use and urban design characteristics and trip reduction incentives both individually and in combination. The findings presented in Section 3.0 focus on this phase of the data analysis. Finally, groups of employment sites having certain transportation characteristics in common were analyzed to determine if these sites also shared any land use or urban design characteristics. It is in this context that the subset of sites having a high percentage

Figure 2.3 Analysis of Data



of people that commute by either walking or bicycling are examined as a part of the Section 3.0 findings.

Identification of Composite Land Use and Urban Design Variables

It was hypothesized that the interactions of individual site characteristics could be very significant. For instance, the presence of a sidewalk and the level of area traffic each may have some influence in measuring the accessibility of services. A sidewalk may enhance accessibility slightly, while increased traffic may inhibit accessibility slightly. However, an area which combines high traffic and no sidewalk may have much lower accessibility than would be expected given that each individual influence is slight. Thus, an analysis methodology is required that allows for the many potential interactions of a site's individual land use and urban design variables to be combined into a meaningful estimate of site characteristics.

The method of Principal Components was used to create composite variables.[3] [4] Briefly, Principal Components analysis can reduce a large number of variables into a smaller set of uncorrelated composite variables. The Principal Components method creates composite variables, called principal components, which are orthogonal linear combinations of the initial variables. For p different initial variables, a total of p different principal components can be formed. The linear combinations are formed sequentially to explain as much of the variability in the initial variables as possible. The first principal component explains the most variation in the initial variables; the second principal component explains the second

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3/ Morrison, D.F., Multivariate Statistical Methods, 2nd Edition, New York; McGraw-Hill Book Company, 1976.

4/ An alternative methodology considered was to test the individual land use and urban design characteristic variables using standard analysis of variance techniques. One could determine which variables had the greater influence on mode share and the change in mode share after the implementation of TDM's. These variables could then be called proxies for the groups of site qualities. For instance, if sites that had vacant lots present nearby experienced a lower than average shift from driving alone to transit use, one might infer that the presence of vacant lots signifies an unsafe area. It seems reasonable that commuters would be less likely to shift from driving alone if their safety is in jeopardy. Similarly, variables that would be proxies of the other site characteristics could be tested.

It was concluded that there were serious difficulties with this technique because of the large number of variables involved. With this many variables, it would be extremely difficult to test all potential interactions. If only five variables are tested as proxies for each of five possible site qualities, there are more than 30 combinations of the variables and their interactions which would have to be tested for each quality. There are also problems of severe multicollinearity (correlation among supposed independent variables) when testing high level interactions which make selection of the appropriate variables an unwieldy task. Another problem is the high number of variables compared to the relatively small number of observations.

Another methodological option considered was to develop an index of each of the site qualities based on individual characteristics. Creating an index a priori to measure the presence of groups of these features at a given site is not feasible for two reasons. First, to do so requires assumptions about the relationships between the individual characteristics and the composite feature being examined. Second, there is potentially a high degree of correlation among the individual characteristics. Each poses serious difficulties to accurate identification of influential factors.

most variation; etc. Because there is correlation among the initial variables, this allows the bulk of the variation to be explained in relatively few principal components.

Principal Components analysis is perhaps most easily understood geometrically. Figure 2.4 shows a cluster of points for n observations of variables x and y. The first principal component explains the most variation, so it will be the linear combination that spans the line shown by P1. Each of the n observations will receive a principal component score, p_{1i} where i is one of the n observations, that is a linear combination of the values of each of the n values x_i, y_i.

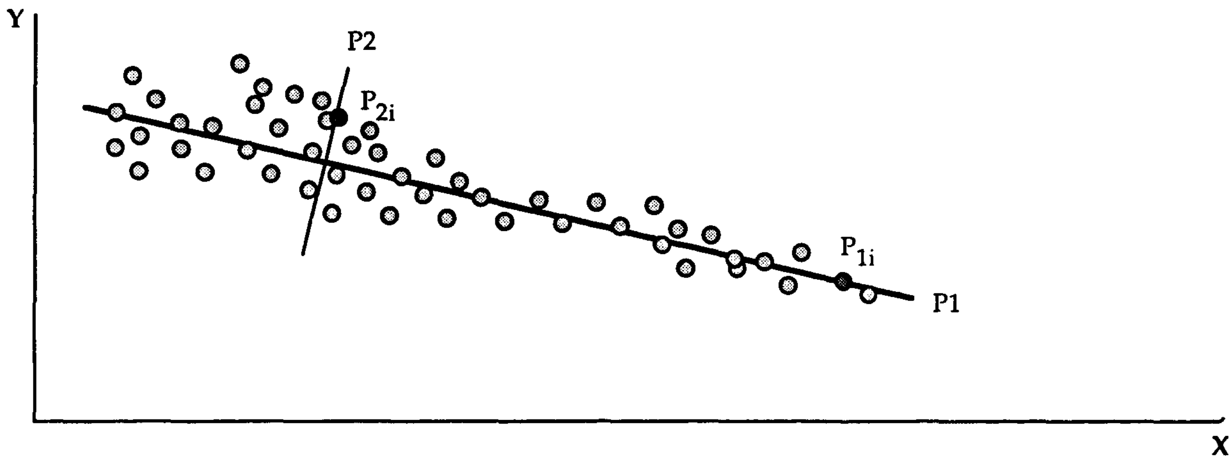
The value of the first principal component, P_{1i}, represents a point on the line P1. Similarly, the second principal component (in this case the only other possible) explains the second most variation in the cluster, so it will be the result of the linear combination that spans the line shown by P2. The value of the second principal component, p_{2i}, will represent a place on the line P2. Finally, the principal components by definition are orthogonal (perpendicular), and thus they will be perfectly uncorrelated. This eliminates any potential problems with multicollinearity.

While this interpretation is applicable for any number of variables, it is most easily visualized in the two-variable instance. If there are three initial variables, there is a three-dimensional cluster of points which would be spanned by three orthogonal principal components. While Principal Components analysis cannot be visualized beyond the three-variable case, the same properties hold true.

Because a principal component is a linear combination of the individual variables, it can easily be seen how each variable influences the principal component by looking at each individual coefficient. In the individual example shown in Figure 2.4, P1 = -.707x + .707y. This means that as x increases, the value of the first principal component decreases. The principal component increases in value when the value of y increases. In this case, the coefficients are equal so each variable has the same impact on P1. In most cases, the coefficients would not be equal. The variable with the larger coefficient has the greater impact on the value of the principal component.

The particular site characteristics determined to influence commuter mode choice are the perception of safety, the accessibility of services for walking on midday trips, the availability of convenience services, the mix of surrounding land uses, and the aesthetics of the area surrounding the work site. Each of these site characteristics results from a mix of the individual land use and urban design characteristics of the area, contained in the data base, and also some unmeasured characteristics. It is possible to estimate the general site characteristics by combining individual land use and urban design characteristics. For example, the augmented Regulations XV data includes variables to help capture the "friendliness" of the area to various commute alternatives (i.e., variables that measure land use and urban design characteristics within two miles of the work site), the ease of satisfying midday trip needs by walking (i.e., variables that measure land use and urban design characteristics within one-quarter mile of each work site), and the general ambiance of the site and its immediate surroundings (i.e., variables that measure the land use and urban design characteristics of the work site itself). By combining land use and urban design variables in meaningful ways, quantifiable variables of the more general site characteristics, such as safety, can be established. These composite variables can then be used to quantify the influence of the various site characteristics on commuter mode choice.

Figure 2.4 Principal Component Analysis



P_{1i} = $-.707\,X_i + .707\,Y_i$

P_{2i} = $.707\,X_i + .707\,Y_i$

Furthermore, the interaction of land use and urban design variables with TDM incentives can be tested to determine additional impacts of implementing TDM's in particular environments.

Table 2.7 lists the individual land use and urban design characteristics from which the principal components were developed. These reduced variable groups were compiled based on a combination of statistical analysis and expert opinion. They were the variables deemed most important to each of the principal components. Diagnostic measures were performed on the independent component variables to test for the potential problems of heteroskedasticity and multicollinearity. These tests indicated that the data were within acceptable parameters, and that remedial measures were not warranted.

The mix of land uses was represented by a principal component of variables which indicated the presence of residential, office, retail, and personal services within one-quarter mile of the work site. As the variety of these land uses increases, the "mix" of land uses increases.

The presence of convenience services was measured by a principal component of variables that indicated the presence of restaurants, banks, child care centers, dry cleaning, drug stores, and post offices within one-quarter mile of the work site. As the number of these services increase, the value of the component measure increases.

The accessibility of services was measured by a principal component of variables indicating the presence of four or more services within walking distance, sidewalks, transit service, and the level of traffic around the site. As each of these variables increases, the value of the principal component increases.

The perception of safety was measured by a principal component of variables which indicate the presence of street lighting, vacant lots, and sidewalks, and the level of pedestrian activity in the area. Street lighting, sidewalks and increased pedestrian activity raise the value of the principal component and the presence of vacant lots reduces it.

The aesthetic level of each site was measured by a principal component of variables indicating the presence of trees and shrubs, wide sidewalks and graffiti around the site. Trees and shrubs and wide sidewalks enhance the level of aesthetics, while graffiti diminishes aesthetic appeal.

Determining Effectiveness of Commuting Behavior

With principal components developed, empirical testing of their impacts on mode choice was possible. Standard analysis of variance techniques were used to determine if the prevalence of the different principal components corresponded to different mode shares.[5] For example, the drive alone share was compared in areas with principal components that indicate high safety with those that were not as safe. If the drive alone shares were found

5/ Neter, John, Wasserman, William and Kutner, Michael H., Applied Linear Statistical Models: Regression, Analysis of Variance and Experimental Design, 3rd Edition, Boston: Richard D. Irwin, Inc., 1990.

Table 2.7 Composite Land Use/Urban Design Variables

Independent Variables	Principal Component
Offices within 1/4 mile of site Residential development within 1/4 mile of site Retail development within 1/4 mile of site Personal services within 1/4 mile of site Open space (parks) within 1/4 mile of site	Mix of Land Uses
Restaurant(s) within 1/4 mile of site Bank(s) within 1/4 mile of site Child care within 1/4 mile of site Dry cleaner(s) within 1/4 mile of site Drug store(s) within 1/4 mile of site Post office within 1/4 mile of site	Availability of Convenience Services
Presence of numerous services (four or more) Frequency with which certain services are present Presence of sidewalks Traffic volume Transit stop	Accessibility of Services
Absence of vacant lots Pedestrian activity Sidewalks Street lighting	Perceived as Safe
Absence of graffiti Presence of trees and shrubs in the sidewalk zone Wide sidewalks Minimal building setbacks	Aesthetically Pleasing

to be different by an amount that was statistically significant at a .95 level of confidence, then safety was considered a significant influence on the drive alone share.[6]

Similar analysis of variance techniques were employed to measure the impact of the TDM incentives. Mode shares were compared in areas with and without different types of transportation incentives. TDM incentives were categorized into one of four groups: financial incentives; assistance programs; flexible work hours; or awards programs. Significant differences in the mode share were attributed to the impact of a TDM. Measures which did not cause a statistically-significant shift in mode share were considered unsuccessful. Trip reduction incentives were analyzed both individually and in combination.

Finally, the interaction affects of land use characteristics and TDM incentives were evaluated. An interaction effect captures impacts that may not have been found by combining the land use with the TDM impacts in a simple additive manner. Mode shares in areas having both particular land use features and TDM incentives were compared to their expected levels given the features and incentives taken individually. Statistically significant differences were attributed to the interaction of the land use of urban design features with the trip reduction program.

6/ The determination of statistical significance used throughout the analyses is based on a difference of means t-test having a 95 percent level of confidence. The difference in the means of two values is compared taking into account the standard errors in their respective values, where the standard error is an indication of the precision of the mean. Imprecise estimates of mean will have relatively large standard errors, whereas precise estimates will have relatively small standard errors. By comparing the standard errors with the difference between the means, one can determine the likelihood of the difference being the result of random imprecision of the estimated means. Testing with 95 percent confidence implies that the likelihood is less than five percent that the difference between two values is simply due to random error.

The test is applied by comparing the difference in the two means to the sum of their respective standard errors. If the sum of the standard errors is larger than the difference between the means, the difference in the means may be due to random errors in estimation. If the size of the difference is larger, then it is unlikely (less than five percent likely in this case) that the difference is due to random error, and is instead an indication that with a 95 percent level of confidence that real differences exist between the two factors being compared.

3.0 Findings

This section presents findings related to the impact of land use and urban design characteristics when combined with transportation demand management (TDM) strategies on work trip mode share. To understand this combined impact, it is important first to identify the impact of transportation demand management measures alone, as well as land use and urban design characteristics alone. Section 3.1 identifies, for the entire sample, the change in mode share between Year One of the analysis (i.e., pre-Regulation XV) and Year Two of the analysis. Section 3.2 describes the impacts of individual TDMs as well as groups of TDMs on mode share across the 330-site dataset.

Hypotheses regarding how land use and urban design characteristics interact with different categories of TDMs to affect work trip mode choice are evaluated in Section 3.3, examining five different categories of land use and urban design characteristics. Mode shares in areas that display particular land use and urban design characteristics are compared to sites that do not have these characteristics. In addition, changes in mode share between sites that share the same land use characteristics but have adopted different types of TDMs are identified. Shifts in mode share when TDMs are introduced in areas that exhibit similar land use and urban design characteristics are documented. These shifts are compared to changes in mode share in areas that do not exhibit these characteristics. A summary of these findings is presented in Section 3.4.

The chapter concludes with an examination of sites having two special characteristics. Section 3.5 evaluates conditions at employment sites having a higher than average walk or bicycle mode share in order to identify the land use and urban design characteristics of these sites that
autosave/cad may be unique. Section 3.6 then examines sites having a low level of single-occupant vehicle commuting.

3.1 Change in Mode Share After TDM Implementation

Table 3.1 displays the average change in work trip mode share between the base year 1988, and the first year after implementation of TDMs for the 330-site dataset. Over the period, the drive alone share decreased from 76.2 to 71.4 percent, an absolute change of 4.8 percent. This shift was more than accounted for by an absolute increase of 5.4 percent for ride-sharing, which accounted for 13.4 percent of all work trips in the base year, and 18.8 percent in Year Two. In relative terms, ridesharing increased by 40.3 percent, a notable increase which can be attributed to the introduction of TDMs.

Table 3.1 Change in Work Trip Mode Share

Mode	Base Year	Implementation Period Year Two***	Absolute Percent Change	Relative Percent Change
Drive Alone	76.2	71.4	-4.8	6.3
Rideshare*	13.4	18.8	5.4	40.3
Transit	4.6	4.4	-0.2	-4.3
Other**	5.8	5.4	-0.4	-6.9
Average Vehicle Ridership (AVR)	1.22	1.25	0.03	+2.5

* Carpool and vanpool.
** Bicycle, walk, etc.
*** The second year varies for each site within the sample, based on when TDMs were implemented at the site. All second year data were collected between 1990 and 1992.

Table 3.2 Categories of TDM Strategies

Financial Incentives

- Transportation allowance
- Bike subsidy
- Carpool subsidy
- Introductory transit pass subsidy
- Other financial subsidy
- Vanpool seat subsidy
- Transit subsidy
- Vanpool subsidy
- Walk subsidy
- Rideshare parking subsidy
- Additional time off with pay
- Other employee benefits

Flexible Work Schedules

- Flexible work hours
- Telecommuting program
- Compressed work week program
- Compressed work week program

Assistance Programs

- Commuter information center
- Commuter fairs
- New hire orientation
- Other marketing elements
- Special interest group
- Regional commuter management agency matching
- Employer-based matching service
- Information booths
- Company owned/leased vanpool
- Other parking management

Award Programs

- Prize drawing - free meal certificate
- Recognition in news letter

Other

- Child care service
- On-site services (e.g., cafeteria, health club, post office)
- Auto service

Both transit and walk/bicycle mode shares decreased (-0.2 percent and -0.4 percent respectively) over the period. (These shifts were not significant at the 95 percent confidence level.) It appears that commuters using these modes switched to ridesharing. This shift may be accounted for by the fact that there were many more categories of incentives offered exclusively for carpooling (10) versus transit (2) and walk/bicycle (4). The rideshare incentives also may have provided bigger financial rewards than those offered for transit and walk/bicycle. (The database does not provide information regarding the magnitude of individual financial incentives.)[1]

The average vehicle ridership (AVR) increased slightly from 1.22 in the base year to 1.25 after employer implementation of the their TDM programs. This is a relative increase of 2.5 percent.

3.2 Impacts of Transportation Demand Management Strategies

A total of 31 different transportation demand management strategies were implemented by employers within the survey sample. As shown in Table 3.2, these strategies can be grouped into five categories: financial incentives, flexible work schedules, assistance programs, award programs, and other strategies. Financial incentives include all TDM strategies that provides an employee with a financial reward for participation. TDM strategies that provide employees with opportunities to alter work schedules to avoid a five day per week rush hour commute are classified under the category of flexible work schedule. Strategies included in the category of assistance programs are those that provide information regarding alternative modes, and help with ride matching. Award programs include prize drawings and recognition in company publications. The category of "other" includes three strategies that do not logically fall under any of the first four categories. Financial disincentives in the form of pricing measures were not implemented at any of the employment sites, and thus are not listed in Table 3.2.

As a group, financial incentives were the only strategies that showed a statistically significant impact on mode share. Table 3.3 displays the shift in drive alone and in ridesharing when financial incentives were absent compared to when they were present. At sites where financial incentives were absent, the average drive alone share decreased by 1.7 percent in the period after implementation of TDM strategies compared to the before period. In contrast, the drive alone share decreased by 6.4 percent when financial incentives were offered. The carpool share increased by 3.2 percent in the absence of financial incentives, compared to 5.7 percent when financial incentives were present. Financial incentives did not have a statistically significant impact on the shift in transit or other modes.

1/ Analysis of variance tests indicate that seasonal changes (i.e., weather) do not significantly affect the bike/walk or transit mode shares, or AVR.

Table 3.3 Impact of Financial Incentives on Mode Share

Mode	Shift in Commute Mode Shares 1989-1991		
	Percent Change When Financial Incentives are Absent	**Percent Change When Financial Incentives are Present**	**Difference (Incentives Present – Incentives Absent)**
Drive Alone	-1.7	-6.4	-4.7
Carpool/Vanpool	3.2	5.7	2.5

Table 3.4 Impact of TDM Strategies on Drive Alone Mode Share 1989-1991*

Strategy	Percent Change in Drive Alone When Absent	Percent Change in Drive Alone When Present	Difference (TDMs Percent – TDMs Absent)
Bicycle Subsidy	-4.4	-7.1	-2.7
Vanpool Seat Subsidy	-4.7	-10.1	-5.4
Transit Subsidy	-3.2	-6.3	-3.1
Vanpool Subsidy	-4.4	-7.7	-3.3
Other Employee Benefits	-3.9	-8.0	-4.1

* Includes strategies that, when present, result in a statistically significant shift from the drive alone mode share at the 95 percent confidence level.

Individual financial incentives that resulted in a statistically significant shift from the drive alone share were bicycle subsidies, vanpool seat subsidies, vanpool subsidies, transit subsidies and other employee benefits. The differences in the drive alone share with and without these subsidies are shown in Table 3.4. Two individual financial incentives, vanpool seat subsidies and transit subsidies, are statistically significant in influencing a shift to carpooling over the period (Table 3.5). It is unlikely, though, that transit subsidies, per se, are actually increasing the carpool share. Instead, the increase in carpool share is likely being caused by carpool incentives which are correlated with the offering of a transit subsidy. That is, firms offering transit subsidies are also providing ridesharing subsidies. While vanpool subsidies probably are actually increasing the vanpool share, there are indications in the data that some employers report vanpooling as part of carpooling.

Individual incentives in the categories of assistance programs, award programs, flexible work schedules, and other had small impacts on mode share that were not statistically significant. Assistance programs as a group, when offered in conjunction with financial incentives, did have a statistically significant impact on the change in AVR over the study period, leading to the conclusion that assistance programs help to facilitate the effectiveness of financial incentives.

■ 3.3 Impacts of Land Use and Urban Design Characteristics on Work Trip Mode Choice

As described in the previous chapter, the technique of principal components analysis was used to develop composite variables to describe areas with land use and urban design characteristics. Composite variables derived using principal components analysis were then used in subsequent analyses to identify the impacts of these individual land use characteristics on work trip mode choice, as well as the impacts of combinations of land use characteristics and TDM strategies on mode choice. Each of the identified land use characteristics was matched with each category of TDM (e.g., mix of land uses and financial incentives; preponderance of convenience services and assistance programs; etc.) It was hypothesized that the change in mode share away from drive alone would be significantly greater when TDMs and land use/urban design characteristics were combined than when TDMs were implemented at sites that did not exhibit the land use characteristics. Analysis of variance techniques were used to test the interactive impacts of the composite variables describing land use characteristics and TDM strategies on mode share. The results of these analyses are described below.

Areas Characterized by a Mix of Land Uses

It is commonly hypothesized that as the number and mix of land uses in close proximity to a work site (i.e., within one-quarter mile) increase, work trip mode shares may shift away from the single-occupant vehicle toward alternative modes. This shift may occur because workers are able to make midday trips (both business and personal) by foot, bicycle, or

Table 3.5 Impact of TDM Strategies on Ridesharing 1989-1991*

Strategy	Percent Change in Carpool/Vanpool When Absent	Percent Change in Carpool/Vanpool When Present	Difference (TDMs Present – TDMs Absent)
Vanpool Seat Subsidy	4.7	10.3	5.6
Transit Subsidy	4.0	5.6	1.6

* Includes TDM strategies, that when present, result in a statistically significant shift from the drive alone mode share at the 95 percent confidence level.

public transit. In addition, employees who live within walking distance of their work may be able to walk or bicycle to their jobs. It also is hypothesized that the relative effectiveness of TDMs is increased at sites with a diverse mix of uses. As the number and strength of TDMs are increased, the mode share may shift even further away from the single-occupant vehicle toward alternative modes.

The analysis conducted partially support these hypotheses. Statistical analysis reveals financial incentives are the only category of TDMs that significantly affect mode shifts areas having a mix of land uses.[2] Table 3.6 shows the difference in share for each mode based on changes in land use mix, and whether or not financial incentives were offered.[3] For each mode share and for Average Vehicle Ridership (AVR), the table shows the percentage of workers using that mode at sites with:

- A limited mix of land uses where no financial incentives were offered;
- Sites with a limited mix of uses where financial incentives were offered;
- Sites with a broad mix of land uses, but no financial incentives; and
- Sites with both a broad mix of land uses and financial incentives available.

The table also shows the standard error associated with each mode share.

As shown in Table 3.6, when the absence or presence of financial incentives is held constant, land use mix does not impact drive alone mode share to a degree that is statistically significant. That is, in areas with no financial incentives offered, there is no significant difference in the drive alone mode share between sites with a limited mix of land uses and sites with a broad mix of land uses. This is also true for sites where financial incentives are offered.

Conversely, when land use mix is held constant, the introduction of financial incentives does have a significant impact on drive alone mode share. At sites with a minimal mix of land uses, the drive alone share decreases by 5.5 percent from 77.2 to 71.7 percent when financial incentives are offered. Similarly, when financial incentives are offered at sites characterized by a diverse mix of land uses, the drive alone mode share decreases by 4.4 percent from 75.2 to 70.8 percent. While in terms of the percentage change in drive alone mode share, the impact of incentives is greatest in areas without a mix of land uses, it is important to realize that the drive alone mode share in mixed uses areas is smaller to begin with. Thus, while the percentage change is smaller, financial TDMs offered at sites with a

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2/ Reference the discussion of statistical significance on page 2-23.

3/ In Tables 3.6 through 3.11 and throughout the analysis, flexible work schedules are treated as a "mode of travel" consistent with their treatment in the original SCAQMD Regulation XV dataset. The percentages contained in the five cells – drive alone; transit; car and van pool; flexible work schedules; and bicycle, walk, other – sum to 100 percent.

For the TDM incentives identified in a particular table, the results reflect a comparison of post- and pre-implementation data. For the land use or urban design characteristic identified, the comparison is between sites with and without that particular characteristic.

Table 3.6 Land Use and Urban Design Feature: Land Use Mix

With and Without Financial Incentives

Financial Incentives	% Drive Alone* – Limited Mix	% Drive Alone* – Substantial Mix	% Transit – Limited Mix	% Transit – Substantial Mix
No	**77.2** (1.1)	**75.2** (1.0)	**3.6** (0.5)	**5.5** (0.5)
Yes	**71.7** (1.4)	**70.8** (1.1)	**2.9** (0.5)	**6.4** (0.7)

Financial Incentives	% Car and Van Pool – Limited Mix	% Car and Van Pool – Substantial Mix	% Flexible Work Schedules – Limited Mix	% Flexible Work Schedules – Substantial Mix
No	**13.4** (0.9)	**13.0** (0.7)	**2.4** (0.5)	**2.7** (0.5)
Yes	**18.7** (1.0)	**17.7** (0.7)	**4.0** (0.9)	**1.9** (0.3)

Financial Incentives	% Bicycle, Walk, Other – Limited Mix	% Bicycle, Walk, Other – Substantial Mix	AVR – Limited Mix	AVR – Substantial Mix
No	**3.0** (0.3)	**3.6** (0.3)	**1.218** (0.016)	**1.229** (0.015)
Yes	**2.6** (0.3)	**3.1** (0.3)	**1.230** (0.017)	**1.271** (0.019)

Land Uses Mix

* The modal share percentages are averages (mean percentages), across all worksites in the sample.
Standard Error = (0.0); 95% Confidence Level

mix of land uses will result in a lower drive alone mode share than when offered at sites without a mix of uses.[4]

When the drive alone mode share at sites with neither a mix of land uses nor financial incentives is compared to the drive alone mode share at sites with both a mix of uses and financial incentives, the difference in drive alone share is 6.4 percent (77.2 percent versus 70.8 percent, respectively). This difference indicates that there is indeed an interactive effect between land use mix and financial incentives that result in a smaller work trip drive alone mode share when both are present.

While land use mix alone does not significantly impact the drive alone share, it does result in shifts in the transit mode share. Among sites that do not offer financial incentives, sites with a mix of land uses have a 1.9 percent higher transit mode share than do sites without a mix of land uses. Among sites where financial incentives are offered, sites with a mix of land uses have a 3.5 percent greater transit mode share for work trips than areas without a mix of land uses.

For sites characterized by both a limited mix of land uses and no financial incentives, the transit mode share is 2.8 percent lower than at sites with both a diverse mix of uses and the presence of financial incentives. In areas characterized by a limited mix of land uses, the introduction of financial and TDM incentives appears to shift trips from transit to rideshare and flexible work schedule, resulting in a lower transit mode share than if no incentives are offered. One reasonable explanation for this shift is that more of the incentives encourage ridesharing than transit use. In addition, it is likely that transit service is more limited and less convenient in areas having a limited land use mix. Thus, when financial incentives are introduced at sites with a limited mix of land use, transit riders are induced to shift to carpool options. When both a broad range of land uses and financial incentives are present, transit regains a portion of the ridership lost to ridesharing in areas with limited land uses. When land use mix is held constant, financial incentives do not significantly impact transit mode share.

As with the drive alone mode share, differences in the land use mix alone do not significantly impact shifts in ridesharing. The addition of financial incentives does result in significant shifts toward ridesharing both at sites with a limited land use mix (+5.3 percent) and at sites with a mix of land uses (+4.7 percent). The rideshare mode share was greatest (18.7 percent) at sites with limited land uses and financial incentives. The slightly lower share (17.7 percent) at sites with both a mix of land uses and financial incentives can be

4/ In interpreting the results of Table 3.6 (and also Table 3.7-3.11), it is important to note that the impacts of financial TDMs and of a particular land use or urban design characteristic are not cumulative. For example, in Table 3.6, the difference in mode share between the upper left cell (sites without either financial incentives or a mix of land uses) and the upper right cell (sites without financial incentives but with a mix of land uses) cannot be simply added to the values of the lower left cell (sites with financial incentives but without a mix of land uses) to determine the impact of the lower right cell (sites having both a mix of land uses and offering financial incentives). For Tables 3.6-3.11, there are some instances when the difference in mode share between sites without either TDMs or a particular land use/urban design characteristic and sites with both TDMs and that land use/urban design characteristics exceeds the sum of the parts, while in other cases this difference is less than the sum of the parts. Factors such as the size of financial incentive offered, as well as unmeasured urban design and land use variables (e.g., density) may influence these differences.

accounted for by the higher share of transit mode share (6.4 percent). Thus, the interactive effect of both land use mix and incentives on ridesharing results in a significant positive change relative to limited use sites with no financial incentives, but the impact of the interaction is tempered by shifts from ridesharing to transit.

The share of workers using flexible work hours is significantly higher at limited land use sites where financial incentives are offered (4.0 percent) than at either sites with a similar land use mix but no financial incentives (2.4 percent) or sites with both a mix of land uses and financial incentives available (1.9 percent). It is possible that these results occur because in areas with a limited land use mix, transportation options are also limited so that flexible hours becomes a more attractive options for both employers and employees. As land use mix intensifies, other transportation options (such as transit and rideshare opportunities) increase, and workers opt for these option at the expense of flexible work hours.

An analysis of the bicycle/pedestrian mode share for different combinations of land use mix and financial incentives does not reveal any statistically significant differences in mode share. While the percentage of people walking and biking to work is higher where land use is mixed, the differences are not significant with a 95-percent level of confidence. The use of bicycling, walking and other travel modes actually decreases with the introduction of financial incentives and other TDMs. This is an indication that the particular mix of incentives selected by employers had the unintended impact of increasing AVR by reducing the tendency of people to bike and walk.

In areas without financial incentives and a limited land use mix, the average vehicle ridership is 1.218. This increases to 1.271 in areas with both a diverse land use mix and financial incentives. Since this is a statistically significant increase, the interaction between land use mix and financial TDMs can be considered positive in reducing the dependence on the single-occupant vehicle.

Areas Characterized by the Availability of Convenience-Oriented Services

The hypothesis tested was that at sites characterized by the presence of convenience-oriented services, workers will commute using alternative modes of transportation more frequently than at sites where convenience services are absent. It was reasoned that when at least four types of convenience-oriented services (such as restaurants, banks, child care centers, dry cleaners, drug stores and post offices) are present, workers will be able to conduct personal business and run errands during the work day without the use of an automobile. It was further hypothesized that when TDMs are provided in an area having a number of convenience-oriented services, the drive alone mode share will further decrease in favor of transit, ridesharing, bicycling and walking.

Statistical analysis revealed that two categories of TDMs, financial incentives and assistance programs, each significantly affected mode shifts at sites characterized by convenience-oriented services. Table 3.7 shows differences in share for each mode based on the availability of convenience services and the level of financial incentives offered. For each mode share and for AVR, the table shows the percentage of workers using that mode at sites with:

- Limited availability of convenience services and where no financial incentives are offered;
- Sites with limited convenience services, but where financial incentives are offered;
- Sites having a mix of convenience services, but no financial incentives; and
- Sites with both a mix of convenience services and financial incentives available.

The table also shows the standard error associated with each mode share.

When the absence or presence of financial incentives is held constant, there is no significant difference in the drive alone mode share between sites without convenience-oriented services and sites having a mix of convenience-oriented services. However, the introduction of financial incentives does significantly shift the work trip mode share away from drive alone both at sites with few convenience-oriented services (-4.3 percent) and at sites characterized by the presence of convenience-oriented services (-5.6 percent). The drive alone mode share is 7.1 percent higher at sites without either convenience services or financial incentives than at sites that both offer financial incentives and have a preponderance of convenience services. This indicates that the interaction effect of financial incentives and the presence of convenience-oriented services results in the greatest overall shift from drive alone to other modes.

The shift from drive alone can be accounted for by gains in both transit and rideshare. Interestingly, that portion of the shift that accrues to transit results from changes in the land use mix. Across all sites without financial incentives, the transit mode share increases from 3.7 to 6.1 percent (+2.4 percent) when the land use mix shifts from limited convenience-oriented services to a mix of convenience-oriented services. Across sites where financial incentives are available, the difference in transit mode share between sites without and with services is 3.7 percent. Differences in the availability of financial incentives do not significantly impact transit mode share when the availability of convenience-oriented services is held constant across sites.

Conversely, the absence or presence of convenience services by itself does not significantly affect ridesharing. Instead, the availability of financial incentives significantly affects ridesharing both at sites characterized by limited convenience-oriented services, and at sites characterized by a mix of convenience-oriented services. At sites without convenience services, the rideshare mode share increases from 13.4 to 18.6 percent (+5.2 percent) when financial incentives are present. When incentives are made available at sites with a selection of convenience-oriented services, the rideshare mode share increases by 5.0 percent from 12.5 to 17.5 percent. The slightly lower share for rideshare at sites with convenience-oriented services can be explained by the higher percentage of transit share at these sites.

Table 3.7 Land Use and Urban Design Feature: Availability of Convenience Services

With and Without Financial Incentives

Financial Incentives	% Drive Alone* — Limited Convenience Services	% Drive Alone* — Mix of Convenience Services	% Transit — Limited Convenience Services	% Transit — Mix of Convenience Services
No	**76.7** (1.0)	**75.2** (1.1)	**3.7** (0.5)	**6.1** (0.7)
Yes	**72.4** (1.1)	**69.6** (1.2)	**3.4** (0.5)	**7.1** (0.9)

Financial Incentives	% Car and Van Pool — Limited Convenience Services	% Car and Van Pool — Mix of Convenience Services	% Flexible Work Schedules — Limited Convenience Services	% Flexible Work Schedules — Mix of Convenience Services
No	**13.4** (0.7)	**12.5** (0.8)	**2.8** (0.5)	**2.2** (0.5)
Yes	**18.6** (0.8)	**17.5** (0.9)	**3.0** (0.7)	**2.4** (0.5)

Financial Incentives	% Bicycle, Walk, Other — Limited Convenience Services	% Bicycle, Walk, Other — Mix of Convenience Services	AVR — Limited Convenience Services	AVR — Mix of Convenience Services
No	**2.9** (0.3)	**4.0** (0.4)	**1.224** (0.015)	**1.223** (0.015)
Yes	**2.6** (0.2)	[illegible]	**1.230** (0.015)	**1.286** (0.023)

Availability of Convenience Services

* The modal share percentages are averages (mean percentages), across all worksites in the sample. Standard Error = (0.0); 95% Confidence Level

The impact of TDMs on alternative mode shares is influenced by the land use characteristics of the sites. At work sites with limited convenience-oriented services, TDMs favor ridesharing. At sites with both financial incentives and convenience-oriented services, both ridesharing and transit benefit from the combination. While the impact on ridesharing is less than at sites without convenience services, the combined affect of the shift to transit and rideshare results in the greatest decrease in the drive alone share.

At sites without financial incentives, the bike/walk mode share does increase significantly when convenience oriented services are present. However, this increase is lost when financial incentives are offered, suggesting that financial incentives encourage ridesharing at the expense of biking and walking. The presence of convenience-oriented services and financial incentives has no significant impact on the percent of people working a flexible hours schedule.

Neither the availability of convenience services nor the availability of financial incentives alone significantly alter the AVR. However, the interactive affect of the presence of convenience services and financial incentives does result in a significant shift from 1.224 at sites without either convenience services or financial incentives, to 1.286 at sites with both.

For employment sites that provide a mix of convenience-oriented services, TDMs that provide assistance to employees in identifying feasible alternatives to driving alone significantly affect shifts in mode share. Table 3.8 displays the impacts of assistance programs on mode share when combined with convenience-oriented services.

The table shows that assistance programs result in a small but significant shift away from the drive alone mode share (-2.6 percent) when offered at sites with limited convenience-oriented services. At sites with a mix of convenience services, the drive alone mode share changes from 75.2 percent without assistance programs to 69.9 percent with assistance programs, a decrease of -5.3 percent. A total of 6.8 percent fewer employees drive alone at sites having both assistance programs and convenience services than in areas with neither assistance programs nor convenience services. This indicates an interactive effect between convenience oriented services and assistance programs causing a shift of trips away from the single-occupant vehicle. Both transit and rideshare realize statistically significant gains to account for this shift from drive alone. Changes in bike/walk and flexible work hours occur, but with one exception are not statistically significant. The mode shifts that occur when assistance programs are offered parallel those that occur when financial incentives are offered, with similar changes in AVR.

Sites Characterized by a High Level of Accessibility

It was hypothesized that work sites providing easy access for transit users, pedestrians and bicyclists, and with easy access to nearby services may realize a smaller drive alone mode share than sites with lower accessibility. Moreover, when TDMs are offered at sites having high accessibility, the drive alone share will decrease further. Statistical analysis revealed that the only category of TDMs to significantly impact changes in work trip mode share

Table 3.8 Land Use and Urban Design Feature: Availability of Convenience Services

With and Without Assistance Incentives

% Drive Alone*

Assistance Incentives	Limited Convenience Services	Mix of Convenience Services
No	**76.7** (1.0)	**75.2** (1.1)
Yes	**74.1** (0.9)	**69.9** (1.2)

% Transit

Assistance Incentives	Limited Convenience Services	Mix of Convenience Services
No	**3.7** (0.5)	**6.1** (0.7)
Yes	**3.0** (0.3)	**7.1** (0.9)

% Car and Van Pool

Assistance Incentives	Limited Convenience Services	Mix of Convenience Services
No	**13.9** (0.7)	**12.5** (0.8)
Yes	**17.9** (0.7)	**17.5** (0.9)

% Flexible Work Schedules

Assistance Incentives	Limited Convenience Services	Mix of Convenience Services
No	**2.8** (0.5)	**2.2** (0.5)
Yes	**2.4** (0.4)	**2.2** (0.5)

% Bicycle, Walk, Other

Assistance Incentives	Limited Convenience Services	Mix of Convenience Services
No	**2.9** (0.3)	**4.0** (0.4)
Yes	**2.5** (0.2)	**3.1** (0.3)

AVR

Assistance Incentives	Limited Convenience Services	Mix of Convenience Services
No	**1.223** (0.015)	**1.223** (0.015)
Yes	**1.213** (0.011)	**1.285** (0.022)

Availability of Convenience Services

* The modal share percentages are averages (mean percentages), across all worksites in the sample.
Standard Error = (0.0); 95% Confidence Level

when combined with site accessibility are financial incentives. The impacts of financial incentives and accessible sites on work trip mode share are displayed in Table 3.9.

The table shows that accessibility alone does not statistically affect drive alone share. That is, when the availability of financial incentives is held constant, there is no significant difference in the drive alone mode share between sites characterized as lacking accessibility and those characterized as providing accessibility. Conversely, at sites where financial incentives are available, there is a significant reduction in the drive alone mode share both for sites not characterized as accessible (-4.3 percent), and at sites characterized as having a high level of accessibility (-5.5 percent). When sites without either access or financial incentives are compared to sites with both access and financial incentives, the drive alone share decrease from 76.4 to 70.5 percent, a change of -5.9 percent. This change is greater than that realized simply by the addition of financial incentives, and indicates that accessibility and financial incentives interact to produce a greater impact on the reduction in the drive alone mode share.

Accessibility appears to impact transit share significantly regardless of the presence of TDMs. When financial incentives are not present, the transit share is 2.0 percent greater for accessible sites than for inaccessible sites. When TDMs are available, this difference increases to 3.3 percent. This gain in transit mode share occurs at the expense of drive alone, rideshare and flexible work hour shares. When land use characteristics are held constant, financial incentives alone do not create a significant shift in the transit mode share. However, sites that combine both financial incentives and a high level of accessibility show the highest transit mode share (6.3 percent).

As with other land use characteristics analyzed, when the availability of financial incentives is held constant, a difference in accessibility by itself is not significant in altering the amount of ridesharing. It is the introduction of financial incentives, whether at low or high access sites, that impacts ridesharing. At low access sites, when financial incentives are present the rideshare mode share increases from 13.8 to 18.8 percent (+5.0 percent). At accessible sites, the addition of financial incentives results in a change in ridesharing from 13.0 to 17.7 percent (+4.7 percent). At high access sites, ridesharing is less than at low access areas because transit captures a greater share. Ridesharing and transit combine to create a cumulative reduction in driving alone that is greatest for high access sites with financial incentives.

Financial incentives result in a reduction in the bike/walk mode share in low access areas. The likely reason for this reduction is that the financial incentives are geared toward ridesharing and transit. Areas with poor access are not particularly pedestrian or bicycle friendly, and it appears that the financial incentives offered in these areas are sufficient to induce cyclists and pedestrians to switch to alternative modes. In areas that are accessible, this shift away from the walk/bike mode is not statistically significant when financial incentives and other TDMs are introduced. The percent of workers on flexible work hour schedules decreased at sites having a higher level of accessibility, and was not affected in a statistically significant manner by financial incentives

There is a significant increase in AVR between areas having low accessibility and no incentives (1.225 AVR) and sites having both high accessibility and financial TDMs (1.272).

Table 3.9 Land Use and Urban Design Feature: Accessibility

With and Without Financial Incentives

Measure	Financial Incentives	Limited Access	Substantial Access
% Drive Alone*	*No*	**76.4** (1.2)	**76.0** (0.9)
% Drive Alone*	*Yes*	**72.1** (1.4)	**70.5** (1.0)
% Transit	*No*	**3.5** (0.6)	**5.5** (0.5)
% Transit	*Yes*	**3.0** (0.7)	**6.3** (0.7)
% Car and Van Pool	*No*	**13.8** (0.9)	**13.0** (0.6)
% Car and Van Pool	*Yes*	**18.8** (1.0)	**17.7** (0.7)
% Flexible Work Schedules	*No*	**3.4** (0.6)	**1.8** (0.4)
% Flexible Work Schedules	*Yes*	**3.8** (0.9)	**2.1** (0.4)
% Bicycle, Walk, Other	*No*	**2.9** (0.3)	**3.6** (0.3)
% Bicycle, Walk, Other	*Yes*	**2.2** (0.2)	**3.3** (0.3)
AVR	*No*	**1.235** (0.018)	**1.222** (0.013)
AVR	*Yes*	**1.229** (0.022)	**1.272** (0.016)

Accessibility

* The modal share percentages are averages (mean percentages), across all worksites in the sample.
Standard Error = (0.0); 95% Confidence Level

This change appears to reflect an interactive effect between accessibility and financial TDMs.

Areas Characterized as Safe

It was hypothesized that in areas perceived as safe, the drive alone mode share would be smaller than in areas where safety concerns may exist. This would occur because employees would be more willing to walk from transit to their job sites, and to make midday trips by foot or transit. For the purposes of this analysis, sites were considered to have a higher level of safety if they were characterized by sidewalks, street lighting, pedestrian activity, and by the absence of vacant lots.

As with many of the other land use categories analyzed, financial incentives are the only category of TDMs that result in significant shifts in work trip mode shift when combined with the perception of safety. Table 3.10 shows difference in mode share based on changes in the perception of safety and the level of financial incentives offered.

When financial incentives are not available, there is a 3.9 percent difference in the drive alone share between areas with low safety compared to areas that are perceived as safe. The availability of TDMs helps this shift. Both at sites that lack the perception of safety, and those that are perceived as safe, the introduction of financial incentives leads to a decrease in the drive alone mode share (-5.8 percent and -4.5 percent, respectively). The interactive affect between the perception of safety and the availability of financial incentives result in an even larger shift away from the single-occupant vehicle for commuting to work (-8.4 percent). Sites that are not perceived safe and that do not offer financial incentives have an above-average drive alone share of 79.0 percent, while sites perceived as safe at which financial incentives are available have a 70.6 percent drive alone mode share.

At sites having a low level of safety, the shift away from drive alone when financial incentives are offered is accounted for by the 5.6 percent increase in ridesharing (from 12.8 to 18.4 percent). At sites perceived as safe, there is a 4.4 percent change in ridesharing when financial incentives are offered. None of the other modes show any significant shifts when the perception of safety is held constant and financial incentives and other TDMs are introduced.

When the level of TDMs is held constant, changes in the perception of safety result in a significant change for the transit and walk/bike mode shares. When TDMs are available, the transit mode share increases by 1.8 percent from 3.6 to 5.4 percent. The bike/walk mode share increases by 1.5 percent between sites not characterized as safe and those that are perceived as safe. This is a large shift, given that the bike/walk mode share accounts for less than 4.0 percent of all trips even at sites perceived as safe.

There is an 8.4 percent decrease in the drive alone mode share between sites having a low level of safety and without TDMs, and sites that are perceived as safe and that offer TDMs. This change is accounted for by significant increases in mode shares for the transit, rideshare, and walk/bike. The perception of safety is the only land use characteristics that results in positive shifts in share for more than two of the model alternatives. The perception of safety and the presence of TDMs seem to interact to achieve the larger shift away from the drive alone mode share.

Table 3.10 Land Use and Urban Design Feature: Perception of Safety

With and Without Financial Incentives

% Drive Alone*

Financial Incentives	Less Safe	More Safe
No	79.0 (1.4)	75.1 (0.9)
Yes	73.2 (2.0)	70.6 (0.9)

% Transit

Financial Incentives	Less Safe	More Safe
No	3.9 (0.8)	4.8 (0.4)
Yes	3.6 (1.1)	5.4 (0.5)

% Car and Van Pool

Financial Incentives	Less Safe	More Safe
No	12.8 (1.1)	13.6 (0.6)
Yes	18.4 (1.2)	18.0 ([illegible])

% Flexible Work Schedules

Financial Incentives	Less Safe	More Safe
No	2.2 (0.6)	2.7 (0.4)
Yes	2.9 (1.3)	2.7 (0.4)

% Bicycle, Walk, Other

Financial Incentives	Less Safe	More Safe
No	2.2 (0.3)	3.7 (0.3)
Yes	1.7 (0.3)	3.2 ([illegible])

AVR

Financial Incentives	Less Safe	More Safe
No	1.206 (0.023)	1.230 (0.012)
Yes	1.229 (0.036)	1.263 (0.013)

Perception of Safety

* The modal share percentages are averages (mean percentages), across all worksites in the sample.
Standard Error = (0.0); 95% Confidence Level

There is also a significant increase in AVR between areas without financial TDMs and a low level of perceived safety compared to sites that are perceived as safe and that also have financial TDMs available (AVR of 1.206 versus 1.263).

Areas Characterized by an Aesthetically Pleasing Urban Setting

It was hypothesized that sites located in an aesthetically pleasing environment would have a lower than average drive alone mode share. Using the Principal Components analysis technique, a group of variables including street noise, lots of signs, an aesthetic appearance, and landscaping combined into a single composite variable that characterized a site as aesthetically pleasing. Only financial incentives were found to have a statistically significant impact on mode share when combined with aesthetic characteristics. Table 3.11 shows the difference in share for each mode based on aesthetics and the level of financial incentives offered.

The drive alone mode share was statistically affected by both financial incentives and by the presence of an aesthetically pleasing work site. For those sites not characterized as aesthetically pleasing, the drive alone mode share is 4.7 percent lower at work sites where financial incentives are offered than at sites without such incentives (72.3 percent and 77 percent, respectively). Similarly, for sites that are aesthetically pleasing, the presence of financial incentives decreases the drive alone mode share from 72.5 percent to 66.6 percent.

When the presence of financial incentives is held constant, site aesthetics has a statistically significant influence on drive alone mode share. At sites without incentives, the drive alone mode share is 77 percent for "less aesthetic" urban sites, and 72.4 percent for "more aesthetic" sites. The combined impacts of both financial TDMs and aesthetically pleasing urban sites is of particular note. Sites without either financial incentives or an aesthetically pleasing quality have an average drive alone mode share of 77.0 percent, while sites with both a high level of aesthetics and financial TDMs have an average drive alone mode share of only 66.6 percent. This is the lowest drive alone mode share for any of the land use and urban design characteristics evaluated in this analysis.

Once again, introduction of TDMs has no significant impact on the transit mode share when land use characteristics are held constant. The transit mode share, however, does shift significantly when the presence of TDMs is held constant and the level of aesthetics changes. When no TDMs are available, the transit share increases from 3.9 to 7.8 percent. At sites that offer financial TDMs, the average transit share increases from 4.2 to 8.3 percent for sites that are aesthetically pleasing. This is the highest transit mode share identified for any of land use or urban design characteristics.

As was true with the other land use and urban design characteristics evaluated, ridesharing varies with the level of financial incentives available. At sites that are not aesthetically pleasing, ridesharing increases from 13.3 to 17.9 percent when financial incentives are introduced. In aesthetically pleasing urban areas, ridesharing changes from 13.9 to 18.9 percent when financial incentives are introduced. As with transit, ridesharing is higher for aesthetically pleasing sites than for any of the other categories of land use and urban design characteristics evaluated.

Table 3.11 Land Use and Urban Design Feature: Aesthetics of Area

With and Without Financial Incentives

Measure	Financial Incentives	Less Aesthetic	More Aesthetic
% Drive Alone*	No	**77.0** (0.8)	**72.4** (1.8)
% Drive Alone*	Yes	**72.3** (0.9)	**66.6** (2.0)
% Transit	No	**3.9** (0.4)	**7.8** (1.1)
% Transit	Yes	**4.2** (0.5)	**8.3** (1.3)
% Car and Van Pool	No	**13.3** (0.6)	**13.9** (1.2)
% Car and Van Pool	Yes	**17.9** (0.7)	**18.9** (1.4)
% Flexible Work Schedules	No	**2.7** (0.4)	**2.0** (0.8)
% Flexible Work Schedules	Yes	**2.9** (0.5)	**2.3** (0.8)
% Bicycle, Walk, Other	No	**3.2** (0.2)	**3.9** (0.6)
% Bicycle, Walk, Other	Yes	**2.6** (0.2)	**3.9** (0.6)
AVR	No	**1.211** (0.011)	**1.285** (0.030)
AVR	Yes	**1.235** (0.014)	**1.337** (0.033)

Aesthetics of Area

* The modal share percentages are averages (mean percentages), across all worksites in the sample. Standard Error = (0.0); 95% Confidence Level

Unlike the other land use and urban design characteristics analyzed, there does not appear to be a tradeoff between transit usage and ridesharing when financial incentives are present at aesthetically pleasing sites. Instead, the interactive affect between aesthetics and financial incentives yields increases in both transit and ridesharing, thus reducing the drive alone share to the low of 66.6 percent.

Due to the large shift away from the drive alone mode share, sites characterized as aesthetically pleasing and where financial incentives are offered achieve an AVR of 1.337. This AVR is higher than that of any other combination of financial incentives and land use characteristics. It also appears to be a result of the interaction between the land use characteristics and the TDMs, as opposed to either one individually. One can conclude, therefore, that the presence of an aesthetically pleasing setting is important in improving the effectiveness of TDMs.

3.4 Summary of Impacts of Land Use and Urban Design Characteristics

To further understand the impact of individual land use and urban design characteristics, the differences in the drive alone share are compared between sites without each land use characteristic and sites exhibiting that land use characteristic (Table 3.12). In this analysis, financial incentives are present at all sites.

The biggest change in the drive alone share (-5.7 percent) occurs between sites that lack an aesthetic urban quality and sites having an aesthetic urban quality. Sites with an aesthetic urban quality realize the lowest drive alone share (66.6 percent) of sites displaying one of the urban design characteristics under study. The next lowest drive alone share is achieved at sites with a preponderance of convenience services (69.6 percent). The drive alone share at sites having a high accessibility to services is 70.5 percent, while at sites perceived as safe the drive alone share is 70.6 percent. At sites with a mix of land uses, the drive alone share is 70.8 percent.

Since land use and urban design characteristics cannot always be easily changed, it may be difficult to change mode share simply by introducing a new land use or urban design characteristic to an existing employment site. However, given that this analysis reveals that land use and urban design characteristics do impact commute mode share, communities may wish to encourage developers of new employment sites to incorporate land use and urban design characteristics that support a lower drive alone mode share into their site designs. These characteristics also can be introduced as part of a major site rehabilitation or modernization project.

It also is important to note that precise causality cannot be measured due to the limitations of the database. For example, areas with a mix of land uses, good accessibility, and lots of pedestrian traffic may also be areas with higher than average density and transit service.

Table 3.12 Comparison of Drive Alone Shares among Sites with Financial Incentives and Alternative Land Use Characteristics

	Percent Drive Alone		
Land Use Characteristics	Sites with Land Use Characteristics Missing	Sites with Land Use Characteristics Present	Absolute Percent Change
Mix of Land Uses	71.7	70.8	-0.9
Accessibility to Services	72.1	70.5	-1.6
Preponderance of Convenient Services	72.4	69.6	-2.8
Perception of Safety	73.2	70.6	-2.6
Aesthetic Urban Setting	72.3	66.6	-5.7

However, density and level of transit service cannot be adequately measured with the existing data so the impacts of these factors on mode share cannot be evaluated separately. Other factors that may influence the results but for which information was not available include parking costs and availability at work sites, weather, and the magnitude of employer-provided financial incentives.

3.5 Land Use and Urban Design Characteristics of Sites with a High Walk or Bicycle Mode Share

The share of work trips made by walking and bicycle as a percentage of the total work trips in the data set is small. This makes identification of work site characteristics that encourage utilization of these modes difficult. To understand the characteristics of sites that have a high walk or bike mode share, sites with a walk or bike mode share of greater than 10 percent were identified and evaluated separately.

Table 3.13 displays the land use characteristics and TDM measures available at sites having a combined bicycle and walking mode share that is greater than 10 percent either before or after implementation of Regulation XV. Twenty-five sites or 7.6 percent of all observations, spread throughout the study area had a walk/bike mode share greater than 10 percent prior to implementation of the Regulation XV trip reduction measures. After implementation, though, the walk/bike mode share declined to 8.3 percent, 6.2 percent lower than the pre-Regulation XV figure of 14.5 percent. As a whole, this group displays a greater percentage of sites having land use and urban design characteristics that encourage alternative modes of travel for the work trip than is true of the entire 330-site data set. The level of TDMs offered at theses sites, however, is below the average for the entire data set. Furthermore, a smaller percentage of these sites offer financial subsidies for walking and bicycling than is true for the entire data set. The walk/bike share at these sites may have declined because incentives promoting ridesharing and transit were offered to employees, with corresponding fewer incentives supporting walking and bicycling being available.

The second column of Table 3.13 summarizes characteristics of sites having a walk/bike mode share greater than 10 percent after implementation of the Regulation XV measures. In contrast to the column one sites, the percentage of employees walking or biking increased at these locations from an average of 12.3 to 13.9 percent. The land use and urban design characteristics of these sites more closely parallel those found to encourage alternative modes than either the data set as a whole or the sites with a pre-Regulation XV walk/bike mode share of 10 percent or more. The percentage of sites offering financial incentives was comparable to that for the entire data set. Furthermore, the percentage of these sites that offered walk and bike subsidies was well above the average for the complete data set. Bicycle racks were also more common at these sites. It appears that both land use and urban design characteristics that encourage alternative modes and the provision of TDMs that are specifically designed to be supportive of bicycling and walking can be effective.

Table 3.13 Characteristics of Sites with a High Walk or Bicycle Mode Share

	Sites with Pre-Regulation XV Walk/Bike Share ≥10%	Sites with Post-Regulation XV Walk/Bike Share ≥10%	All Sites
Numbers of Observations	25.0	14.0	330.0
Pre-Reg XV Walk/Bike Share	14.5%	12.3%	3.3%
Post-Reg XV Walk/Bike Share	8.3%	13.9%	2.8%
Difference – Pre-Reg to Post-Reg XV	-6.2%	+1.6%	-.5%
Site Characteristics			
Aesthetic Urban Environment	35.0%	24.0%	16.0%
Perceived Safe	88.0%	92.0%	72.0%
Access to Services	68.0%	79.0%	53.0%
Mix of Land Uses	68.0%	71.0%	52.0%
Numerous Convenience-Oriented Services	56.0%	64.0%	35.0%
Financial Incentives	56.0%	64.3%	66.1%
Assistance Programs	72.0%	71.4%	82.1%
Flexible Work Schedules	44.0%	35.7%	47.6%
Award Programs	36.0%	42.9%	50.3%
Bicycle Subsidies	12.5%	23.1%	17.1%
Walk Subsidies	16.7%	38.5%	18.7%
Bike Racks	45.8%	61.5%	41.0%

3.6 Sites with Low Single-Occupant Vehicle Use

The analysis identified 21 work sites at which 50 percent or fewer of the employees commuted by single-occupant vehicle (SOV). Within the context of the 330 work sites sampled, these sites provide one indicator of a practical "upper bound" for AVR and utilization of non-drive alone travel modes for the trip between home and work. As such, they serve as a point of reference against which the potential of other sites may be judged. Table 3.14 shows the average of the commute mode shares for these 21 sites. Ridesharing accounts for the majority of non-SOV commuting, having a 36 percent modal share. Transit also carries a large proportion (12.8 percent) of non-SOV commuters, a level that is almost three times the transit mode share for the sample as a whole. Average vehicle ridership is 1.68, compared to the base year average of 1.22.

These modal shares, however, do not appear to be the result of a particular mix of land use design, and TDM strategies. While employees at these 21 sites are the least reliant on single-occupant automobiles, the TDM incentive levels and the land use/urban design characteristics at the sites are not significantly different from the average for all sites in the sample. Factors other than those analyzed apparently account for the low SOV mode share.

Table 3.14 Sites Having a Low Percentage of Single-Occupant Vehicle Commuters

Mode	Average Percent
Drive Alone	41.5%
Transit	12.8
Rideshare	36.0
Flexible Work Schedules	5.6
Bike, Walk, Other	4.6
Average Vehicle Ridership (AVR)	1.68

4.0 Conclusions

The findings presented in the previous section lead to the following general conclusions that can guide implementation of land use, urban design, and transportation demand management strategies in urban settings.

1. **Financial Incentives are Important as Part of a TDM Strategy**

   A successful travel demand management strategy should be built around a core of financial incentives, regardless of the land use and urban design characteristics of a particular site. As a group, financial incentives are the only TDM strategies that consistently result in a statistically significant reduction in the drive alone mode share. At sites where financial incentives are not included among the TDMs offered, the drive alone mode share decreased by 1.7 percent over the study period compared to 6.4 percent decrease in the drive alone mode share at sites where financial incentives are included among the TDMs offered. For each land use category, financial incentives account for the majority of the reduction in the drive alone share. Individual financial incentives that resulted in a statistically significant shift from driving alone were transit, vanpool, and bicycle subsidies and other employee benefits.

2. **Specific Land Use and Urban Design Characteristics Influence Mode Choice**

   Urban design and land use characteristics that can be controlled by public officials and private business working in a cooperative partnership can influence a person's choice of commuting mode. The findings demonstrate that the availability of TDM strategies and transportation alternatives, combined with opportunities to accomplish midday errands without having to drive, reduce the use of single-occupant vehicles for commuting.

   The data reveal that when financial incentives are present, the greatest reduction in the drive alone share is realized in areas with an aesthetically pleasing urban character. The drive alone mode share at these sites is at least three percent less than at sites exhibiting any of the other land use characteristics analyzed. This appears to be a result of the availability of alternative modes (e.g., transit service), and the quality of the environment. Sites with a preponderance of convenience-oriented services realize the next greatest reduction in the drive alone mode share, followed by sites with good access to services, sites with the perception of safety, and sites with a mix of land uses.

3. **A Positive Interactive Effect Exists Between Land Use Characteristics and Financial Incentives**

   Travel demand management strategies have a larger influence on reducing the drive alone mode share than do land use characteristics, when each is considered individually. However, the findings further reveal that there is a positive cumulative impact on increasing average vehicle ridership (AVR) and reducing drive alone mode share when both financial incentives and one of the five land use characteristics analyzed are present. When both are present, the increase in AVR is always greater (by at least 2.5 percent) than when TDMs are present in an area without any of the land use characteristics, or when TDMs are absent from sites where the land use characteristics are present.

The impacts on mode share, however, are not linearly additive as further TDMs as well as land use and urban design characteristics are included at a site. The cumulative effect is less than the sum of the parts.

In implementing a regional TDM strategy, efforts should focus on areas that exhibit at least one of the land use characteristics studied as there is a greater potential for increases in the AVR in these areas. Consideration of this interactive effect when designing a TDM strategy may result in a more effective and efficient program. Adoption of policies that support compatible development of work sites with the land use and urban design characteristics found to encourage alternative modes is warranted.

4. **Tradeoffs Exist Between Ridesharing, Transit, and Walk/Bike**

   Modal decisions are made not only between driving alone and alternative modes, but also among available alternative modes. The TDM programs examined are most beneficial in increasing the level of ridesharing. This increase in ridesharing, however, results not only from a decrease in driving alone mode, but also comes at the expense of transit, walking, and bicycling. Transit and walk/bike mode shares are highest at sites with supportive land use and urban design characteristics. This further indicates that mode choice is influenced by both land use characteristics and the availability of TDMs.

   From a policy standpoint, it is important to understand these tradeoffs when designing a transportation management program. For example, a TDM strategy that increases ridesharing at the expense of transit, walking, or bicycling may not be supportive of broader regional transportation policies or goals. By understanding the tradeoffs that may occur given particular land use characteristics, a TDM program can be designed to strengthen incentives that will encourage the full range of available non-drive alone modes. It may be effective to focus TDM strategies on ridesharing in areas that do not exhibit land uses that are supportive of transit, walking, and bicycling, TDMs that support transit and walk/bike should be featured in areas where the land uses are supportive of these modes.

5. **Employer-Provided Transportation Assistance Programs are Most Helpful at Sites Having a Variety of Convenience-Oriented Services**

   Employer-provided transportation assistance programs have a small but statistically significant impact on reducing the drive alone modal share (-5.3 percent) and increasing the AVR (from 1.223 to 1.285) at sites having a mix of convenience-oriented services. Assistance programs were not found, by themselves, to have a significant impact on either the drive alone share or AVR at sites with other land use characteristics. For sites having a high level of convenience-oriented services, a TDM strategy featuring assistance programs should be successful in helping to achieve increases in AVR. A program that includes assistance programs but not financial incentives, though, will have a smaller positive impact than a program that includes financial incentives.

6. **Selected Individual Sites Attain High Levels of Non-Drive Alone Commuting**

   While the average level of walking and biking over all the sites surveyed is 5.4 percent, selected sites have post-implementative mode shares that are two and one-half times this level. These sites are characterized by land use and urban design characteristics that encourage alternative modes of travel for the work trip. Furthermore, these sites offer financial incentives in the form of walk and bicycle subsidies that are well above the average for all the sites analyzed.

   Twenty-one of the 330 sites examined have less than half of their employees commuting by driving alone, leading to an average vehicle ridership of 1.68 compared to the overall average of 1.25. Ridesharing accounts for the majority of alternate mode commuting, achieving a share of 36 percent, with transit accounting for 12.8 percent of the work trips at these sites. These figures provide one indication of the practical upper bound that may be achievable in terms of the distribution of commuting mode shares and the level of average vehicle ridership.

7. **Transferability of Results**

   The impetus for the implementation of TDM strategies at many employment sites within the Los Angeles metropolitan area has been the Regulation XV trip reduction ordinance enacted by the South Coast Air Quality Management District. Many Los Angeles area employers, though, had implemented a diverse range of TDMs for a variety of reasons prior to enactment of the Regulation XV ordinance. An evaluation of TDM strategies at these particular locations based only on a Regulation XV "before" condition, therefore, may understate their level of effectiveness since the TDM measures already would have been in place.

   The impetus for the provision of TDM measures or supportive urban design characteristics is not relevant to an analysis of their effectiveness. Similar results should be obtained independent of the factors motivating their implementation.

   The data used in this analysis are specific to Los Angeles county, and thus reflect the particular socioeconomic and geographic characteristics of that particular portion of the Los Angeles metropolitan area. There are, however, numerous urban areas in the U.S. that are similar to this portion of Los Angeles in terms of their land use characteristics, densities, socioeconomic characteristics, and commute trip travel characteristics. The results of this study are directly applicable to the development of TDM programs for these areas.

   It is recognized, though, that the drive alone mode share is higher and that the development density is lower in the Los Angeles metropolitan area than in many older areas in the United States. For these areas, the results of this study are considered a conservative estimate of the interactive effects of land use and transportation demand management strategies on mode choice. Areas having land use characteristics that are more supportive of alternative modes of transportation could have higher levels of effectiveness than reported here. In addition, the results are transferable to other urban areas in terms of the relative ranking of importance of the land use and TDM factors analyzed.

Appendix A

Site Survey Data Collection Form

Survey Collected By:______________
Date:______________

WORKPLACE NAME: ______________________________
WORKPLACE ADDRESS: ____________________________

GENERAL ENVIRONS

Land Use

1. mixed use? yes no

2. predominant single use: ________________________________

3. special features/notable sites:

yes (describe):________________________________

no (none)

4. building type(s): ________________________________

STREET CHARACTERISTICS

5. main street(s) (list): ____________________________

6 traffic levels: low medium high

7. sidewalks yes no

8. landscape quality low medium high

Describe the area briefly:

SITE AREA DATA BLOCK CODE ________________

LAND USE CHARACTERISTICS WITHIN APPROX. 1/4 MI. OF THE SITE

CHARACTERISTICS	YES	COMMENTS
LAND USE MIX Single Use		
Mixed Use		
- Horizontal Mixing (List ground story uses)		
- Vertical Mixing (List upper story uses)		
LAND USE TYPE Residential		
Office		
Retail		
Heavy Industrial		
Light Industrial		
Auto-related		
Institutional		
Open Space		
Parking (off street)		
Personal services (list)		
Business services (list)		
Other (list)		
GRAIN Coarse		
Fine		

Comments:

SITE AREA DATA BLOCK CODE ______________

SERVICES WITHIN WALKING DISTANCE OF THE SITE (APPROX. 1/4 MI.)

TYPE OF SERVICE	YES	FREQUENCY # per block	DISTANCE FROM SITE
Restaurants/Coffee Shops			
Groceries			
Banks/ATM Machines			
Parks/Open Space			
Child Care			
Other services, e.g.: -Dry cleaning/laundry -Drug stores -Entertainment: movies, videos, etc. -Haircuts -Health club/exercise/dance -Copies -Post Office -Travel agent -Parking lot -Parking structure -Other (list)			

Comments:

SITE AREA DATA
STREET CHARACTERISTICS

BLOCK CODE:______________

(Record for street on which project is located and for each other major street, if different)

STREET NAME __________________________

STREET TYPE Minor Street	YES	COMMENTS
Collector		
Arterial		
Freeway		
DESIGN FEATURES Median		
On Street Parking		
Other (explain)		
TRAFFIC[1] Light		
Moderate		
Heavy		
STREET LAYOUT [2] One Way		
Two Way		
Total Number of Through Travel Lanes, Both Directions (Describe)		
Special Turn Lanes (Describe)		
PUBLIC TRANSIT Bus Lines[3]		
Rail (explain type)		
NOISE Quiet		
Moderate		
Loud		

Comments:

---

[1] Note time of observation in comments section

[2] Note approximate street width (in ft) in comments section

[3] List number of bus lines in comment section

SITE AREA DATA
LAND USE-SIDEWALK INTERFACE

BLOCK CODE:______________

(Record for street on which project is located and for each other major street, if different)

STREET NAME ________________________

STREETWALL CHARACTERISTICS	YES	COMMENTS
SIDEWALK EDGE - BUILT EDGE Buildings Set Back? (Describe - # ft.)		
Vacant lots? (Sketch or describe)		
Parking along sidewalk?		
STREETWALL QUALITY Continuous		
Fragmented		
Transparent		
Blank wall		
Monotonous		
Interesting		
ADJACENT USES ARE: Open		
Fenced		
Walled		
SIGNAGE - FOR USE (Describe) Small		
Large		
Attached to Building		
Free-Standing		
Neon		
SIGNAGE - UNRELATED TO PARCEL USE Billboards		
Graffiti		

SITE AREA DATA
SIDEWALK CHARACTERISTICS

BLOCK CODE:______________

(Record for street on which project is located and for each other major street, if different)

STREET NAME ________________________

SIDEWALK CHARACTERISTICS	YES	COMMENTS
FORMAL - (List Width in Feet)		
PAVEMENT TYPE Unpaved - dirt or gravel		
Asphalt		
Concrete		
Brick/Tile/Paving Stone		
MAINTENANCE QUALITY Smooth Pavement		
Poor/Broken or Tilted Slabs		
Clean		
Littered		
SIDEWALK ZONES Tree/Shrub Planting Strip		
Arcades/Awnings		
Other (Explain)		
STREET FURNITURE Benches		
Kiosks		
Newspaper Boxes		
Mailboxes		
Public Phones		
Street Lighting		

SITE AREA DATA
PEDESTRIAN CHARACTERISTICS

BLOCK CODE:_______________

(Record for street on which project is located and for each other major street, if different)

STREET NAME ___________________________

PEDESTRIAN CHARACTERISTICS NO PEDESTRIAN ACTIVITY	YES	COMMENTS
Businesspeople		
Blue collar/laborers		
Shoppers		
Street people		
PEDESTRIAN ACTIVITY Dynamic		
Static		
Concentrated		
Scattered		
Varies by Time of Day (Describe)		

Comments:

SITE AREA DATA BLOCK CODE:______________
LANDSCAPING CHARACTERISTICS ALONG STREETS/SIDEWALKS

(Record for the street on which the project is located, and for the most significant major street if different)

STREET NAME: ________________________________

CHARACTERISTICS	YES	COMMENTS
TREES (list type in comments)		
SPACING Sparse		
Average		
Dense		
Interrupted		
Uniform		
SIZE Small		
Medium		
Large		
SHADE		
CANOPY EFFECT		
OTHER VEGETATION (explain in comments)		

Comments:

WORKPLACE DATA
PARCEL AND BLOCK CHARACTERISTICS

WORKPLACE NAME:____

WORKPLACE ADDRESS:____

CHARACTERISTICS	YES	COMMENTS
BLOCK FORM Superblock		
Block with Alley		
Mid-block Connection		
Internal Public Way		
BLOCK DENSITY Empty		
Partially Built		
Fully Built		
FAR (if known list in comments)		

Typical Parcel Size: ______________________sq. ft.

Typical Number of Parcels in Block: ________________

Block Dimensions: ___________________________sq. ft.

Comments:

WORKPLACE DATA
CHARACTERISTICS OF BUILDING(S)

WORKPLACE NAME:______________________________________
WORKPLACE ADDRESS:____________________________________
BUILDING NAME (IF KNOWN) ________________

CHARACTERISTICS	YES	COMMENTS
SIZE Low-rise (1-2 stories)		
Med-rise (3-7 stories)		
High-rise (>7 stories)		
DISTINCTIVE ARCHITECTURAL STYLE? (Describe in comments)		
AESTHETIC APPEARANCE Poor		
Average		
Pleasant		
MATERIALS Stucco		
Glass		
Brick		
Concrete		
Timber		
Stone		
Tile		
Concrete		
Other (List)		
SETBACK FROM STREET (#Ft.)		
ORIENTATION Inward		
Outward		
SCALE Consistent with other buildings in area?		
MAINTENANCE Poor		
Average		
Good		

Draw building footprint here or on attached sheet:

WORKPLACE DATA
TRANSPORTATION CHARACTERISTICS

WORKPLACE NAME:____

WORKPLACE ADDRESS:____

1. on-street parking? yes no

    metered? yes no

    describe hours of operation:

2. off-street parking?

    location:
    amount:

3. distance to bus stop _____ ft.

4. distance to rail transit _____ ft.

5. sidewalk width at main entrance _____ ft.

6. typical sidewalk distance in area ______ ft.

7. Number cyclists parked ____________ (time of day observed)

8. street people? yes no

9. dope dealers? yes no

Comments:

PHOTOS

General environs:

- typical views (2-4)
- notable features (2-4)
- barriers (1-2)

Workplace and vicinity:

visible facades of workplace bldg, (1-4)
ground floor closeups (2-3)

- main public entrances
- entrance from parking
- parking lot, if surface

other (6-8):

- sidewalk view in front
- landscaping; urban furniture
- bus stop(s)
- landscaping
- street views
- street life

Appendix B

Procedures and Instructions Provided to Data Collection Staff

PROCEDURES

OVERALL INSTRUCTIONS

This data collection effort is designed to gather information on urban design characteristics of particular workplaces and their environs. The data will be used, together with information on employee mode choices, parking costs, etc., to assess the impact of urban design characteristics on travel behavior.

Mode choice at a particular workplace will probably be most strongly influenced by the quality of alternatives available at that workplace. However, urban design characteristics may support or deter the use of commute alternatives. Clearly the ease of getting to and from a bus stop (walking distance, safety, security, etc.) will be a factor in transit use. Moreover, it has been argued that workers may be more willing to do without their cars if they can readily walk to restaurants, personal services, banks, etc. Both the availability of these land uses within walking distance (say, 1/4 mi.) and the ease of walking (presence of sidewalks, ease of crossing the streets, personal safety considerations, etc.) may affect travel choices. The data we will be assembling will help us to assess these factors.

You will be collecting data at three levels: (1) the **general environs** in which the project is located (this will range between a half square mile and two square miles, depending on the location); (2) the **site area** (within approximately a quarter mile of the workplace, or a smaller area if barriers restrict movement in some direction(s)); and (3) the **workplace & vicinity**, i.e., the building characteristics, placement on the site, and immediate area. The general environs can be thought of as setting the urban context for the site and in most cases will be somewhat larger than the area typically thought to be "within walking distance" of the workplace (1/2 mi. or a 10-15 min. walk, assuming people walk 2-3 mi./hr. in urban/suburban settings.) The site area will contain the land uses (restaurants, child care post offices, banks/bank machines, etc.) and transportation facilities, (parking, transit stops, etc.) within "easy" walking distance. The workplace vicinity will be the block or subdivision parcel (whichever is appropriate) for the workplace, and will be the location for specific measurements of such items as distance to closest bus stop/transit station, distance to parking, distance to building entrance from sidewalk, etc. At each successive level of detail you will need to be more precise in the measurement of the information requested; however, your overall impressions also are important in assessing the qualities of the sites and should be recorded as well.

Although some of the data sought may be gathered any time, other data items (e.g., pedestrian volumes) will be meaningful only if collected during conventional working hours (7:30 - 5:30 M-F). Therefore you should plan to be on-site during the key periods for at least a while, or to make a return trip to the site during these periods.

Distances can in general be estimated by using odometer readings (if your odometer works!) or by pacing off the distance. Please take actual measurements of small distances such as sidewalk width, setbacks, etc. where possible.

BEFORE YOU START:

You should have with you:

_____ A street map (MAP 1) showing the general environs and indicating the general site area(s) for which you will be collecting data (provided to you.) In some cases you also will be provided a preliminary site area diagram (MAP 2); in other cases this second map is not available and you will have to sketch the site area yourself.

_____ The specific address of the workplace or workplaces for which you will be collecting data (provided to you).

_____ A survey form on which to summarize your observations - one per site (provided to you). You may wish to take rough notes on this form and copy it over later.

_____ Notebooks or paper and clipboards (one per team member). This should be paper suitable for sketching and diagramming - sketch pads, graph paper, or plain white. (Some of each is recommended.)

_____ Pencils with erasers.

_____ Pens: black, blue, red, green (you may want to use different colors to note different things: use black for the base map drawings, green to denote landscaping, red to denote traffic controls, blue for recording land uses.)

_____ A measuring tape at least 10 ft. long.

_____ A camera and film (allow for at least 8 shots per workplace and an additional 10-15 shots for the site area and the general environs). Note: In some cases security personnel may ask you not to take photos. Please immediately comply with their requests.

_____ (Optional) A tape recorder for recording your observations for later transcription.

_____ Your ID (in case you are questioned about your activities by a person in authority!)

GETTING STARTED

In carrying out the data collection, you should first locate the workplace or workplaces, since the various levels of analysis are centered around it (or them, in the case of a cluster of several workplaces in one area). Once you have pinpointed the workplace(s), you may wish to proceed with an overall reconnaissance of the general environs, then focus in on the smaller site area and finally taking a more detailed look at the workplace and its immediate vicinity. Alternatively, you may prefer to record the data for the workplace, then the site area, then the general environs. Whichever procedure is more comfortable for you, feel free to use - as long as you record the data at all three levels. (If several workplaces share the same general environs and have the same or overlapping site areas, only record the shared information once and cross-reference it).

In general you should aim to collect all the data for each site in two to three hours (not including the travel time to the area). Based on the pretests, you may find that you are much slower the first couple of times - it may take you four or five hours as you're learning. You will speed up considerably with experience.

(A) RECONNAISSANCE OF GENERAL ENVIRONS

Drive or walk around the area shown in Map 1. You should assess the predominant characteristics of the area and prepare a brief description. Here, we want an overview; more detailed descriptions will be prepared in later steps. However you should provide enough detail that others will get a good idea of what the area is like.

In some cases the general environs of the workplace will contain several distinct subareas (e.g., Westwood Village contains a commercial center with a retail node to the west and an office/hotel/condo strip to the east, with an apartment district to the northwest, single family houses to the northeast, etc.). If this is the case, locate each such subarea on the map or in a separate sketch by drawing a rough boundary line and describing the uses, etc. Annotations on the map, sketches, photographs, and attached verbal descriptions should be used to communicate the nature of the area.

1) What are the principal **land uses** (both first floor and higher)? If land uses change from one part of the area to another, describe each subarea. Please identify each subarea on Map 1 or in a sketch and record your observations. Locate the workplace site and mark it on the map (*).

NOTE:

In some areas, land uses will be highly mixed (e.g., first floor uses ranging from professional offices to single family residences to restaurants and shops to apartment buildings; multi-story buildings containing multiple uses interspersed with single story, single use buildings, etc. Please record this on the survey form and in photos.

2) Note on the map any **special features and notable sites**: positive and negative. These may include landmarks - major buildings - public uses such as a post office - parks - other open space (e.g., a cemetery) - noted entertainment spots - sidewalk cafes - whatever is "special". Also note vacant land, boarded up or otherwise empty buildings, new construction underway, etc. TAKE PHOTOS.

3) Describe the **buildings**: height/number of stories, bulk, typical frontage, typical front and side yard setbacks (from street curb), building materials, type and size of signage, design style, approximate age, maintenance (good, so-so, poor.) If the area is mixed, describe subareas. PHOTOGRAPH VIEWS OF TYPICAL STREETS OR AREAS.

4) Describe the typical **street characteristics** in the general area or in subareas, if appropriate. Note the major streets and their widths, numbers of lanes, types of traffic controls (signals, signs, other, none), etc.; note the general level of traffic. Also note the presence or absence of sidewalks in

various areas, level and quality of landscaping; presence of notable noise, fumes, etc. If there are notable features (beautifully landscaped medians, a major transit transfer point, a large cab stand, etc.) record them. PHOTOS.

(B) DESCRIPTION OF SITE AREA

You will be assembling fairly detailed information about the "site area", the area that is approximately 1/4 mile (1320') in each direction from the workplace. Unless you have been provided a site area map, you will need to prepare one.

Starting at the workplace and taking the nearest street(s), begin by either driving or walking the perimeters of the area. If there are barriers, e.g., freeways, that constrict access to various portions of the area that lies within the 1/4 mi. boundary, please note them. (Be sure to note whether the barrier restricts cars only, or pedestrians only, or both.) The barrier(s) will become the new "outer limits" of the site area. In some cases the next major boulevard or arterial will serve as a boundary or perimeter for the site, beyond which it is unlikely most employees would venture on foot (e.g., where the area beyond the boulevard is a residential neighborhood). If, however, the 1/4 mi. distance leaves you short of a major street, freeway on-ramp, etc. that is an important access route to the site, extend the perimeter to include that street or ramp. Note the perimeters on your maps and describe briefly.

Be sure to note the following information:

1) What are the principal **land uses** (both first floor and higher)? If land uses change from one part of the area to another, describe each subarea. Identify each subarea on the map or sketch and record your observations.

2) Note on the map any special features notable sites: positive and negative. These may include landmarks - major buildings - public uses such as a post office - parks - other open space (e.g., a cemetery) - noted entertainment spots - sidewalk cafes - whatever is "special". Also note vacant land, boarded up or otherwise empty buildings, new construction underway, etc. TAKE PHOTOS.

3) Describe the buildings: height/number of stories, bulk, typical frontage, typical front and side yard setbacks (from street curb), building materials, type and size of signage, design style, approximate age, maintenance (good, so-so, poor.) If the area is mixed, describe subareas. PHOTOS.

4) Describe the typical street characteristics in the general area or in subareas, if appropriate. Note the major streets and their widths, numbers of lanes, types of traffic controls (signals, signs, other, none); note the general level of traffic and traffic speeds (posted and actual), as well as the mix of vehicles - cars, trucks, buses.(Record the time of day of this observation.) Also note the presence or absence of sidewalks in various areas; the presence or absence of street

furniture; the level and quality of landscaping; if present, billboards, graffiti, high noise levels, noticeable fumes, etc. If there are other notable features (beautifully landscaped medians, a major transit transfer point, a large cab stand, etc.) make a note of them and take PHOTOS.

We also want to collect more detailed information:

5) Along each major street, prepare a map or diagram showing the first floor and upper floor land uses on BOTH SIDES of the street for approximately 1200' in each direction from the workplace. Also record this information along the street(s) on which the work site fronts, if this is not a major street.

6) For each major street (and the work site street(s), if other), describe the street characteristics in detail. Record and locate in a sketch of the street: width, number of lanes, turning lanes/bays, traffic controls (signals, signs, other, none), turning or directional movement restrictions, etc.; on-street parking (permitted? metered? other controls?), signage, transit shelters, other street furniture (benches, newspaper boxes, planter boxes, etc.), billboards (for what?), landscaping (types of plant materials, spacing of street trees, if any, maintenance quality, etc.), any other notable features. Look for and make record: sidewalk cafes/tables, public art, other focal points; high levels of grafitti, street people, misc. criminal activity (drug dealers, hookers,...), other negatives.

(3) DATA ON WORKPLACE & VICINITY

1) Describe the building in which the workplace is located: its height, bulk, front, side and rear setbacks, materials, age, etc. PHOTOGRAPH ALL VISIBLE FACADES VISIBLE FROM PUBLIC STREETS.

   In some cases the workplace may be multi-building. You may be able to get a map from the employer or office park manager, etc. which shows the building locations and footprints; or you may find a posted orientation map which you can copy. If not, sketch a site plan showing the buildings and their relative locations and orientations as best you can.

2) Is the building a single tenant or multi-tenant building? If the latter, try to determine the number of tenants (employers/businesses), if possible. (Check building directory in parking lot or lobby.) If the building includes first floor retail or services (cafeteria, restaurant, bank teller machine, day care, other...), list them. If the building is partially vacant (either visibly so, or indicated by "space available" signs, be sure to record this and if possible, estimate the vacancy rate.

3) Describe on-site parking, if any (surface, structure, number of each, location with respect to building entrance(s)). PHOTOS.

4) Diagram the building footprint(s) and identify all major "public" entrances to the building(s) (including entrances from parking lot, if feasible.) Identify the "main" public entrance (s). Photograph them. (You do not need to photograph entrances for freight, etc.)

5) If you are permitted access inside the building, note the distance from each entrance to the closest elevator (if one is present); estimate the distance from each of the major entrances. Are some entrances easier to use (shorter distance, less circuitous, more sheltered, etc.) than others? Note any differences.

6) Measure distance from main entrance to nearest public street. PHOTOGRAPH THE ENTRANCE.

7) Measure walking distance from main entrance to nearest bus stop(s). PHOTOGRAPH THE BUS STOP(S).

8) Measure sidewalk width in front of main entrance and estimate the typical width (if it changes) on the way to the bus stop. If the usable space is restricted by newspaper boxes, plantings, bus benches, etc., please note this. PHOTOGRAPH A TYPICAL STREET VIEW.

9) Note the location of any bike parking visible on/adjacent to the building site. PHOTO.

10) How many pedestrians are on the street in front of the workplace? Provide a general impression: none, very few, some, many. In addition, count pedestrians for five minutes in front of main entrance, your side of the street only (unless the sidewalk is on the opposite side only!). Also, record the time at which you are observing. (Note: Because not all sites will be recorded at the same time of day we will use this count as a qualitative indicator rather than a numeric estimate of activity. If you are on site several times please keep track of pedestrian activity each time. If you have discretion over when to do this count, please aim for 8-9 am, noon-1 pm, or 4:30-5:30 pm.)

11) How many cyclists are on the street? (Follow the same procedure as for pedestrians.)

12) Now, walk from the main entrance to the nearest restaurant (if there is one within 1/4 mi.) Make note of your overall assessment of/reaction to the street. Consider the following.

    Are there other people on the street? Note sex, approximate ages, dress, etc. Are there street people? Where? Are the streets empty or crowded? Do you feel safe?

    Are the building frontages transparent or opaque? Do you find things to look at or do you feel uncomfortable or exposed? Are there places you could sit and talk with a friend, in nice weather? Views to enjoy?

TAKE PHOTOS.

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