AN INVESTIGATION OF INDUCED TRAVEL AT MIXED-USE DEVELOPMENTS

A Thesis

by

BENJAMIN ROBERT SPERRY

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

May 2008

Major Subject: Civil Engineering

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Approved by:

Chair of Committee,	Mark Burris
Committee Members,	Eric Dumbaugh
	Luca Quadrifoglio
Head of Department,	David Rosowsky

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ABSTRACT

An Investigation of Induced Travel at Mixed-Use Developments. (May 2008)

Benjamin Robert Sperry, B.S., University of Evansville

Chair of Advisory Committee: Dr. Mark Burris

Existing literature suggests that mixed land-use developments have the potential to reduce traffic by "capturing" some trips internally and providing a pedestrian-friendly environment to facilitate walking for some trips. However, these elements which are meant to provide the traffic-reducing benefits also reduce the overall cost of travel, thereby increasing the total amount of travel. This "induced" travel has implications for the site planning process, which assumes that all internal trips are replacing trips on the external street network.

In this investigation, travel survey data were analyzed to determine the nature and extent of induced travel at mixed-use developments. The study site was a 75-acre suburban infill mixed-use development in Plano, Texas. Features of the study site included a diverse land-use mix, a grid-style street layout, and pedestrian-oriented streetscapes. The travel survey was administered as an interview of persons exiting buildings at the site and gathered information about two trips made by the respondent, including whether the trip made at the time of the interview was induced. A trip was considered induced if the respondent would not have made the trip if it had required travel outside of Legacy Town Center.

Analysis found that in the morning, four percent of all trips at the study site were induced; in the afternoon, about one-quarter of all trips were induced. Induced trips accounted for one-eighth of internal trips in the morning and forty percent of internal trips in the afternoon. Most internal trips made in an automobile were replacements for off-site travel while most trips made on foot were induced. Based on this study, it is evident that some internal trips at mixed-use developments are not "captured" from external streets, but represent additional trips, induced by travel cost savings in the mixed-use environment. However, it is demonstrated that, even with this additional travel, mixed-use developments still contribute to a reduction in overall vehicle-miles of travel. Stakeholders are encouraged to consider these findings when evaluating new land-use policies or the traffic impacts of proposed mixed-use developments.

In Loving Memory of:

Rachel Anne Sperry, 1985-1998

Jarred Austin Ashmore, 1983-2007

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I would also like to thank Brian Bochner of the Texas Transportation Institute for serving as the principal investigator of the project, supervising the data collection efforts, and teaching me nearly everything that there is to know about travel behavior at mixed-use developments. Other Texas Transportation Institute researchers, staff, and student workers that contributed to the success of this project include Matt Ciarkowski, Laura Higgins, Geoff McDonald, Curtis Morgan, Lisa Nimocks, David Pearson, Jeff Warner, and Joe Zietsman.

I would like to thank all of Legacy Town Center's property management companies and their respective staffs for their support of the data collection efforts. Special thanks are extended to Elizabeth McCoy of Trammel Crow Company for allowing the project to take place at Legacy Town Center and Bob Bula of the Marriott Hotel at Legacy Town Center for providing the space to conduct the training session prior to starting the data collection. Thanks also go to Laurence Car-Moebel of ProStaff for coordinating the hiring of the data collection personnel, to each of the temporary workers for giving their best throughout the data collection effort, and to the travelers at Legacy Town Center for participating in the travel surveys.

I wish to extend my gratitude to the Texas Department of Transportation for providing the necessary financial support to make this project a reality. Thanks go to the members of the project panel, Duncan Stewart and Maria Burke. I strongly believe that as more mixed-use developments are built across the state, the results of this research will fill a critical need in the planning community and a return on the investment in the project will be realized.

Finally, I would like to thank my family and friends for their continued support of my academic pursuits.

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CHAPTER I
INTRODUCTION

Travel is a derived demand, that is to say, the demand is not for the travel itself, but the activities that the travel is supporting, such as work, shopping, school, or vacation. In pursuit of these activities, the traveler will spend finite resources to travel from one location to another. The two primary resources consumed by personal travel are the out-of-pocket travel cost (the cost to operate a vehicle or buy a ticket) and the traveler's opportunity cost (the value of what the traveler could be doing instead of traveling). Since travel is a resource-consuming activity, it might also be said that travel is simply a series of decisions whereby travelers will weigh the amount of resources required for each alternative against the benefit gained from selecting a particular alternative, selecting the alternative that accomplishes the traveler's objectives with the least amount of cost. Decisions such as whether to make a trip or not, where to go, what mode of travel to use, when to make the trip, and which route to select are all part of an underlying, and in some cases, subconscious, interconnected decision-making process inherent in virtually all personal travel. For transportation planners, the challenge is to aggregate trends in individual decision-making processes into useful information that can be employed to predict travel demands on a larger scale.

In transportation planning, one of the most important tasks is estimating trips and predicting travel behavior to determine future transportation system needs, both at the macroscopic level (entire region or urban area) and the microscopic level (individual land parcel, property, or site). The first step of traditional regional transportation planning models, such as the urban transportation modeling system (UTMS) "four-step" model, is to estimate the number of trips generated by a household or analysis zone (Meyer and Miller 2001). Regression equations, category (cross-classification) analysis, or the Institute of Transportation Engineers' (ITE) *Trip Generation* report (ITE 2003) can be used at the zonal level to estimate trip generation. This estimate is then used in the remaining steps of the "four-step" process to predict the impacts of this travel demand on the existing transportation network and the transportation network improvements required to maintain acceptable operating conditions.

This thesis follows the style of the *Journal of Transportation Engineering*.

A similar four-step process is used at the site planning level to estimate the needs of the transportation network immediately adjacent to the site of a proposed development. Stover and Koepke (2002) include "analysis of the traffic impact of specific proposed development, the adequacy of the access drives, and the suitability of the on-site circulation and parking" as the products of the site planning process. Also called traffic impact analysis, the site planning process evaluates the impact of proposed developments on the adjacent transportation network (local streets, arterials, interchanges, or traffic control devices) and if any capacity improvements will be required to maintain acceptable operating conditions. In some jurisdictions, developers may be required to pay an "impact" fee to fund the necessary transportation improvements or otherwise mitigate potential traffic issues before zoning variances or construction permits are approved.

One recent real-estate development trend, both in suburban greenfield and urban infill areas, is the construction of compact, walkable, mixed land-use developments as an alternative to the sprawling, low-density single-use projects that dominated post-World War II development patterns in the United States. Advocates of these mixed-use projects point to, among other things, the traveler's ability to accomplish multiple trip purposes at a single destination and the pedestrian-friendliness of mixed-use developments in support of a claim that this style of development actually reduces vehicle-miles traveled (VMT) in an urban area. Along with this claim of reduced VMT are the associated benefits, including congestion relief and improved air quality.

Some research, however, suggests that the transportation benefits of mixed-use developments are not as straightforward as advocates claim. Elements of the mixed-use environment which are meant to reduce travel may in reality reduce the costs of travel, which in turn will increase the overall demand for travel if basic microeconomic principles are considered. As a response to the change in travel cost, travelers may change their behavior by switching routes, travel modes, or time of travel; additionally, previously suppressed trips may be undertaken. Researchers studying urban freeways are familiar with this concept, known as induced travel, where the decreased cost of travel as a result of increased freeway capacity will induce travelers to shift their routes, travel mode, or time of travel, ultimately returning the recently expanded freeway to its previously congested condition. The basic premise behind induced travel at mixed-use developments is that certain elements of the mixed-use environment,

such as the interactive land use mix, the pedestrian-friendly atmosphere, or the proximity of the land uses, may reduce the cost of travel, which in turn may actually cause travelers to make additional trips, internal to the development, that would not have occurred if the origin-destination pair consisted of two stand-alone, single-use properties.

RESEARCH PROBLEM

Supporters of mixed-use developments as a cure for urban traffic congestion ills argue that placing several high-traffic origin-destination pairs within the same development will reduce vehicle traffic by internalizing some trips. However, because of the reduced travel costs realized by travelers at a mixed-use development, it is possible that new internal trips are generated; these internal trips are not substitutes for external travel, but rather, they are extra "induced" trips. If the transportation planning community is to promote mixed-use developments as a solution to urban traffic congestion issues, then an accurate representation of the travel behavior at a mixed-use development site must be considered, including any induced travel that may be present.

One method used in the site planning process for estimating trip generation for proposed mixed-use developments is outlined in the Institute of Transportation Engineers' *Trip Generation Handbook* (ITE 2004). This method requires the planner to estimate trip generation for each component land use of the proposed mixed-use development as a single-use, free-standing site and adjust this estimate to account for trips remaining internal to the site, with the end result being the number of trips that have one end external to the proposed development. One of the underlying assumptions of this method is that all of the trips remaining internal to the site are substitutes for travel outside of the site on the external transportation network. If induced travel is occurring, it should be accounted for in the site planning process to ensure adequate sizing of the transportation network around the proposed site.

RESEARCH OBJECTIVES

The goal of this investigation was to determine the percentage of internal trips at a mixed-use development site that are "induced" and would not have occurred if both trip ends were not located inside a mixed-use development. The specific objectives were as follows:

- Conduct a travel survey at a mixed-use development to determine the travel characteristics of the site;
- Determine the percentage of trips that are "induced" as previously defined;

- Determine quantitative and qualitative factors impacting induced trips on the site; and
- Investigate the impact of these induced trips on the current mixed-use development site planning practices.

DATA AND METHODOLOGY

To accomplish the research objectives, data obtained from a survey of travelers at a typical mixed-use development site were analyzed. Interviews were administered to persons exiting buildings at the subject mixed-use development site. Completed surveys provided information about the trip the respondent was taking at the time of the interview and the trip the respondent took before arriving at the location where the interview took place. Respondents indicating that their destination was internal to the subject mixed-use development site were asked if they would be willing to make the trip if travel outside of the site was required. Trips made by travelers that were unwilling to travel outside of the study site for their trip were classified as induced trips. Counts of person-movements entering and exiting buildings on the site (referred to as door counts) and multimodal cordon counts were also obtained to supplement the travel survey data. Data were collected for two periods, a morning peak period (6:00 AM to 10:00 AM) and an afternoon peak period (3:00 PM to 7:00 PM) on selected weekdays between Tuesday, May 22, 2007 and Tuesday, May 29, 2007. The travel survey efforts resulted in a total of 379 interviews during the morning period and 467 interviews during the afternoon period. Extracted from these interviews was information about a total of 1,288 trips at the study site.

The mixed-use development site selected for this research was named Legacy Town Center, located in the Dallas, Texas suburb of Plano. The suburban infill site was 75 acres in size, and contained a land-use mix that included office, retail, restaurant, residential, cinema, and hotel. The study site exhibited several features consistent with mixed-use development design, including a diverse, interactive land-use mix, pedestrian-oriented streets, and the creation of a sense of community through open space.

THESIS OUTLINE

After the Introduction, this Thesis will address the issues of the research problem through the following Chapters: Literature Review, Data Collection, Methodology and Analysis, and Conclusions and Recommendations. A summary of each Chapter is provided below.

Chapter II, the **Literature Review**, provides an overview of the relevant past research on the subject of mixed-use developments, their impact on travel behavior, and induced travel. The primary focus of the Literature Review is on the defining characteristics of mixed-use developments and how these elements are related to induced travel. Past research into travel behavior at mixed-use developments is offered in support of a framework of thinking about the traveler response to possible changes in the cost of travel that are present in a mixed-use development. From the information presented in the Literature Review, the purpose of this investigation is better defined.

Chapter III, **Data Collection**, provides the details of the process employed to collect the travel survey data used to evaluate induced travel at mixed-use developments. A detailed description of the subject mixed-use development site, Legacy Town Center, is provided, including a description of the six on-site land uses and the transportation characteristics of the site. Development of the travel survey is also discussed in this Chapter, along with a summary and evaluation of the data collection efforts.

Chapter IV, **Methodology and Analysis**, includes a description of the data reduction and the computational process that was used to develop the final origin-destination tables used in the analysis. Assumptions that were critical to the methodology are also identified and discussed. This Chapter also includes a detailed analysis of the data obtained from the travel survey. The percentage of trips that were induced, by land use and time period, are identified and compared to the percentage of trips that were internal to the study site. This comparison offers insight as to how many internal trips are actually replacing external trips, and how many are newly generated (induced). The induced and internal trip percentages are also compared for two modes of travel, automobile and walking. Potential relationships between traveler characteristics and the induced trip percentages are also analyzed. This Chapter concludes with a discussion of how the study findings can be incorporated into the site planning process.

Chapter V, **Conclusions and Recommendations**, provides a summary of the entire investigation and identifies the most relevant findings. Three final recommendations are provided and future research topics are discussed.

CHAPTER II
LITERATURE REVIEW

The first task in the investigation of induced travel at mixed-use developments was a comprehensive review of the existing literature associated with the topics relevant to the investigation. The literature review provides an overview of mixed-use developments, including the definition of a mixed-use development and the transportation characteristics of mixed-use developments. The concept of induced travel is also introduced and past research into travel behavior at mixed-use developments is offered in support of a framework for considering induced travel at mixed-use developments. Within the proposed framework, the role of this investigation is revealed, laying the foundation for the remaining research tasks.

MIXED-USE DEVELOPMENTS: A BACKGROUND

The focus of this investigation was planning at the site level; specifically, estimating trips that are generated by a particular type of site known as a mixed-use development. Before proceeding with the investigation, some discussion about the mixed-use development built environment is necessary to understand the context in which the investigation will be conducted.

What is a Mixed-Use Development?

The *Trip Generation Handbook* defines a multi-use development as a "single real-estate project that consists of two or more ITE land use classifications between which trips can be made without using the off-site road system" (ITE 2004). ITE also reports that multi-use developments are typically between 100,000 and 2 million square feet in size. In the ITE definition, a multi-use development must include two or more ITE land use classifications, thereby excluding sites such as shopping malls, office buildings or hotels with small retail shops attached, or a service station with convenience market, since those land uses have their own classifications in the *Trip Generation* report (ITE 2003). The Urban Land Institute (ULI) extends the definition of a mixed-use development to include (Schwanke 2003):

- Three or more significant revenue-producing uses that in well-planned projects are mutually supporting;
- Significant physical and functional integration of project components including uninterrupted pedestrian connections; and

- Development in conformance with a coherent plan that frequently stipulates the type and scale of uses, permitted densities, and related items.

Each of the above points suggests the subtle difference between the ITE definition of a "multi-use" development and a "mixed-use" development. In its most generic form, a multi-use development is simply two or more land uses at the same site. At a mixed-use development, each of the site elements (component land uses, buildings, transportation facilities, etc) are designed and positioned relative to other site elements in a deliberate manner to encourage a high level of interaction among on-site land uses. ULI defines this level of interaction between on-site land uses as market "synergy," representing the level of on-site support that exists for each land use pair. To that end, ULI proposed a framework for measuring market synergy at a mixed-use project, shown in Table 1. There is no set formula for what mix of land uses define a mixed-use development; however, the synergy relationships from Table 1 suggest that ideal land-use combinations are those that contain the highest synergy. Including the highly synergistic or interactive land uses within a site may lead to increased site activity, which could also result in greater profit for the developer.

Table 1: Framework for Estimating Synergy in a Mixed-Use Project (Schwanke 2003)

Land Use	Office	Residential	Hotel	Commercial	Civic
Office	N/A	●●	●●●●●	●●●●	●●●
Residential	●●	N/A	●●●	●●●●	●●●●●
Hotel	●●●●●	●●●	N/A	●●●●	●●●●
Commercial	●●●●●	●●●●●	●●●●●	N/A	●●●●
Civic	●●●●	●●●●●	●●●●●	●●●	N/A
Key: ●●●●● = Highest Synergy					

Under the umbrella of parameters defining a mixed-use development, the actual design of a mixed-use site can take a variety of forms. ULI categorizes the design and physical configuration of mixed-use projects into three groups: mixed-use towers, integrated multi-tower structures, and mixed-use town centers/urban villages/districts (Schwanke 2003). Mixed-use towers and integrated multi-tower structures integrate the component land uses vertically, that is, stacked on top of each other in the same building. Conversely, projects such as the mixed-use town center, urban village, or district focus primarily on the horizontal integration of land uses (side-by-side in the same building or multiple buildings). In some cases, a hybrid of vertical and

horizontal integration is achieved by horizontally mixing land uses such as retail or restaurant at the building's street level, then vertically integrating several upper levels of another land use, such as office or residential.

Mixed-Use Development Design Trends

Of the three configuration groups of mixed-use developments previously mentioned, the form most popular among new mixed-use development construction is the mixed-use town center, urban village, or district (Schwanke 2003). Known by such catchphrases as neo-traditional neighborhood development, New Urbanist town center, transit-oriented development, or pedestrian pocket, the designs of new mixed-use projects are inspired by the ideas of Duany and Plater-Zyberk (1991), Duany, Plater-Zyberk, and Speck (2000), and Calthorpe (1993). Mixed-use developments conceived using these principles are designed and constructed recognizing the significant role that the physical design and layout of a community plays in shaping the social and travel behavior of its residents (Audirac and Shermyen 1994). Berman (1996) identifies the following physical characteristics and resulting social effects of neotraditional mixed-use developments:

- A mixed-use core within walking distance of residents;
- Employment and civic centers;
- Gridded streets that provide multiple paths for drivers and pedestrians;
- Narrow streets with sidewalks and alleys running behind homes;
- Housing for different income levels;
- Higher housing density and smaller lots than those in conventional suburbs;
- Streets that are social spaces as well as transportation facilities;
- Common open spaces such as village greens;
- Distinct architecture modeled on the region's vernacular;
- Creation of a sense of community; and
- Creation of a sense of tradition.

For transportation planners, the most relevant aspect of mixed-use developments is how these physical characteristics impact the behavior of travelers at a particular site.

TRANSPORTATION CHARACTERISTICS OF MIXED-USE DEVELOPMENTS

Numerous studies (Cervero and Kockelman 1997, Ewing and Cervero 2001, Kuzmyak et al. 2003 to name a few) have examined the relationship between the built environment and traveler behavior. While the extent of the built environment's influence on travel behavior continues to be the focus of much debate, the link between the two is inseparable. One of the underlying themes that appears almost universally in planning literature is the claim that pedestrian-oriented, neo-traditional mixed-use developments built in urban environments can contribute to a reduction in vehicular travel by mixing a variety of origins and destinations within the same development (eliminating the need to travel on the external street system) and by encouraging travelers to walk to their destinations, rather than drive (reducing vehicle travel within the development). As a result, mixed-use developments built with the previously discussed characteristics are promoted as a land-use solution to urban traffic concerns such as roadway congestion and air quality (see, for example, Stone and Johnson 1992 or Frank 1998). In addition to an interactive land-use mix, Berman (1996) identifies the grid street layout and the pedestrian-friendly streetscape as the most influential features of mixed-use development design relevant to the assumed traffic-reducing benefits. This section provides an overview of these design features and their influence on the travel behavior of mixed-use developments. Another unique transportation aspect of mixed-use developments, shared parking, is also discussed. Finally, existing research on the impact of mixed-use developments on the regional-level transportation network is identified.

Grid Street Network

One of the distinguishing characteristics of new mixed-use developments built with traditional neighborhood design features is the grid street network. In contrast to the hierarchical street networks dictated by conventional suburban development (i.e. AASHTO 2004), these high-density grid street networks closely resemble the street networks of older American cities such as New York and Chicago. Evolution of street patterns from the grid street networks of older cities to the hierarchical street networks of conventional development is shown in Figure 1. Mixed-use developments built with an emphasis on traditional neighborhood design features will employ a street network similar to the gridiron layout shown in Figure 1.

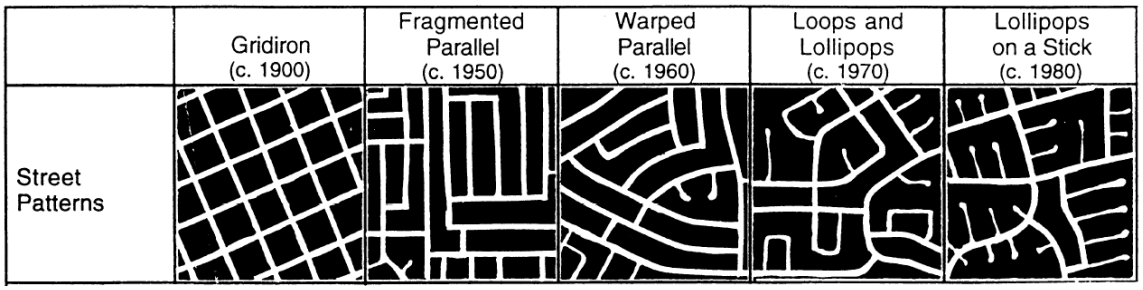

Figure 1: Schematic Drawings of the Evolving Street Network (Southworth and Owens 1993)

One concern about the grid street network is its ability to facilitate traffic movement with the same "efficiency" as the conventional street network design. In response to criticism of the traditional grid street design, Kulash (1990) developed a simulation model comparing the conventional, hierarchical street network with the traditional grid network with the goal of determining if the grid street network could support the same amount of traffic as the conventional street network. Using volume to capacity ratio and level of service as measures, Kulash found that arterial and collector streets in the traditional neighborhood street network (grid) performed better than their conventional counterparts; the performance of local streets was similar between the two network types. Kulash concluded that there were four main reasons why the traditional street network operated more efficiently than the conventional street network:

- Large streets of the sparse conventional network operate under a deficiency of scale (the streets are less efficient at moving traffic as they increase in size);
- Turning movements are more efficient on smaller, traditional street networks;
- Increased route choices offered by traditional networks make real-time route choices possible, not forcing all traffic onto a single arterial roadway; and
- Uninterrupted flow is more likely to occur on a dense grid network because smaller streets make it possible to have more unsignalized intersections.

A similar study conducted by McNally and Ryan (1993) found that the traditional street network design resulted in less vehicle-miles traveled, less total vehicle-hours, higher mean speeds, and shorter trip lengths when compared with the conventional street network. Another byproduct of the grid street network is increased neighborhood legibility, which essentially means that the grid network is easier to navigate than the conventional network.

Pedestrian-Friendly Streetscape

Mixed-use developments also contribute to a reduction in vehicle travel by creating environments that facilitate walking as a travel option. In a broader sense, pedestrian activity is encouraged by recognizing that the streets of mixed-use developments must be multimodal corridors, designed to accommodate not just automobiles, but pedestrians, bicyclists, and transit users as well. Specifically, pedestrian activity is supported by design elements that increase pedestrian safety, generally by reducing automobile speeds. Mixed-use development streets employ traffic calming measures, such as speed humps, raised crosswalks, or chokers, which have been shown to reduce vehicle speeds (thus creating a safer environment for pedestrians) when properly applied (Ewing 1999). Other streetscape elements, such as on-street parking, wide sidewalks, and trees or other vegetation beside the street are used to increase pedestrian safety by providing a buffer between the automobile traffic and the pedestrian traffic. In response to the growing popularity of "traditional" neighborhood and street design, the ITE Transportation Planning Council Committee 5P-8 (1999) developed a recommended practice for traditional neighborhood street design.

Shared Parking

Another interesting characteristic of mixed-use developments is the potential for shared parking at the site. Logic suggests that in an auto-oriented environment, no new development will succeed unless it provides sufficient parking supply to satisfy even the highest of demands. As a result, conventional developments of the post-World War II era contain a vast supply of parking that dominates the landscape of the site. It is not uncommon to visit a suburban shopping mall, for example, that has significantly more property dedicated to parking cars than selling retail merchandise. In a mixed-use development, however, the existence of multiple land uses in close proximity accommodates shared parking. The idea behind shared parking is that the parking demand for any given land use will vary throughout the day, and that the parking demand for different land uses will peak at different times. For example, the parking demand for an office building will be highest during the weekday, while a movie theater will require its peak parking demand during evenings and weekends. If a mixed-use development contains an office building and a movie theater, it is possible that a parking space used by an office employee during the day can be used by a theater patron in the evening. As a result, the quantity of parking required at a mixed-use development could be lower than what is required at

conventional developments, freeing valuable land within the property for revenue-generating activities, pedestrian facilities, or open space.

In an effort to increase the application of the shared parking concept, the Urban Land Institute, in partnership with the International Council of Shopping Centers, published *Shared Parking*, which contains guidance on computing the parking requirements for locations where shared parking may occur. Fourteen case studies from *Shared Parking* of mixed-use development sites ranging from 48,566 square feet to 1,274,700 square feet in size containing a mix of retail, dining, entertainment, and office land uses are summarized in Table 2 with the computed reduction in the number of parking spaces required when accounting for shared parking. The figures cited in Table 2 suggest that the required parking supply at a mixed-use development could be as much as one-third less than conventional developments.

Table 2: Shared Parking Case Studies (Smith 2005)

Case Study Site	Shared Parking Reduction (%)
Puente Hills Mall	18
Fashion Island	19
Veterans Plaza	3
Long Beach Towne Center	29
Covina Town Square	26
Burbank Empire	12
Westfield Promenade	25
Ahwatukee Foothills Towne Center	18
Irvine Spectrum (2002)	17
Irvine Spectrum (2003)	24
Reston Towne Center	33
Easton Towne Center	24
Block at Orange	30
Village Glen Plaza	24

Other studies of parking demand at mixed-use developments have reached similar conclusions. Steiner (1998) investigated six traditional neighborhood shopping centers and found that the weekday demand for parking spaces at all but one of the shopping areas was less than the minimum requirements for the number of parking spaces at traditional neighborhood developments recommended by Calthorpe (1993) applied to the study sites. A study of the mixed-use town centers of three small New England cities by Marshall and Garrick (2006) found

that, when compared with three conventional control sites, travelers at the mixed-use study sites used 11 percent less parking on an average day and nearly 20 percent less during the peak period. The most important point about shared parking at mixed-use developments is that due to shared parking, less acreage at a site is needed for parking and can be used for other activities.

Regional Impacts of Mixed-Use Development

The site planning process is concerned with the identification and mitigation of the transportation impacts of a new development on the street network immediately adjacent to the proposed site. Conversely, the regional transportation planning process is focused on estimating travel demand and the resulting needs of the transportation network on a larger geographic area. If policies encouraging mixed-use developments are to be included as a solution to traffic congestion in urban areas, it must be shown that their application does indeed produce the intended benefits for the entire urban area, and not just the transportation network near the site. Gordon and Peers (1994) reported that daily vehicle-miles traveled (VMT) reductions on the order of 20 to 25 percent could result from the innovative design and successful application of the "pedestrian pocket" concept proposed by Calthorpe (1993), crediting the "internalization of many routine trips, reduced automobile mode split, and a higher capture rate of internal jobs by residents" as three factors that contributed to the VMT reduction. Ewing et al. (1994) studied six communities in Palm Beach County, Florida and found an inverse relationship between the community's level of accessibility (density, mixed-use, and central location) and personal vehicle-hours of travel (VHT). An evaluation of proposed development sites in Atlanta, Georgia (one infill mixed-use development site and three greenfield conventional development sites) by Walters et al. (2000) showed that the infill mixed-use development site exhibited travel reductions from 14 to 52 percent compared to the greenfield locations. Using travel survey responses from Seattle, Washington-area neighborhoods, McCormack et al. (2001) found that residents of the two subject mixed land-use neighborhoods traveled 28 percent fewer miles than the residents of the remainder of the city, 73 percent fewer miles than the residents of the inner suburbs, and 120 percent fewer miles than the residents of the outer suburbs.

Summary

In general, the existing literature on travel behavior at mixed-use developments tends to conclude that properly implemented mixed-use developments in urban areas will reduce vehicle traffic, decongest urban freeways, and improve air quality. A vast amount of additional research

on travel behavior at mixed-use developments does exist, with most of these studies reaching the aforementioned conclusion. This investigation will not neglect these other studies; rather, their findings and conclusions will be applied in the remainder of this Chapter to present an alternate view of travel behavior at mixed-use developments upon which this investigation is based.

INDUCED TRAVEL

One of the basic principles of microeconomic theory is the relationship between the demand or supply of a good or service relative to its cost. As the price of a good or a service decreases, consumers will generally demand more of that good or service, and vice versa. Consider the generic situation of Figure 2, which consists of a demand curve (labeled D) and two supply curves (labeled S1 and S2) defining the quantities of a particular good or service demanded or supplied at a particular price level. Under supply condition 1, a certain quantity Q1 of the good or service is demanded at price level P1. If supply condition 2 is introduced to the market, the equilibrium price of the good or service decreases to P2. There are two fundamental impacts of this price decrease. First, consumers in the market under supply condition 1 will experience a consumer surplus equal to the area of rectangle ABCD; second, consumers demanding this good or service unwilling to pay price P1 but are willing to pay price P2 will enter the market, with a consumer surplus equal to the area of triangle BDE.

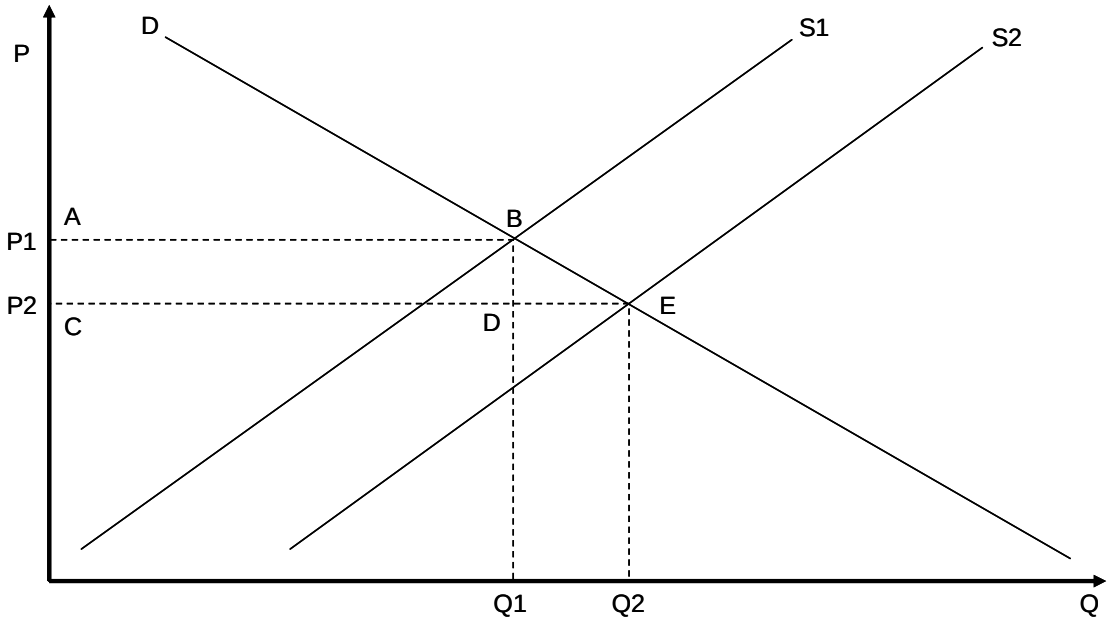

Figure 2: Generic Demand and Supply Curves D, S1, and S2

These concepts can also be used to model short-term travel behavior. If one considers Q to be the quantity of travel and P as the generalized cost of travel, it is evident how an increase in the supply of travel available, such as an increase in roadway capacity or the addition of an extra bus on a transit route, will reduce the cost of travel, thereby increasing the demand for travel. This increase in the demand for travel is generally known as "induced" travel. In the generic case, subtracting Q1 from Q2 determines the number of "induced" travelers. Depending on the context for which the demand and supply curves of Figure 2 are defined, induced travel can assume several forms. Downs (1992) proposed that the decreased cost of travel as a result of increased freeway capacity elicited traveler response in the form of increased travel demand primarily through the shifting of vehicles from alternate routes (such as a parallel arterial street) to the freeway, the shifting of travel from the shoulder periods to the peak periods, and the shifting of travel from public transportation to personal vehicle. In addition to Downs' "triple convergence," Lee et al. (1999) included destination shifts (travelers selecting a different destination for their trips based on a change in travel cost) and additional travel by current facility users as other sources of induced travel. Cervero (2003) suggested that the previously mentioned shifts are short-run "behavioral" responses to changing travel costs, and that in the long-run, "structural" changes can be expected. Pickrell (1999) provides a more in-depth discussion of these "structural" changes, most notably how the long-term location and distribution of households and businesses are affected by changing transportation costs.

MIXED-USE DEVELOPMENTS AND INDUCED TRAVEL

Much of the existing literature has found that mixed-use developments in urban areas will reduce vehicular traffic by mixing a variety of trip origins and destinations within the same development and by encouraging travelers to walk for their trips, rather than drive. While this might be true, it should not be assumed. Consider again the scenario presented in Figure 2 as a model of travel behavior. Under supply condition S1, a certain amount of travel (Q1) takes place at a particular generalized cost of travel (P1). Suppose that this first supply condition and its corresponding equilibrium generalized cost of travel and travel quantity were representative of the market for travel at a conventionally-designed, single land-use, suburban development. At a mixed-use development, travelers realize a savings in the cost of travel due to their ability to remain internal to the site for some trips (less expensive than the cost of off-site travel) and the ability to walk for some trips (which, in most cases, costs less than driving for the short distances

that are typical at mixed-use developments). As a result of these travel cost savings, more travel can be supplied at a mixed-use development for the cost, as compared to a conventional development. Thus, the curve defining the supply of travel at a mixed-use development may be represented by supply condition S2 in Figure 2. Consequently, the marginal cost of travel (that is, the cost of making an additional trip having already made one) at a mixed-use development is lower than the marginal cost of travel at a conventional development. It could be argued, then, that mixed-use developments actually have *more* travel than conventional developments, not less travel as some past research has suggested. Evidence from existing research that supports the two primary travel cost-saving elements of mixed-use developments (trip internalization and an increase in the use of alternate travel modes) is presented in the following paragraphs.

Trip Internalization

The placement of an origin and destination within a single development site (such is the case at a mixed-use development) creates the opportunity for travel between two on-site land uses without traveling on the external street network. By facilitating internal travel, the travel supply curve is shifted to the right, since the cost of travel within a particular site is generally less than if external travel was required. These trips, which have both ends (origin and destination) within the site, are known as internal trips (Stover and Koepke 2002). Of particular concern in the site planning process is the internal trip capture rate, which is the percentage of trips that remain internal to the site (ITE 2004). In the site planning process, trip generation estimates for proposed mixed-use developments can be adjusted by the internal trip capture rate to reflect the potential for on-site travel. The concept of internal trip capture is both logical and of great interest in the transportation planning community; however, existing literature on the topic is anything but conclusive with respect to the magnitude of internal trip capture at mixed-use developments.

One of the earliest efforts to quantify internal trip capture at mixed- or multi-use developments was a 1984 study of the Brandermill planned unit development (PUD), located in suburban Richmond, Virginia. The Brandermill study found that 45 percent of the morning peak hour trips, 55 percent of the afternoon peak hour trips, and 51 percent of the daily trips were internal to the site (JHK & Associates 1984). For home-based trips, 35 percent of the daily trip origins and 39 percent of the daily trip destinations had both trip ends within the Brandermill PUD site. For shopping trips, between 52 and 66 percent had both trip ends inside Brandermill.

The Brandermill results were obtained through a combination of driveway vehicle counts, household travel surveys, and retail/office area intercept surveys of the site.

In 1987, a technical committee of the Colorado/Wyoming Section of ITE published a study of trip generation for mixed-use developments. In the study, surveys were conducted of persons entering and exiting nine mixed-use development sites in northern Colorado. The survey results found that roughly three-quarters of the persons entering or exiting the mixed-use development sites had only one trip purpose. The balance (approximately 25 percent) had two or more trip purposes at the subject sites; this finding suggested that a reduction in trips of up to 25 percent may be possible at a mixed-use development site. However, a comparison of driveway traffic volumes recorded at the study sites with the appropriate volumes estimated by *Trip Generation* (ITE 1982) led the study authors to conclude that a more accurate estimate of trip generation for mixed-use developments could be obtained by reducing the peak hour single-use trip generation estimates by 2.5 percent (ITE Technical Committee 1987).

In response to the growing number of mixed-use development sites in Florida, the Florida Department of Transportation (FDOT) funded two separate studies in the early 1990s investigating the traffic characteristics of mixed-use developments. The result of these two studies was extensive data collection efforts at six mixed-use development sites in the south Florida region. The six sites ranged from 26 to 253 acres in size, and contained both office and commercial land uses. Five of the six sites contained residential units, and two had on-site hotels. Travel surveys were distributed to travelers at each of the six sites, and the results were analyzed to determine the travel characteristics of the sites. For the six sites, the average daily internal trip capture rate was 36 percent, distributed as shown in Table 3 below.

Table 3: Daily Internal Trip Capture Rates at FDOT Study Sites

Study Site	Internal Capture Rate (%)	Source
Boca Del Mar	33	Tindale, Oliver, and Associates 1993
Country Isles	33	Tindale, Oliver, and Associates 1993
Crocker Center	41	Walter H. Keller, Inc. 1995
Galleria Area	38	Walter H. Keller, Inc. 1995
Mizner Park	40	Walter H. Keller, Inc. 1995
Village Commons	28	Tindale, Oliver, and Associates 1993

Comparing the mid-day period (Noon to 2:00 PM) with the afternoon peak period (4:00 PM to 6:00 PM), Tindale, Oliver, and Associates (1993) found that the mid-day period (32 percent) had a slightly higher internal capture rate than the afternoon period (29.5 percent). Stratifying the results by the type of traveler found that workers employed at the study site averaged a 47 percent internal trip capture rate while the capture rate for non-workers (users) averaged 37 percent (Walter H. Keller, Inc. 1995).

A study of 20 master-planned communities in south Florida by Ewing et al. (2001) found internal trip capture rates ranging from zero to 57 percent (average 25 percent), with variables such as the size of the community and regional accessibility having an impact on the internal trip capture rate. Comparing a neo-traditional mixed-use neighborhood in North Carolina with a nearby conventional neighborhood, Khattak and Rodriguez (2005) found that 21.4 percent of trips produced in the neo-traditional neighborhood remained internal to the neighborhood, significantly different than the internal trip percentage of 5.3 percent computed for the conventional control site.

One major contribution of the FDOT mixed-use development studies was an effort to determine the internal trip capture rate between individual land use pairs. Using the findings of the two FDOT studies, a methodology for estimating the trip generation for proposed mixed-use developments incorporating internal trip capture rates was developed and adopted by ITE for inclusion in the Second Edition of the *Trip Generation Handbook*. The ITE *Trip Generation Handbook* methodology for estimating internal trip capture for a mixed-use development requires the planner to estimate trip generation for each component on-site land use as a single use site, then apply a percentage internal capture and a balancing process between each land use pair to determine the total internal and external trips (ITE 2004). However, this method has several shortcomings. First, the data is limited to only the six FDOT study sites. Second, the method is limited to the mixing of office, retail, and residential uses, and does not provide any data for other land use types within a mixed-use development that may influence the number of internally captured trips, such as restaurant, cinema/entertainment, or hotel. Finally, the ITE method does not account for other characteristics of a mixed-use development that might impact the internal trip capture, such as the availability of transit or the degree of connectivity between the on-site land uses. Recognizing these limitations, the National Cooperative Highway Research Program (NCHRP) initiated a project in August 2005 to enhance the process for

estimating internal trip capture. The NCHRP project[1] collected data at two mixed-use development sites and the forthcoming project documentation is expected to outline an improved ITE *Trip Generation Handbook* method which incorporates additional land uses, travel mode considerations, and proximity into the estimation process (Bochner et al. 2006).

Alternate Travel Modes

The emphasis placed on facilitating pedestrian activity at mixed-use developments (origin-destination pairs in close proximity coupled with a pedestrian-friendly environment) results in travelers realizing a savings in their cost of travel, since walking or bicycling is less expensive than travel by automobile. Freidman et al. (1994) compared traditional communities with standard suburban communities and found that the use of alternate modes such as transit, bicycle, or pedestrian was nearly double for home-based work trips and 65 percent higher for home-based non-work trips in the traditional communities. In their study of two San Francisco, California-area neighborhoods, Cervero and Radisch (1996) showed that the share of non-work trips taken by alternate modes was approximately 10 percentage points higher in the compact, mixed land-use, and pedestrian-oriented neighborhood of Rockridge, compared to the conventional suburban neighborhood of Lafayette. McCormack et al. (2001) studied six neighborhoods and found that the mixed-land use neighborhoods of Queen Anne and Wallingford generated more walking trips (coincidentally, 10 percentage points more) than conventional neighborhoods and the suburban areas as a whole, as shown in Table 4.

Table 4: Percent Walking Trips at Seattle-Area Study Neighborhoods (McCormack et al. 2001)

Location/Neighborhood	Neighborhood Type	Percent of Walk Trips
Queen Anne	Traditional, Mixed-Use	18.1
Wallingford	Traditional, Mixed-Use	17.7
North Seattle	Conventional	8.8
Kirkland	Conventional	7.8
Inner Suburbs	Suburban Region	2.8
Outer Suburbs	Suburban Region	2.0

[1] NCHRP Project 8-51, *Enhancing Internal Trip Capture for Mixed-Use Developments*, is ongoing at the time of this writing. The author of this Thesis has been actively involved with this project in his role as a Graduate Assistant Researcher at the Texas Transportation Institute.

Some past research has tied specific attributes of neotraditional mixed-use developments to patterns of travel by alternate modes. Frank and Pivo (1994) found that a residential density greater than 13 residents per acre would be necessary before significant changes in the share of walking trips could be observed. Cervero (1996) showed that the existence of retail shops within 300 feet of a residence will increase the propensity of workers to commute via alternate modes. Moudon et al. (1997) found that the "completeness" of the pedestrian facilities within a particular area (specifically, block size and sidewalk length) had a significant impact on the number of pedestrian trips in mixed-use, medium-density neighborhoods. These findings suggest that high-density, mixed-use, pedestrian-friendly developments are locations where travelers may realize travel cost savings through walking or bicycling instead of driving.

Although the focus of mixed-use developments is on facilitating the pedestrian as the primary non-personal vehicle mode of travel, it should be acknowledged that "transit-oriented developments" are increasing in popularity (Cervero 2004). Mixed land-use development around transit stations (generally rail, although sometimes bus) is thought of as a way to support transit service by taking advantage of increased residential and/or employment densities that are present at mixed-use developments. Additionally, placing amenities at the transit station such as grocery stores, retail shops, or child care facilities make the transit service more attractive by providing the opportunity to accomplish several non-work trip purposes at each end of the daily commute. These features of transit-oriented development may reduce the cost (by increasing the convenience) of transit relative to other modes, particularly for work trips. By the same logic, Cervero (1988) showed that carpooling may be facilitated by mixing land uses, allowing for midday or after-work errands by employees of suburban mixed-use job centers. Freidman et al. (1994) found that carpooling was higher in the neotraditional neighborhoods compared to conventional suburban neighborhoods.

DISCUSSION: REDISTRIBUTION OR GENERATION?

Thus far, the findings of past research efforts on the subject of traveler response to certain elements of the mixed-use environment have been identified and discussed as they pertain to a savings in the generalized cost of travel, causing a rightward shift in the travel supply curve. Cervero (2003) offers that the impacts of these savings are either redistributive or generative in nature; that is to say, are trips being redistributed to other routes, modes, times, or destinations, or are new trips (previously suppressed for any number of reasons) being generated

as a response to a change in the costs of travel? Speaking in terms of the graphical representation of this situation presented by Figure 2, what percentage of travelers fall into rectangle ABCD (redistributed) versus triangle BDE (new generation)? The question of redistribution or generation is a critical issue in the debate over mixed-use developments as a land-use solution to urban traffic problems. Advocates of mixed-use developments claim that internal travel and the increased use of alternate travel modes at mixed-use developments are replacing (redistributing) travel on the external transportation network and trips made in a single-occupant automobile. However, given the concepts of Figure 2 and the arguments presented in the previous section of this Chapter, it is evident that at least some new trip generation could be occurring at mixed-use developments. For the transportation planning community, it is critical to examine this issue before passing judgment on the advertised transportation benefits of mixed-use developments. Existing research has identified redistributive effects of the shift from automobile to walking; the issue of redistribution or new trip generation with respect to internal trips is slightly less clear.

Mode Substitution

In the mixed-use environment, Q1 travelers experience a cost savings equal to the area of rectangle ABCD in Figure 2 by redistributing their trips, either by replacing an external trip with an internal trip, or by replacing a driving trip with a walking trip. Much of the research on this topic has focused on the latter, studying the replacement of automobile trips with walking trips in the mixed-use environment. As part of a study on pedestrian behavior and attitudes in six Austin, Texas neighborhoods (two each of three neighborhood types), Handy (1996) surveyed residents in the six study neighborhoods about their most recent walk to the store with respect to what the resident would have done if walking was not an available option for their most recent trip to the store. Across the three neighborhood types (traditional, early modern, and late modern), more than two-thirds of the respondents would have driven to the store, suggesting that a walking trip to the store was indeed a substitute for a driving trip to the store. The work of Cervero and Radisch (1996) found that the total household trip rates between automobile-oriented and pedestrian-oriented neighborhoods were similar, and inferred that walking trips within the pedestrian neighborhood were substitutes for automobile trips. Khattak and Rodriguez (2005) arrived at a similar conclusion in their study comparing a neotraditional neighborhood and a conventional neighborhood in North Carolina, finding that residents of the

neotraditional neighborhood were replacing driving trips with walking trips, even when the analysis was controlled for residential self-selection by neotraditional neighborhood residents.

Greenwald (2003) addressed the question of mode substitution with a slightly different approach. By treating automobile, walking, and transit as consumer goods, Greenwald developed activity-based travel models to test the sensitivity of travelers to various characteristics of mixed-use developments by suggesting that the willingness of travelers to substitute between walking and automobile and transit and automobile was the ratio of the median travel times between the two modes. By this definition, if the median travel time for a trip made on foot decreased or the median travel time for a trip made by auto increased (as one might suspect would be the case in a mixed-use environment), walking would be the travel mode selected by the traveler (if travel time was the only factor in the decision). Greenwald found that an increase in the number of street intersections or an increase in the mixed-use index (a quality measure of mixed-use developed for the model) would result in more travel on foot; an increase in the average parcel (lot) size would result in less travel on foot. The findings of Greenwald's study, coupled with the results of other studies investigating the substitution of walking trips for automobile trips in the mixed-use environment, suggest that for the most part, travelers in mixed-use developments are substituting automobile trips with walking trips-a finding that supports at least a portion of the advertised transportation impacts of mixed-use projects.

Induced Travel: Do Mixed-Use Developments Generate New Trips?

Because of the travel cost savings in the mixed-use environment, there exists an additional group of travelers (defined by Q2-Q1) that receive a benefit equal to the area of triangle BDE in Figure 2 and will enter the market for travel, generating new trips that were previously suppressed. Considering that one of the claimed transportation benefits of mixed-use developments is a reduction in the amount of travel around a site, the prospect of new trips being generated by a mixed-use development site should be of great importance to the research community; however, there has been little research conducted on the issue to date.

One of the first investigations on the subject of new trip generation at mixed-use developments was conducted by Crane (1996), who developed a framework for analyzing the traveler response to several design characteristics of the neotraditional, mixed-use environment. In his framework, Crane considered how an increase or decrease in three design elements present at mixed-use developments-the grid street network, traffic calming, and mixed/intensified land

uses-would cause a change in the costs of travel. Crane evaluated these travel cost changes as they impacted three separate measures: car trips, VMT, and the car mode split. Table 5 shows a summary of Crane's findings. It is evident from Table 5 that the potential for an increase in automobile trips, as well as travel by all modes, exists in the mixed-use environment.

Table 5: Qualitative Effects of Neighborhood Design Features on Travel (Crane 1996)

Traffic Measure	Design Element			
	Grid (Shorter Trips)	Traffic Calming (Slower Trips)	Mixed/Intensified Land Uses	All Three
Car Trips	Increase	Decrease	Increase or Decrease[2]	Increase or Decrease[3]
VMT	Increase or Decrease[1]	Decrease	Increase or Decrease	Increase or Decrease
Car Mode Split	Increase or Decrease	Decrease	Increase or Decrease	Increase or Decrease

[1] Depending on how sensitive trips by each mode are to trip length.
[2] Depending on trip purpose, trip length, and induced congestion.
[3] Depending on relative mix of elements.

Crane used this framework to evaluate data obtained from a travel survey in the San Diego, California region, finding that the neighborhood grid-style street pattern had no significant effect on automobile or pedestrian travel (Crane and Crepeau 1998).

Other research efforts on travel behavior at mixed-use developments have suggested the possibility for increased travel in the mixed-use setting. Handy (1996), in her study of Austin, Texas neighborhoods, found that approximately 13 percent of survey respondents in the six study neighborhoods would have stayed home rather than walk to the store, if walking to the store was not available, implying that at least some induced travel was occurring. McCormack et al. (2001) suggested that mixing land uses could make shopping activities more convenient, which would allow more time for additional travel.

Research Problem

Mixed-use developments claim to reduce traffic by capturing trips internally and providing a pedestrian-friendly atmosphere to facilitate walking for those internal trips. However, these elements which provide the traffic-reducing benefits of mixed-use developments also reduce the overall cost of travel, thereby increasing the amount of travel. If the

transportation planning community is to promote mixed-use developments as a solution to urban traffic congestion issues, then an accurate representation of the travel behavior at a mixed-use development site must be considered. This would include a better understanding of the proportion of trips that are induced by a mixed-use development.

This induced traffic also has implications for the techniques used by planners to evaluate the traffic impacts of proposed mixed-use development sites. One methodology for estimating the number of trips generated by a proposed mixed-use development site, recommended by ITE, implicitly assumes that all internal trips at the site are replacing external trips (ITE 2004). However, some internal trips may be new trips, and not replacements. If new trips are indeed being generated, they must be incorporated into the site planning process so that the transportation network adjacent to a proposed mixed-use development site can be adequately sized for the anticipated traffic demand.

CHAPTER III
DATA COLLECTION

Some literature (Crane 1996, Handy 1996, McCormack et al. 2001) has suggested that the travel cost savings realized from the convenience of a complementary, interactive land-use mix and the proximity of these land uses in a mixed-use development induces travelers to make additional internal trips with the same travel "budget," trips that would not have been made if additional costs (such as off-site travel between single-use sites) were required. Since the decision to make additional trips within a mixed-use development is an individual behavior, the best method to determine the extent of induced travel is to conduct a travel survey, and specifically ask travelers at a mixed-use development site about the induced nature of their trip. This Chapter provides the details of the data collection efforts, including a description of the mixed-use site where the travel survey was conducted, the design of the travel survey, a description of the travel survey activity, and a summary of the data collection efforts.

DESCRIPTION OF SUBJECT MIXED-USE DEVELOPMENT SITE

The mixed-use development site selected for the data collection was named Legacy Town Center, a 75-acre suburban infill mixed-use development in Plano, Texas, a northern suburb of Dallas. Legacy Town Center was located near the intersection of the Dallas North Tollway and Texas State Highway 121 within the Legacy Business Park, an office park containing numerous major corporate headquarters and other large office buildings. The location of Legacy Town Center relative to the Dallas area is shown in Figure 3. Legacy Town Center, which opened in 1999, was developed by the real estate division of the Legacy Business Park's largest tenant, Electronic Data Systems, as a way to make the area around their company's headquarters more appealing to employees (El Nasser 2004). The site, which was designed by the well-known mixed-use development architecture firm of Duany, Plater-Zyberk, and Associates, has received accolades for its design and impact on the surrounding region. Legacy Town Center was identified by the United States Environmental Protection Agency as an illustration of "smart growth" principles (USEPA 2007) and was recognized by the North Central Texas Council of Governments in 2004 with an award for leadership in development excellence, calling the site a "wonderful example of infill development amidst existing corporate

campuses, which can serve as an opportunity for similar projects in the Metroplex" (NCTCOG 2004).

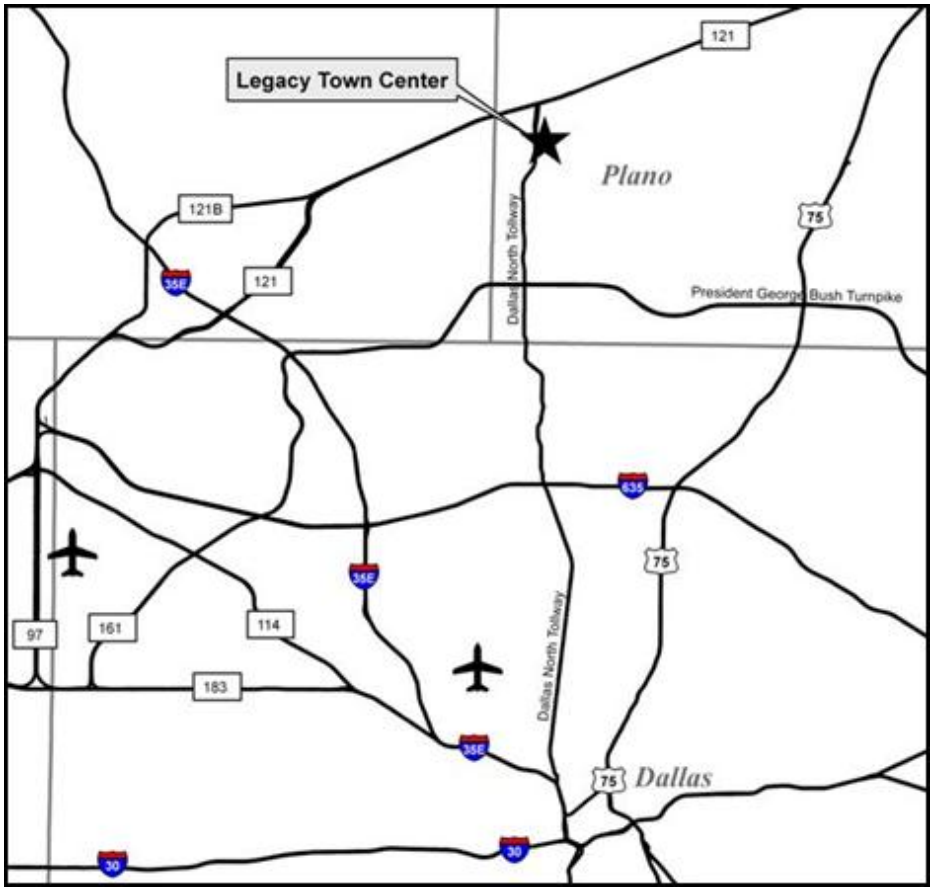

Figure 3: Location of Legacy Town Center in Dallas, Texas Area

Description of On-Site Land Uses

Figure 4 is a site plan of Legacy Town Center showing the on-site land-use mix, which included office (shaded in green), mixed-commercial (retail, restaurant, and movie theater, shaded in yellow), residential (orange), and hotel (blue). Land-use integration on the site was primarily horizontal, but some vertical integration existed in the mixed-commercial areas. To provide a sense of the site's size and scale, the distance between the streets on the north and south edges of the site (right and left in Figure 4) was approximately 1,600 feet, and the distance between the west and east boundaries (up and down Figure 4) was approximately 1,200 feet. Therefore, the absolute maximum travel distance at Legacy Town Center (diagonally across the

property) was approximately 2,000 feet. A more detailed description of each on-site land use follows. All development information, unless otherwise noted, was unpublished data provided by the appropriate developer or management company, and was representative of the site at the time of the travel survey.

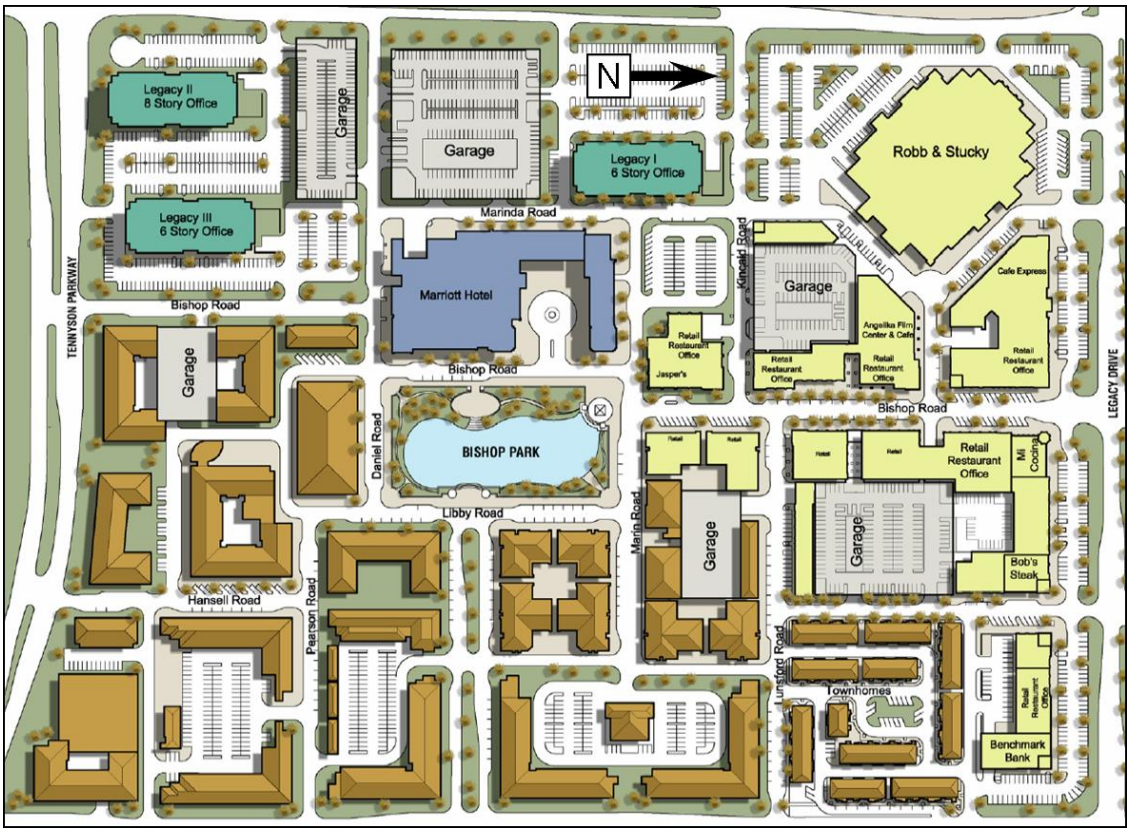

Figure 4: Site Plan, Legacy Town Center (Provided by Trammel Crow Company)

The office component of Legacy Town Center consisted of three mid-rise office buildings and additional office space on the upper levels of some buildings in the mixed-commercial area. Characteristics of the three office buildings are described in Table 6 below.

Table 6: Description of Office Buildings, Legacy Town Center

Office Building Name	Floors	Occupied Square Feet	Total Square Feet
Legacy Town Center I	6	153,230	153,766
Legacy Town Center II	8	53,415	207,076
Legacy Town Center III	6	38,394	153,866

Within the mixed-commercial area, office properties existed on the upper levels of three buildings, with a total of 65,725 square feet occupied. None of the information provided by the developer suggested that vacant office space existed in this area of Legacy Town Center. As such, the total office component of Legacy Town Center consisted of 580,433 square feet, of which 310,764 square feet (about 53.5 percent) were occupied at the time of the survey.

The mixed-commercial area of Legacy Town Center consisted of a variety of retail shops and restaurants, as well as a movie theater. The retail component included a large specialty furniture store, a variety of specialty shops, and convenience/service-oriented properties, as described in Table 7. Including four vacant retail properties totaling 8,894 square feet, there were a total of 196,264 square feet of retail space in Legacy Town Center. Not including the 93,000 square foot specialty furniture store, the largest retail space in Legacy Town Center was 8,020 square feet, and the mean retail store size was 2,518 square feet.

Table 7: Distribution of Retail Types, Legacy Town Center

Retail Type	Number	Total Square Feet
Clothing/Accessories	12	22,266
Convenience/Service	13	25,069
Furniture/Housewares	8	121,909
Gifts/Specialty	6	16,700
Other	3	10,320
Total	42	196,264
Note: Classifications assigned by author.		

Some of the convenience and service-oriented retail shops were open during the morning peak period to serve customers before work and remained open into the evening hours. The remainder held more traditional retail hours, opening mid-morning and closing by 6:00 PM.

Four general types of restaurants existed at Legacy Town Center: high-end, sit-down quality restaurants, high-turnover restaurants, fast-food restaurants, and a drinking establishment. The number and total square feet for each type of restaurant are shown in Table 8.

Table 8: Distribution of Restaurant Types, Legacy Town Center

Restaurant Type	Number	Total Square Feet
Quality, Sit-Down	5	29,451
High-Turnover	7	25,581
Fast Food	4	7,296
Bar/Drinking	1	6,990
Total	17	69,318
Note: Classifications assigned by author.		

Two fast food restaurants (a coffee shop and a juice bar) were open during the morning, as was a sit-down bakery which was classified as a high-turnover restaurant. Most of the on-site restaurants were open starting for the midday meal, but some of the quality restaurants were only open for the evening meal. Operating hours for the drinking establishment extended later into the evening, anchoring the nightlife of the area. Ten of the restaurants provided some outdoor seating for their patrons, which increased the activity along the street.

The on-site movie theater at Legacy Town Center consisted of five screens and a total of 1,019 seats. The largest of the five auditoriums contained 299 seats. The films shown at the theater were generally independent or foreign movies that would most likely not be shown in a mainstream, multiplex-style movie theater. There was a weekday matinee offered at the theater, and occasional special events were held in one or more of the auditoriums.

The residential component of Legacy Town Center included apartments with a variety of floor plans and privately-owned townhomes. The residential space in Legacy Town Center was mostly located on the south and east sides of the property (see Figure 4). Additionally, one of the mixed commercial buildings contained four upper levels of residential units. A total of 1,449 apartment units existed at Legacy Town Center, with roughly 1,300 of these units occupied at the time of the survey (approximately 90 percent occupancy). At the time of the survey, 60 of the 63 townhomes had been purchased from the developer and were occupied. The hotel component at Legacy Town Center consisted of an upscale conference hotel, which contained 404 guest rooms and approximately 32,000 square feet of conference and meeting space.

Transportation in Legacy Town Center

Legacy Town Center was bordered on all four sides by major roadways: Dallas North Tollway Frontage Road to the west, Legacy Drive to the north, Parkwood Boulevard to the east,

and Tennyson Parkway to the south. From these surrounding roadways, a total of 18 access points connected travelers to the interior of Legacy Town Center. The internal streets of Legacy Town Center resembled two-lane local streets, arranged in a partial grid layout. To encourage pedestrian activity, elements such as speed humps, on-street parking, inviting sidewalks, street trees, and street furniture were strategically placed along streets at Legacy Town Center. Many of these elements can be seen in the street scene at Legacy Town Center shown in Figure 5.

Figure 5: Street Scene at Legacy Town Center (Photo Taken by Author)

One Dallas Area Rapid Transit (DART) crosstown bus route passed near Legacy Town Center, with two bus stops located on Tennyson Parkway along the south edge of the property, connecting the site and the surrounding business park with the DART light rail stations at Parker Road or Forest Lane. According to published schedules, at the time of the survey, service on this bus route operated weekdays only, with 30-minute approximate headways during the peak periods and one-hour headways during the non-peak times (DART 2007). The on-site hotel at

Legacy Town Center operated a shuttle service for their guests between the hotel and the surrounding business park, as well as a nearby shopping mall if requested.

There were a total of 6,070 parking spaces at Legacy Town Center, distributed as shown in Table 9. Several parking garages were reserved for residents and on-site employees, with the appropriate credentials required for access. Public parking consisted of two large garages, multiple surface lots located adjacent to the mixed-commercial buildings, and on-street parking spaces. Including garages, surface lots, and street parking, a total of 2,156 spaces were available to the public at no cost. An additional 285 garage spaces that were signed as reserved for employees until 6:00 PM weekdays were available to the public during the evenings and weekends. The public could access the hotel garage, however, payment was required. Many of the restaurants offered valet parking services for their patrons, which reduced the number of free parking spaces available to the public during the valet operating hours.

Table 9: Distribution of Parking Spaces, Legacy Town Center

Parking Space Type	Number of Spaces
Resident Only	1,608
Employee Only	1,436
Employee Only Shared	285
Hotel Garage	585
Public Garage	744
Public Surface	1,060
Public Street	352
Total Parking Spaces	6,070

The parking spaces available at Legacy Town Center were observed to be more than sufficient to handle the parking demand associated with the site's level of activity at the time of the survey. Thus, it can be said that the investigation was not limited with respect to travelers choosing to not come to the study site because of perceived concerns about finding adequate amounts of parking.

Legacy Town Center as a Study Site

In this investigation, the impact of mixed-use development design on travelers' behavior-specifically, induced or additional travel-was being measured. As such, the application of the investigation's results in planning practice is limited to the extent that the selected study

site could emulate typical mixed-use development design. The following attributes of Legacy Town Center made it an ideal study site for this investigation:

- **Diverse, Interactive Land Use Mix:** As previously described, there were six distinct land uses at Legacy Town Center, creating multiple opportunities for travel with both trip ends (origin and destination) within the development. Additionally, the land-use mix was interactive; that is to say, the land uses present created origin-destination pairs that would logically have some level of interaction, such as retail and restaurant.
- **Grid-Style Street Layout:** The arrangement of the streets in Legacy Town Center resembled a partial grid layout consistent with typical mixed-use development design, as shown in Figure 4. While it was not a complete grid system, there was enough of a grid to increase neighborhood legibility and allow travelers to select from several routes to travel through the development.
- **Pedestrian-Friendly Design:** The maximum walking distance at the site, approximately 2,000 feet, did not impose any restrictions on those able to travel on foot. As shown in Figure 5, the streetscape of Legacy Town Center accommodated the pedestrian by offering wide sidewalks, shade trees, and benches. Additionally, pedestrian safety was enhanced by traffic calming measures such as speed humps and bulb-outs, as well as on-street parking creating a buffer between vehicles and pedestrians.
- **Parks/Open Space as Focal Point:** One objective of mixed-use development design is to create a sense of community by providing parks or open space where residents, employees, and visitors can interact. In the center of Legacy Town Center was a park named Bishop Park, which contained a lake surrounded by walking paths and sitting.

One attribute of Legacy Town Center that was an issue for this study was the lack of accessibility at the site for non-automobile travelers. The infrequent headways of the bus route serving the site made transit an unattractive option, and the site's location within a business park (large parcels of land and a conventional street system) made walking to the site impractical. Outside of the concerns about accessibility, the study site, Legacy Town Center, sufficiently emulated characteristics of mixed-use development design for the results of this investigation to be applied to the mixed-use development planning process.

DATA COLLECTION DESIGN

To determine the extent of induced travel at mixed-use developments, an origin-destination travel survey was conducted at Legacy Town Center. The following paragraphs describe the design of the travel survey and the required tasks leading up to the survey deployment.

Travel Survey Design

Several of the past studies investigating travel behavior at mixed-use developments were reviewed to develop the survey for this research. Ultimately, an interview format similar to the format employed in the NCHRP project for enhancing internal trip capture at mixed-use developments was selected for this investigation (Bochner et al. 2006). Under this format, trained personnel were positioned outside predetermined building exits at Legacy Town Center, approach persons exiting these buildings, and ask them if they would take time to respond to the survey questions. If the person exiting the building was willing to participate in the travel survey interview, the person administering the interview would read the questions and record the responses. Unlike some past studies, which considered trip characteristics as a function of one or more trip purposes, the travel survey in this investigation was designed to capture information about the respondent's origin and destination, stratified by land use. The survey instrument was designed to record information about two trips: the trip that the respondent was making at the time of the interview, and the trip that the respondent made prior to arriving at the location where the interview was administered. For each of the two trips, the trip end location (internal or external) and land use were recorded, as well as the mode of travel for the trip. If the destination of the trip the respondent was making at the time of the interview was identified as internal, an additional question was asked about the induced nature of the trip. This question is discussed in greater detail below. When identifying the respondent's previous location, it was necessary to ask the respondent what time he or she arrived at the interview location, to approximate the time of day that the previous trip took place. For all interviews, the respondent was asked how he or she initially traveled to Legacy Town Center that day, with a follow-up question about the availability of an automobile for this trip if the respondent indicated that he or she accessed the site by a means other than automobile driver. A copy of the travel survey interview form can be found in Appendix A.

Design of Induced Travel Question

The most important element of the travel survey, with respect to this investigation, was the question about the induced nature of the respondent's trip. When designing the survey instrument, identifying the proper wording for this question proved to be challenging. The issue of induced travel at mixed-use developments revolves around whether or not travelers in the mixed-use environment respond to lower travel costs in that environment by making additional trips. Thus, it was necessary to incorporate some element of the cost of travel into the design of the induced travel question. Also, it was necessary to design the survey questions such that a respondent was only burdened one or two minutes to complete the entire travel survey. Several iterations of the question were considered, and the final version of the question read as follows:

Would you be making this trip if you had to travel outside Legacy Town Center?

This question attached a cost (travel outside of Legacy Town Center) to the trip the respondent was making at the time of the interview, and asked that individual to consider if he or she would have made the trip even with this additional cost. A "yes" answer to this question indicated that the trip was not induced because the respondent would have been willing to make the trip regardless of the additional costs. A "no" answer to the question suggested that the respondent was making an induced trip because the marginal cost to travel outside Legacy Town Center (either real or perceived) was higher than what the respondent was willing to pay for his or her trip. Before the survey was deployed at Legacy Town Center, the induced travel question was pilot-tested at several locations and it was concluded that the question was understood by those who participated in the pilot testing. One potential issue of this question that needed to be addressed was the presence of competing opportunities near the study site. For example, if a competing location was available across the street from the study site, the marginal cost of traveling outside of the site would be low and travelers would not encounter much resistance traveling outside of the site to reach their destination. However, this was not that case at Legacy Town Center; given its location in the middle of Legacy Business Park, a drive of at least several minutes would be required for travel to other sites where similar services were offered.

With this origin-destination intercept survey, it was nearly impossible to survey the entire population of interest, either because potential respondents did not want to participate in the survey, or because potential respondents were passing by while a survey interview was being administered with another traveler. Therefore, additional data collection was required in the

form of door entrance and exit movement counts to determine the population size from which the interview respondents were drawn. Also, a full site multimodal cordon count was performed to gain a better understanding of the travel activity of Legacy Town Center as a whole.

Pre-Survey Tasks

Before deploying the survey, several tasks were required to lay the foundation for a successful data collection effort. Contacts were made with the developer of Legacy Town Center to obtain the necessary permission to conduct the travel survey and collect data at the site. It was discovered that a majority of the properties at the site had been sold to other developers, which required each developer to be contacted individually to request permission. Permission to conduct the travel survey was approved for every property except for the large specialty furniture store; additionally, securing permission to interview at the townhomes was difficult, since each townhouse was individually owned. Several site visits were made to Legacy Town Center before the survey deployment to meet with the developer representatives and investigate locations to position interview personnel to best accomplish the research goals.

The data collection efforts required a large number of personnel to administer the travel survey interviews or record door counts and cordon counts. A temporary employment agency in the Dallas area was contacted to hire the needed personnel. A total of 40 individuals were provided by the temporary employment agency, as this was the number of workers necessary to sufficiently meet the research requirements. The temporary employment agency pre-screened potential workers to determine if they were able to work all of the scheduled times for data collection and if they could look and speak professionally towards interview respondents.

Since the research involved interaction with human subjects, it was necessary to obtain approval from the Texas A&M University Office of Research Compliance's Institutional Review Board (IRB) before conducting the travel survey. The submitted protocol (# 2007-0291) was approved by the IRB and it was determined that the travel survey met the criteria for exemption, which required no further Board review. A copy of the IRB approval documentation can be found in Appendix B.

DESCRIPTION OF DATA COLLECTION ACTIVITY

In general, the time periods of concern in the site planning process are the weekday morning and afternoon peak periods (Stover and Koepke 2002). As such, the travel survey

efforts at Legacy Town Center were deployed during a morning peak period (6:00 AM until 10:00 AM) and an afternoon peak period (3:00 PM until 7:00 PM). Given the size of Legacy Town Center and the number of personnel available, two days' worth of morning and afternoon peak periods were scheduled to sufficiently collect data across the entire site. Morning peak period data collection occurred on Wednesday, May 23 and Thursday, May 24, 2007. Afternoon peak period data collection occurred on Tuesday, May 22 and Wednesday, May 23, 2007. It was determined that an additional afternoon peak period was needed to sufficiently collect data, scheduled for the afternoon of Thursday, May 24. However, there was rain during nearly all of the afternoon peak period that day, and so the extra afternoon was rescheduled and successfully completed on Tuesday, May 29. Before the first data collection period (afternoon of May 22), the data collection personnel met in a conference room at the on-site hotel for a two-hour training session on the data collection process. Outside of the one previously mentioned period of rain, the weather during the data collection periods was ideal and did not limit the amount of activity at Legacy Town Center.

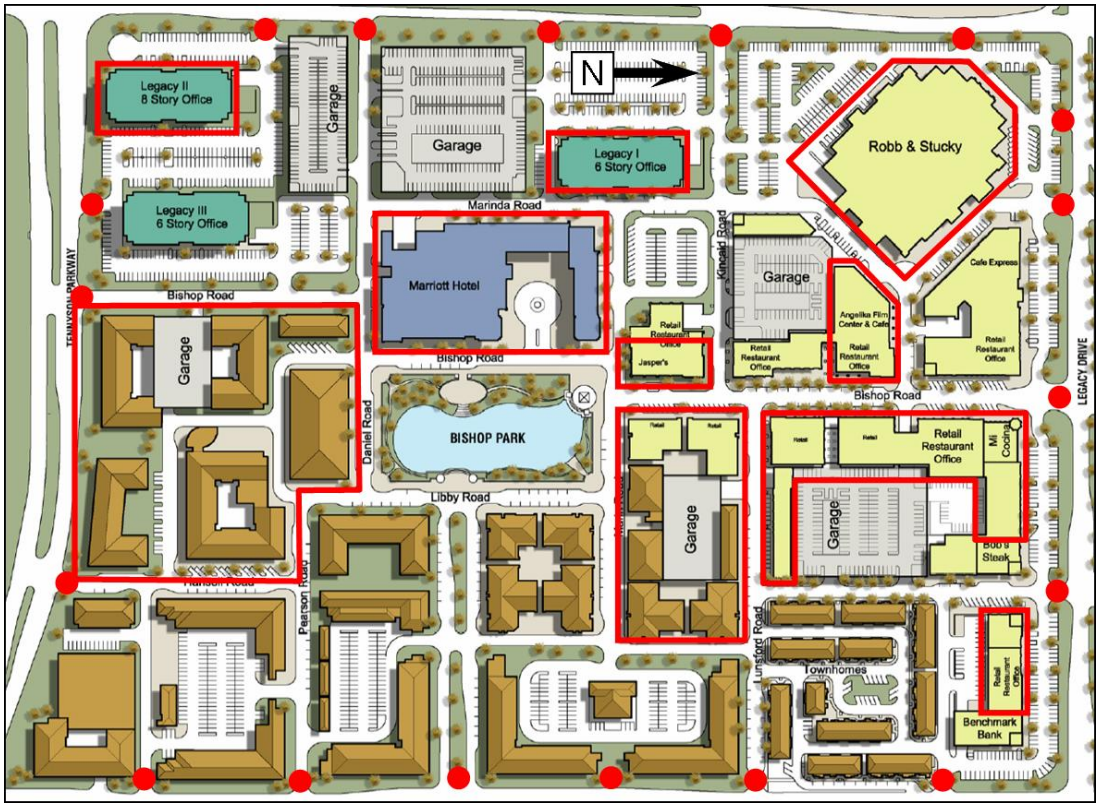

Figure 6: Data Collection Areas at Legacy Town Center

The locations where data were collected at Legacy Town Center are shown in Figure 6. The red circles represent the site's 18 access points where cordon counts were performed. The buildings or groups of buildings outlined in red represent locations where door entrance and exit movements were recorded. Within these areas, interview personnel were positioned outside the doors of selected buildings to intercept travelers exiting those doors. Interviews in the residential area (colored in orange) were conducted at building exits, as well as on the sidewalks leading from apartment buildings and on driveways coming out of parking lots or garages. A single interviewer was assigned to intercept travelers at one or multiple doors, depending upon the amount of activity anticipated at the door(s). For each door where interviews were being conducted, door entrance and exit movements were recorded. Additional door counting assignments were made in locations where positioning an interviewer would have been impractical due to low activity, yet the entrance and exit movements were still required. The size of Legacy Town Center and the number of access points (doors) at certain land uses made it difficult to obtain door movement counts for the entire site. The percentage of development units for each land use that had door movement counts recorded is shown in Table 10.

Table 10: Percentage of Occupied Development Units with Door Movement Counts

Land Use	Morning Peak Period			Afternoon Peak Period		
	Counted	Occupied	Percent Counted	Counted	Occupied	Percent Counted
Office[1]	241,678	310,764	77.8	217,450	310,764	70.0
Retail[1]	5,771	5,771	100.0	135,666	196,264	69.1
Restaurant[1]	6,550	6,550	100.0	45,076	69,318	65.0
Residential[2]	581	1,361	42.7	581	1,361	42.7
Cinema[3]	N/A	N/A	N/A	1,019	1,019	100.0
Hotel[4]	344	344	100.0	344	344	100.0
[1]Square Feet, [2]Dwelling Units, [3]Seats, [4]Occupied Rooms						

DATA COLLECTION SUMMARY

The primary data element collected in this investigation was the travel survey responses. Cordon counts and door entrance and exit counts were also collected to support the travel survey data. The following paragraphs summarize the data that were obtained relevant to the investigation of induced travel at mixed-use developments. An evaluation of the travel survey and data collection efforts is also included.

Cordon Count and Door Count Data

Data obtained from the cordon count were compiled and summarized for the entire study period as well as the peak hour of person-trips (the highest four consecutive 15-minute periods) within each study period. For the morning peak period, a total of 4,197 person-trip ends were recorded, with approximately equal numbers entering and exiting the property (see Table 11). The average vehicle occupancy during the morning peak period was 1.11 persons per vehicle. Of the total person-trips, only 120 trips (less than 3 percent) were taken using transit, walking, or bicycle. Similar results were observed for the morning peak hour of person-trips, which occurred between 7:30 AM and 8:30 AM. For the morning peak period, the observed door counts totaled 3,515 person trip-ends.

Table 11: Cordon Count Summary, Morning Period

Land Use	Morning Peak Period			Morning Peak Hour		
	Enter	Exit	Total	Enter	Exit	Total
Total Person-Trips	2,067	2,130	4,197	819	779	1,598
Person-Trips (Personal Vehicles)	1,892	1,923	3,815	770	725	1,495
Person-Trips (Motorcycle)	0	1	1	0	0	0
Person-Trips (Delivery Trucks)	80	69	149	17	12	29
Person-Trips (Hotel Shuttles)	30	82	112	11	29	40
Person-Trips (Transit)	0	2	2	0	0	0
Person-Trips (Walking)	65	52	117	21	13	34
Person-Trips (Bicycle)	0	1	1	0	0	0
Total Vehicles	1,850	1,809	3,659	741	645	1,386
Vehicle Occupancy	1.08	1.15	1.11	1.08	1.19	1.13
Note: Morning Peak Hour: 7:30 to 8:30 AM						

During the afternoon peak period, a total of 6,954 person-trip ends were recorded with approximately 53 percent entering and 47 percent exiting Legacy Town Center (see Table 12). The average vehicle occupancy was 1.20 persons per vehicle, higher than the morning peak period. As with the morning peak period, less than 3 percent of the person-trips in the afternoon peak period were made via transit or non-motorized travel modes.

Table 12: Cordon Count Summary, Afternoon Period

Land Use	Afternoon Peak Period			Afternoon Peak Hour		
	Enter	Exit	Total	Enter	Exit	Total
Total Person-Trips	3,715	3,239	6,954	1,187	1,122	2,309
Person-Trips (Personal Vehicles)	3,495	3,085	6,580	1,107	1,066	2,173
Person-Trips (Motorcycle)	6	5	11	3	1	4
Person-Trips (Delivery Trucks)	68	69	137	20	22	42
Person-Trips (Hotel Shuttles)	33	13	46	22	6	28
Person-Trips (Transit)	6	0	6	0	0	0
Person-Trips (Walking)	107	67	174	35	27	62
Person-Trips (Bicycle)	0	0	0	0	0	0
Total Vehicles	2,934	2,727	5,661	947	960	1,907
Vehicle Occupancy	1.23	1.16	1.20	1.22	1.14	1.18
Note: Afternoon Peak Hour: 5:00 to 6:00 PM						

The highest peak hour of person-trips between 4:00 PM and 6:00 PM (the hours considered for traffic impact analysis purposes) occurred between 5:00 PM and 6:00 PM, with 2,309 person trip-ends recorded during the hour. The highest peak hour of person-trips for the entire afternoon peak period occurred between 6:00 PM and 7:00 PM, with 2,461 person-trips taken during the hour. Given the amount of retail activity at Legacy Town Center, it is not surprising that the hourly person-trip volumes were highest near the end of the afternoon data collection period. For the afternoon peak period, the observed door counts totaled 6,103 person trip-ends, as shown in Table 13.

Table 13: Door Count Movements (Person-Trips)

Land Use	Morning Peak Period			Afternoon Peak Period		
	Enter	Exit	Total	Enter	Exit	Total
Office	464	77	541	67	362	429
Retail	128	112	240	585	621	1,206
Restaurant	597	553	1,150	1,335	946	2,281
Residential	287	710	997	647	592	1,239
Cinema	N/A	N/A	N/A	221	108	329
Hotel	187	400	587	318	301	619
Total	1,663	1,852	3,515	3,173	2,930	6,103

The cordon count and door count data provided some interesting insights into the complete profile of travel at the study site, Legacy Town Center. Based on the cordon count

data, it is clear that personal vehicle was the dominant travel mode used by travelers entering or exiting the site. One of the limitations of the study site, a lack of frequent transit service, was confirmed, as less than one-tenth of one percent of all person-trips passing across the site boundary were going to or coming from the DART bus line. The door count data indicate that at least some of the land uses were exhibiting travel patterns that might be expected; the directional split of person trips at the office, for example, were predominantly entering in the morning and exiting in the afternoon.

Travel Survey Data

The number of exit movements, number of interviews, percent interviewed, and the number of valid trips collected from the travel survey, stratified by land use are summarized in Table 14. A valid trip consisted of a defined origin, destination, and time of day that the trip occurred. During the morning peak period, the travel survey efforts resulted in a total of 379 interviews from which a total of 520 valid trips were obtained. In addition to the exit interviews, entrance interviews were conducted with persons entering the office during the morning peak period. In the afternoon peak period, a total of 467 survey interviews were conducted with 768 valid trips obtained from the surveys.

Table 14: Summary of Travel Survey Data Collection

Morning Peak Period (6:00 AM to 10:00 AM)				
Land Use	Movements	Interviews	Percent Interviewed	Valid Trips
Office (Exit)	77	13	18	13
Office (Enter)	464	38	7	38
Retail	112	24	21	46
Restaurant	553	99	18	198
Residential	710	160	23	175
Cinema	N/A	N/A	N/A	N/A
Hotel	400	49	12	50
Total	2,316	379	16	520
Afternoon Peak Period (3:00 PM to 7:00 PM)				
Land Use	Movements	Interviews	Percent Interviewed	Valid Trips
Office	362	81	22	143
Retail	621	72	12	127
Restaurant	946	96	10	177
Residential	592	113	19	125
Cinema	108	53	49	102
Hotel	301	52	17	94
Total	2,930	467	16	768

For every surveyed trip origin that indicated an internal destination, the respondent was supposed to be asked about the induced nature of that trip. The number of internal trips and response rate for each land use where interviews were administered are shown in Table 15. During the morning peak period, the response rate was 70.4 percent. In the afternoon period, nearly all of the respondents making internal trips (93.5 percent) answered the question about induced travel.

Table 15: Induced Travel Question Response Rate

Land Use	Morning Peak Period		Afternoon Peak Period	
	Internal Trips	Percent Response	Internal Trips	Percent Response
Office	3	66.7	3	66.7
Retail	8	12.5	44	97.7
Restaurant	15	86.7	40	87.5
Residential	28	78.6	54	100
Cinema	N/A	N/A	23	78.3
Hotel	0	N/A	21	100
Total	54	70.4	185	93.5

Additional discussion of the figures presented in Table 15 is provided in the next section, as part of an overall evaluation of the data collection efforts.

Evaluation of Travel Survey Procedures

Every element of the design and execution of an experimental procedure (such as the travel survey employed in this investigation) has the potential to influence the quality and completeness of the data set obtained from the procedure. The information presented in Table 14 and Table 15 provides an opportunity to evaluate the results of the data collection efforts with respect to both the design of the travel survey and its implementation.

Recall that the travel survey was designed to record information about two trips, the trip the respondent was making at the time of the interview, and the trip the respondent had made prior to arriving at the interview site. For respondents departing the residences and the hotel in the morning peak period, the previous location question was a source of confusion for most respondents, since the trip they were making at the time of the interview was their first trip of that day. Thus, this question was ignored and it was assumed that no previous trips were made to those locations in the morning. For other land uses in the morning, and all land uses in the

afternoon, properly completed surveys should have contained valid information for two trips. Land uses with the number in the "Valid Trips" column of Table 14 close to double the number of travel surveys for that land use indicate that more complete travel surveys were conducted at those locations. Land uses where incomplete travel surveys were obtained, such as exit interviews at the office in the morning, or residential interviews in the afternoon, indicate possible issues with respondents' comprehension of the survey questions, respondents' willingness to complete the entire survey, or the ability of the interview personnel to administer the survey properly.

Measures of quality and effectiveness for the implementation of the travel survey include the percent of persons exiting that were interviewed and the response rate for the induced travel question. The sample rate (the percent of persons exiting that were interviewed) was influenced by the number of potential respondents declining to participate in the travel survey and the number of persons who exited the building while a travel survey was being conducted. If all surveys and movements are considered, the average sample rate for both the morning and the afternoon peak periods was 16 percent. If only exit interviews are included (not including the entrance interviews conducted at the office in the morning), the sample rate for the morning increased to 19 percent. Given the potential influences on the sample rate, coupled with the challenges that researchers usually encounter when conducting travel surveys, the sample rates obtained in this investigation were acceptable. Of greater concern to this investigation was the proportion of respondents who indicated they were taking an internal trip that were asked about the induced nature of their trip. During the morning period, 70.4 percent of those travelers making internal trips were asked and had a valid response to the induced travel question. One set of survey responses obtained from a certain retail location in the morning had to be discarded due to incorrectly recorded answers, resulting in a low response rate for that land use. In the afternoon peak period, nearly all of the respondents making internal trips (93.5 percent) provided a valid answer to the induced travel question, an excellent response rate by any standard.

Overall, the data collection efforts were successful. The management entities of Legacy Town Center were very supportive and accommodating of the data collection efforts. The use of temporary labor employees as interview personnel presented some challenges, but the training session and frequent quality control checks of the collected data throughout the process mitigated the few issues that occurred. In general, most travelers at Legacy Town Center were

willing to give a few minutes and provide responses to the travel survey. Some resistance was encountered, particularly when attempting to interview residents in their vehicles. In summary, the data set that was obtained through the efforts presented in this Chapter was sufficient to meet the research objectives and will provide some unique insights on the travel characteristics of mixed-use developments.

CHAPTER IV
METHODOLOGY AND ANALYSIS

In Chapter II, the potential for induced trips as a traveler response to travel cost savings at mixed-use developments was introduced. Chapter III described in detail the process by which nearly 850 travel survey interviews were conducted with travelers at the study site, the Legacy Town Center mixed-use development in Plano, Texas. The objective of this investigation was to analyze the information obtained from these travel surveys to gain some understanding of the nature and extent of induced travel at mixed-use developments. This Chapter describes in detail the methodology used to prepare the data set for analysis. Discussion of the analysis and findings is provided in this Chapter, concluding with some thoughts as to how the findings may be incorporated into the site planning process for mixed-use developments.

This investigation defined an "induced" trip as one that had both trip ends internal to Legacy Town Center and would not have been made if travel outside the site were required. What elements of the mixed-use environment have the potential to influence induced travel? If one considers "induced" travel to be synonymous with "optional" travel, then it might be reasonable to assume that there will be less induced travel during the morning period than the afternoon period, since travelers in the morning peak period may wish to spend their optional time participating in an activity other than travel. However, the placement of a coffee shop near an office building may induce a significant amount of traffic during that time (although some office employees might say the morning coffee is most assuredly not optional!). On-site land uses and the direction of travel may exert a tremendous amount of influence on the induced travel profile. For example, it's reasonable to assume that a majority of travelers going to an office building or a residence are probably not making induced trips and would have traveled to those places regardless of where they were located. Retail shops, restaurants, and the cinema will probably induce a significant amount of travel between them (it already happens at conventional shopping malls). Guests staying at the on-site hotel may be induced to make a trip to one of the many on-site eating establishments, instead of eating at the hotel's restaurant. Other characteristics captured in the travel survey, such as the mode of travel or the traveler's mode of access to the site, may also play a role in shaping the induced travel picture. One of the travel cost-saving characteristics of mixed-use developments is the convenience of walking

instead of driving for trips within the site. Consequently, one might expect the induced share of the internal travel to contain a majority of the internal trips made on foot. However, Crane (1996) showed that auto travelers could also realize travel cost savings in the mixed-use environment, so the potential for induced travel via auto is definitely a possibility. A traveler's ability to make an induced trip requires that traveler to have a choice, specifically, the option to travel off-site instead of remaining inside the site. Some travelers may not have that option easily available, having accessed the site as a transit rider, carpool participant, taxi passenger, or are without an automobile for whatever reason, such as an out-of-town business traveler staying at the hotel. These are just a few thoughts on the potential influences of induced travel; the analysis will reveal a more complete picture.

METHODOLOGY

As described in Chapter III, a total of 846 travel survey interviews were administered with travelers exiting specific buildings at Legacy Town Center. Each interview was assigned a reference number and all interview responses were entered into a computer spreadsheet program for analysis. Numeric values were assigned to represent certain variables on the travel survey interview responses, such as land uses and modes. After the travel survey interview responses were entered into the spreadsheet, several quality control checks were performed to ensure the integrity of the data set. Errors that were uncovered during these reviews were either corrected or recoded to indicate that the record was not suitable for analysis. The following paragraphs describe the methodology used to transform the data set from "raw" travel survey interview responses to a profile of travel activity at Legacy Town Center. Underlying assumptions that were critical to the methodology are identified and discussed as well.

Classification of Trips

In this investigation, the basic unit of concern for the analysis was the trip. To be considered a valid trip, a trip record had to contain the following three components:

- Origin End Land Use and Location (Internal or External to Legacy Town Center)
- Destination End Land Use and Location (Internal or External to Legacy Town Center)
- Time of Day that the Trip Took Place

Each travel survey interview was designed to record information about two trips: the one that the respondent was taking at the time of the interview, and the one that the respondent had

completed prior to arriving at the location where the exit interview was administered. For the trip the respondent was taking at the time of the interview, valid responses for the location (internal or external) and the land use of the destination had to be provided in the interview to be included in the analysis. For the trip the respondent had made prior to arriving at the interview location, valid information about the location (internal or external) and land use of the respondent's previous location were required, as well as his or her the time of arrival at the interview location (to approximate the time of the trip). For external trips, the land use of the external trip end was not necessary for the analysis. Based on these definitions, a total of 1,288 valid trips (2,576 trip ends) were obtained from the interviews. Although it was not a specific requirement to be counted as a valid trip for this analysis, nearly all of these trips had the mode of travel for the trip identified. Each trip was classified as either internal or external. A trip was classified as internal if both trip ends were located inside the study site, Legacy Town Center. Trips that had one end located inside the study site and one end outside the study site were classified as external trips. There were no trips obtained from the travel surveys that had both trip ends outside the study site. If the respondent indicated that he or she was making an internal trip at the time of the interview, the question about the induced nature of their trip was supposed to be asked. Out of a total of 239 trips the respondents were making at the time of the interview with internal destinations, 211 provided usable information about the induced nature of their trip.

Development of Analysis Tables

After identifying the valid trips from the travel survey interview responses, the next step in the process was to "decompose" the data set into smaller segments for analysis. First, each of the 1,288 trips was assigned into one of the two study periods. Surveyed trips occurring between 6:00 AM and 10:00 AM were assigned to the morning peak period and trips occurring between 3:00 PM and 7:00 PM were assigned to the afternoon peak period. This screening resulted in a total of 601 trips during the morning peak period and 632 trips during the afternoon peak period[2]. Trips not occurring during one of these two time periods (a total of 55 trips) were discarded from the analysis. Next, trip ends within each study period were classified as either entering or exiting buildings at Legacy Town Center. Finally, the entering or exiting trip ends were classified by the land use of the trip's destination or origin, respectively. As a result of this

[2] Each travel survey interview was designed to obtain information about two trips. In the decomposition process, it was found that interviews that were conducted during the afternoon peak period (particularly at the office) contained information about trips that occurred during the morning peak period.

three-step decomposition process, a total of four tables were developed that identified, for each of the six subject land uses at Legacy Town Center (office, retail, restaurant, residential, cinema, and hotel) the total number of entering (or exiting) trips, the number of trips from (to) each origin (destination) land use for internal trips, as well as the number of trips originating from (destined to) locations external to Legacy Town Center. This decomposition process was repeated using only the induced trip data, resulting in four additional tables. These analysis tables can be found in Appendix C. Decomposition of the trip data in this fashion (first by time period, then by direction of travel, then by land use) easily allowed the research findings to be transferred to an appropriate application in the mixed-use development site planning process.

Weighting Process

The data obtained from the travel survey interviews represented a sample of all trips taken at the study site, Legacy Town Center. Conducting an analysis and drawing conclusions about mixed-use development travel behavior from these trips without considering the influence of sample rates and the relative amount of each land use on the site would bias the results towards land uses with higher sample rates. This section describes the process used to expand the trips obtained from the travel survey interviews to represent activity for the entire site.

The first step of the weighting process was an adjustment to the analysis tables to reflect the fact that the trips obtained from the survey were samples of all the trips entering or exiting buildings at the site. The door entrance and exit movement counts obtained as part of the data collection efforts were employed in this process. The door count weighting factor for each time period (T), travel direction (D), and on-site land use (L) was computed using the following Equation (1):

$$DoorCountFactor_{TDL} = \frac{\sum Movements_{TDL}}{\sum SurveyedTrips_{TDL}} \quad (1)$$

Where: *DoorCountFactor*= Door Count Weighting Factor Used in Analysis
Movements= Door Count Movements Recorded in Data Collection
SurveyedTrips= Number of Trips Obtained From Survey

To illustrate this computation, consider an example of trips entering the offices during the morning peak period. The travel survey obtained a sample of 122 trips out of the observed total of 464 person-trips entering the offices during the morning peak period. Thus, the door

count weighting factor for trips entering the office in the morning peak period was computed to be 3.803. Stated differently, each surveyed trip entering the office during the morning peak period was assumed to represent itself plus an additional 2.803 trips not captured in the travel survey. The door count weighting factors used in the analysis of the Legacy Town Center travel survey data are shown in Table 16.

Table 16: Door Count Weighting Factors Used in Analysis

Land Use	Morning Peak Period		Afternoon Peak Period	
	Entering Trips	Exiting Trips	Entering Trips	Exiting Trips
Office	3.803	6.417	7.444	4.067
Retail	4.000	4.308	7.597	8.065
Restaurant	5.528	5.422	9.144	9.184
Residential	8.969	3.532	15.047	4.813
Cinema	N/A	N/A	6.906	2.077
Hotel	17.000	7.407	10.966	5.902

These same factors were also applied to the analysis tables containing only the induced travel data. Note that by taking the inverse of each of the values in Table 16, one can obtain the sample rate; that is to say, the percentage of recorded person-trips that were documented in the travel survey. Once the survey data were weighted to reflect the number of trip ends actually recorded at the site, a second weighting process was employed to account for portions of the land uses at Legacy Town Center where no door entrance and exit movement counts were recorded due to the number of doors at the site (over 100) and the desire to direct a bulk of the personnel resources towards the travel survey interviews. This factor, called the development unit factor, was computed for each time period (T) and on-site land use (L) using the following Equation (2):

$$DevelopmentUnitFactor_{TL} = \frac{\sum OccupiedDevelopmentUnits_{TL}}{\sum CountedDevelopmentUnits_{TL}} \quad (2)$$

Where: *DevelopmentUnitFactor*= Development Unit Weighting Factor Used in Analysis
OccupiedDevelopmentUnits= Number of Occupied Development Units
CountedDevelopmentUnits= Number of Development Units with Door Counts

Both entrance and exit movements were recorded at each location where door counts took place, so it was not necessary to develop separate weighting factors for each direction of

travel. At Legacy Town Center, development units included occupied square footage (office, retail, and restaurant), occupied dwelling units (residential), number of seats (cinema), and occupied rooms (hotel). The development unit weighting factors used in the analysis of the Legacy Town Center travel survey data are shown in Table 17. A development unit weighting factor of 1.000 for any land use indicates that all of the occupied development units at Legacy Town Center for that land use were counted in door entrance and exit movement counts.

Table 17: Development Unit Weighting Factors Used in Analysis

Land Use	Morning Peak Period	Afternoon Peak Period
Office	1.286	1.429
Retail	1.000	1.447
Restaurant	1.000	1.538
Residential	2.343	2.343
Cinema	N/A	1.000
Hotel	1.000	1.000

To illustrate this computation, consider the previous example of the office land use during the morning peak period. Door counts were obtained at recorded comprising 241,678 of the 310,764 total occupied square feet of office space at Legacy Town Center. Thus, the development unit weighting factor was computed to be 1.286. The development unit weighting factors were applied to the analysis tables in a similar manner as the door count weighting factors. Note that the development unit weighting factors shown in Table 17 are equal to the inverse of the corresponding percentages listed in the "Percent Counted" column of Table 10 in Chapter III. To compute the total trips for a particular time period (T), travel direction (D), subject on-site land use (L), and the on-site land use (or external location) of the opposite trip end (M), the following Equation (3) was employed:

$$TotalTrips_{TDL,M} = SurveyedTrips_{TDL,M} * DoorCountFactor_{TDL} * DevelopmentUnitFactor_{TL} \quad (3)$$

Where: *TotalTrips*= Total Number of Trips Used in Analysis (Internal or Induced)
Other Variables as Previously Defined

To illustrate the application of the door count weighting factor and the development unit weighting factor to the survey results, assume that six of the 122 surveyed trips entering the office during the morning peak period originated at the on-site residential units. Applying the

factoring process described in this section, per Equation (3), these six trips were factored to equal 29.34 trips, which was rounded to the nearest whole trip (29) for the analysis. To find the total number of induced trips for each time period, travel direction, and subject on-site land use, the variable "$SurveyedTrips_{TDL,M}$" in Equation 3 was replaced with the total number of induced trips obtained from the travel survey for each time period, travel direction, and subject on-site land use. The fully weighted analysis tables for all trips and induced trips in each time period and travel direction are provided in Appendix C. To compute the proportion of trips for a given time period (T), travel direction (D), subject on-site land use (L), and the on-site land use (or external location) of the opposite trip end (M) that were internal or induced, the following Equation (4) was used:

$$Proportion_{TDL,M} = \frac{TotalTrips_{TDL,M}}{\sum_{M} TotalTrips_{TDL}} \quad (4)$$

Where: *Proportion*=Proportion of Interest (Percentage Internal or Induced)
Other Variables as Previously Defined

Continuing the example of trips entering an office during the morning peak period, it was found that a total of 596 person-trips entered an office during the morning peak period and using Equation (4), it was found that 4.9 percent of these trips originated at an on-site residence.

Methodology Assumptions

By weighting the survey results using the process described in this section, a more accurate representation of travel behavior at the study site was formed with the data obtained from the travel survey. However, the accuracy of this process relied upon two key assumptions, each discussed in greater detail below.

First, aggregating all trips entering or exiting the six on-site land uses (office, retail, restaurant, residential, cinema, and hotel) by land use eliminated the ability to examine any variation in the travel patterns exhibited by individual units of a particular land use. For the cinema and hotel, this was not a concern, since there was only one theater and one hotel at the site (thus, no variation among individual units). At the other four land uses, it was likely that at least some variation existed in the travel patterns of survey respondents using different units of a particular land use. This issue of variability was considered and partially addressed during the design of the travel survey; specifically, during the selection of locations where the interview

personnel were assigned to administer the exit interviews. In the case of the offices and the residential units, concerns were raised about the proximity of these land uses to the on-site retail shops and restaurants. Logically, the offices and residential units that were farther away from the shops and eateries at the site could have different travel patterns than those that were located closer to the commercial core of Legacy Town Center. To address this concern, interview personnel were positioned at the office building and apartment buildings at the south end of Legacy Town Center (farthest away from the retail shops and restaurants) and also at the exits of the office units and apartments located above the retail shops and restaurants. It was also suspected that different types of retail shops and restaurants might exhibit different travel patterns. This concern was addressed by assigning interview personnel in such a manner that travel surveys were conducted with persons exiting a full cross-section of the different types of retail shops and restaurants that existed at Legacy Town Center.

For the analysis, aggregating the survey data by land use (assuming no intra-land use variability in travel patterns) offered two important advantages. First, aggregating the survey data by land use, instead of by individual door or establishment, did not depend on the survey respondent providing a specific location as an answer for their destination or previous location, resulting in more surveyed trips included in the analysis. For example, if survey respondents did not know specifically where they were going at the time of the interview, they might have responded by stating "shopping" or "to eat" as their destination. Aggregating the analysis by land use allowed these trips to be included as trips to retail and restaurant, respectively. In a similar manner, survey respondents that did not wish to disclose the specific location of their destination may have provided responses of "my office" or "my apartment" instead, which were assumed to be trips to the office and residential, respectively. The second advantage to aggregating the survey results by land use was related to the research objectives. One of the objectives of this study was to investigate ways to incorporate the study's findings into the mixed-use development site planning process. Aggregating the travel survey results by land use facilitated the transfer of the research findings to potential applications in the site planning process, where the level of detail provided to the planner may be no greater than a sketch estimate of the number of development units of each type of land use.

The second assumption of the methodology involved the use of the development unit weighting factor. Applying the development unit weighting factor assumed that all occupied,

but uncounted, areas of the study site exhibited the same patterns of travel behavior as the counted and surveyed areas. If the only data element of concern was the percentage of trips for a particular land use and travel direction meeting a certain criteria, then the development unit factor had no significance on the final outcome. However, if one wished to develop a travel profile for the entire site, it would be necessary to account for unsurveyed portions of the site in some manner. For this study, the ratio of total occupied development units to counted development units, shown by Equation (2), was the only way to account for these unsurveyed areas of the site. Excluding the development unit weighting factor would have had no impact on the directional travel characteristics but would have biased the overall results toward land uses where a majority of the occupied development units had recorded entrance and exit counts.

Statistical Considerations

In the analysis of the travel survey data, there were two basic statistical considerations. For this investigation, the proportions of interest were the percentage of induced trips and the percentage of internal trips entering or exiting buildings at Legacy Town Center, stratified by time period and land use. First, it was necessary to demonstrate that the sample size (that is, the number of trips obtained from the travel survey) for each proportion of interest was sufficiently large enough that the proportions reported in the analysis were within a specified margin of error. To determine if a sample size was statistically significant, the following Equation (5) was used (Cochran 1977):

$$n_o = \frac{t^2 pq}{d^2} \quad (5)$$

Where: n_o = Initial Estimate of Statistically Significant Sample Size
t = t-statistic Corresponding to Desired Confidence Level (1.645 at α=0.1)
p = Proportion of Interest
q = $(1 - p)$
d = Desired Margin of Error (±10% for this investigation)

One important variable that is not included in Equation (5) is the population size. For this investigation, the population size (that is, the size of the population from which samples are obtained) was the total number of persons entering or exiting doors of a particular land use. For a large population size, Equation (5) is sufficient. However, for smaller population sizes (as was

the case in this investigation), the computational procedures for estimating a statistically significant sample size require an adjustment to the initial estimate provided by Equation (5) to account for smaller population sizes. This adjusted value of the statistically significant sample size is given by Equation (6):

$$n = \frac{n_o}{1 + \left(n_o / N \right)} \quad (6)$$

Where: n = Final Adjusted Estimate of Statistically Significant Sample Size
n_o = Initial Estimate of Statistically Significant Sample Size from (5)
N = Population Size

This number was rounded up to the nearest integer to ensure a sufficient estimate. A proportion of interest was obtained from a statistically significant sample size if the sample size obtained in the travel survey was greater than the required sample size computed by (6).

The second statistical consideration in this investigation concerned the confidence interval for the computed proportions. The confidence interval for each proportion of interest was computed using the following Equation (7), also from Cochran (1977):

$$p \pm \left[t \sqrt{1 - f} \sqrt{pq / n - 1} + \frac{1}{2n} \right] \quad (7)$$

Where: p = Proportion of Interest
t = t-statistic Corresponding to Desired Confidence Level (1.645 at α=0.1)
f = Proportion of Population Sampled, n/N
N = Population Size
$q = (1 - p)$
n = Number of Samples Obtained from Travel Survey

At first glance, the computation of Equation (7) may seem redundant. However, it was necessary to determine if zero was included in the confidence interval computed around each proportion of interest. If zero was included in the confidence interval, it could be said that the proportion of interest was not significantly different than zero (at α=0.1) and that induced or internal trips did not significantly impact the travel characteristics of a particular travel direction or land use.

Overview of Analysis

The primary item of concern in this investigation was the percentage of trips at the study site, Legacy Town Center, that were induced, defined as a trip the respondent would not have made if it had required traveling outside Legacy Town Center. While these percentages provided some interesting insight and points for discussion by themselves, the key to uncovering the real issues of this investigation was a comparison between the percentage of induced trips and the percentage of internal trips for each travel direction and land use. Recall from the literature review that one of the claimed transportation benefits of mixed-use developments is that trips made internal to the mixed-use development site are replacing trips made on the external street network and that current mixed-use development site planning processes assume that all internal trips are replacements for external trips. The ratio of the percentage of "induced" trips entering or exiting a particular land use to the percentage of internal trips entering or exiting that same land use is an indication of how many internal trips are actually replacing external trips, and how many represent new trip generation as a result of travel cost savings realized in the mixed-use environment. As this ratio increases towards one, internal trips shift from being replacements for external trips to being new or previously suppressed trips.

The analysis results are reported by time period, with separate sections for morning peak period trips and afternoon peak period trips. All analysis results are reported as person-trips entering or exiting buildings at Legacy Town Center. For each time period, the findings are reported as follows:

- **All Trips:** The analysis of the travel survey data for each time period starts by providing a broad overview of all the travel activity at Legacy Town Center during that time period, including a distribution of the induced, internal, and external trip ends by land use, mode of travel, and mode of access.
- **Land Use:** This analysis identifies trends and patterns in the relationship among the individual land uses at Legacy Town Center and internal or induced travel behavior. The land use analysis also identifies which land use pairs had a significant amount of internal travel between them, and whether these internal trip ends were replacing travel external to the study site or generating new trips (induced travel). Induced and internal trip percentages for individual land use pairs that were drawn from a statistically significant sample size (for a 10 percent margin of error) and were found to be

significantly different than zero are identified. Results obtained from the detailed study of each land use can also have direct application into the mixed-use development site planning process, if appropriate.

- **Mode of Travel:** One of the primary travel cost-saving elements in the mixed-use environment is the ability to walk for some trips within the development. The mode of travel analysis examines the induced and internal trip percentages for trips made in an automobile (driver or passenger) and on foot. From this analysis, it was determined if the walking trip ends at Legacy Town Center were replacing external trips or generating additional travel internal to the site[3,4].

- **Traveler Characteristics:** This analysis examines the influence of certain traveler characteristics on the induced and internal trip percentages. For example, the traveler's mode of access could be a key indicator of their ability to travel to an off-site destination. Another potential indicator of induced or internal travel analyzed here is the traveler's ability to access an automobile for their trip. Also, the travel characteristics of a particular segment of travelers, on-site residents, may offer some unique insights into the behavior of an important contributor to the total travel at the site[3].

MORNING PEAK PERIOD ANALYSIS

Analysis of the travel survey data indicated that a total of 5,008 person-trips occurred during the morning peak period (6:00 AM to 10:00 AM), of which 1,571 (31.4 percent) were internal to the site. Of these internal trips, 201 (4.0 percent) were found to be induced, meaning that 12.8 percent of the internal trips during the morning peak period were additional trips and not replacements for external trips. Of the total person-trips during the morning, 2,180 trips (43.5 percent) were entering buildings at Legacy Town Center and 2,828 trips (56.5 percent) were exiting buildings at Legacy Town Center. The directional split favoring the exiting trips was not surprising, since there were more residential units at Legacy Town Center producing trips out of the site than offices attracting trips into the site.

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[3] For the mode of travel and traveler characteristics analyses, it was impossible to conduct a statistical analysis since it was not possible to determine the size of the population from which the interview samples were drawn (i.e. the total number of trips made in an automobile) based on the collected data.

[4] Strictly speaking, all of the trips analyzed in this investigation were person-trips made on foot entering or exiting buildings at the study site. However, for the mode of travel analysis, a trip that was made in an automobile was considered an automobile trip, even though the traveler clearly walked between an automobile (either a parking location or passenger drop-off location) and a building at the study site.

For trips entering buildings at Legacy Town Center, it was found that 772 trips (35.4 percent) had their origin internal to Legacy Town Center and 104 trips (4.8 percent) were induced, meaning that 13.6 percent of the internal trips entering buildings at Legacy Town Center were induced. The destination land use for all entering trips of each classification (induced, internal, and external) is shown in Table 18. A majority of the induced and internal trips entering buildings at Legacy Town Center had a residence as their destination. A majority of trips entering buildings at Legacy Town Center from external locations had a destination of the office, but restaurant and residential also had a substantial percentage of these trips.

Table 18: Destination Land Use of All Entering Trips, Morning Peak Period

Destination Land Use	All Entering Trips (N=2,180)		
	Induced (N=104)	Internal (N=772)	External (N=1,408)
Office	19.2%	15.2%	34.0%
Retail	7.7	10.4	3.4
Restaurant	16.3	26.6	27.8
Residential	40.4	43.5	23.9
Hotel	16.3	4.4	10.9
Note: Columns may not equal 100 percent due to rounding.			

For trips exiting buildings at Legacy Town Center, it was found that 799 trips (28.3 percent) had their destination internal to Legacy Town Center and 97 trips (3.4 percent) were induced, meaning that 12.0 percent of the internal trips exiting buildings at Legacy Town Center were induced. The origin land use for all exiting trips of each classification (induced, internal and external) is shown in Table 19. A majority of the induced and internal trips exiting buildings at Legacy Town Center had a residence as their origin. As would be expected, more than half of the trips exiting buildings at Legacy Town Center with an external destination had their origin at an on-site residence.

Table 19: Origin Land Use of All Exiting Trips, Morning Peak Period

Origin Land Use	All Exiting Trips (N=2,828)		
	Induced (N=97)	Internal (N=799)	External (N=2,029)
Office	17.5%	6.1%	2.5%
Retail	4.1	5.5	3.4
Restaurant	10.3	12.3	22.4
Residential	68.0	71.5	53.8
Hotel	0.0	4.6	17.9
Note: Columns may not equal 100 percent due to rounding.			

The mode split for each classification of trip is shown in Table 20 for trips entering buildings at Legacy Town Center and Table 21 for trips exiting buildings at Legacy Town Center. For both travel directions, approximately two-thirds of induced trips were made on foot with the balance made by an automobile driver. No trips made on a bicycle during the morning peak period were obtained from the travel survey.

Table 20: Mode of Travel for All Entering Trips, Morning Peak Period

Mode of Travel	All Entering Trips (N=2,180)		
	Induced (N=104)	Internal (N=772)	External (N=1,408)
Auto Driver	33.7%	57.9%	86.9%
Auto Passenger	0.0	5.0	9.4
Taxi	N/A	0.0	0.4
Transit	N/A	0.0	1.8
Walk	66.3	37.2	0.0
No Response	N/A	0.0	1.5
Note: Columns may not equal 100 percent due to rounding.			

For all internal trips, about one-third of the trips in both travel directions were made on foot. Based on the discussion of the site accessibility and analysis of the cordon count data in Chapter III, it was expected that most external travel would involve an automobile. This was the case, as a vast majority of the external trips in both directions (96.3 percent of entering trips, 90.0 percent of exiting trips) were taken in an automobile, either as a driver or a passenger. While there was not much DART bus transit activity at Legacy Town Center, trips made on "transit" also included trips made using the hotel shuttle; as a result, the second most frequent mode of travel for trips exiting Legacy Town Center was the bus or hotel shuttle, accounting for 8.2 percent of these trips.

Table 21: Mode of Travel for All Exiting Trips, Morning Peak Period

Mode of Travel	All Exiting Trips (N=2,828)		
	Induced (N=97)	Internal (N=799)	External (N=2,029)
Auto Driver	33.7%	63.6%	85.3%
Auto Passenger	0.0	1.6	4.7
Taxi	N/A	0.0	0.7
Transit	N/A	0.0	8.2
Walk	66.3	34.8	1.1
No Response	N/A	0.0	0.0
Note: Columns may not equal 100 percent due to rounding.			

The mode of access for each classification of trip is shown in Table 22 for trips entering buildings at Legacy Town Center and Table 23 for trips exiting buildings at Legacy Town Center. No trips made by travelers accessing the site in a taxi or on a bicycle were obtained from the travel survey. Nearly all of the trips entering Legacy Town Center from external origins accessed the site in an automobile; this was not surprising, given the concerns about site accessibility discussed in Chapter III.

Table 22: Mode of Access for All Entering Trips, Morning Peak Period

Mode of Access	All Entering Trips (N=2,180)		
	Induced (N=104)	Internal (N=772)	External (N=1,408)
Auto Driver	9.6%	48.2%	87.4%
Auto Passenger	9.6	10.2	8.0
Transit	0.0	0.7	0.0
Walk	0.0	6.0	0.0
None (On-Site Resident)	80.8	31.9	4.6
None (On-Site Hotel Guest)	0.0	2.2	0.0
No Response	0.0	0.8	0.0
Note: Columns may not equal 100 percent due to rounding.			

On-site residents accounted for a substantial amount of the induced travel in both directions, as well as a majority of trips exiting buildings at the site to an external destination. Most of the internal trips, however, were made by individuals accessing the site as an automobile driver. One unexpected outcome was that while there were internal trips made by travelers accessing the site as a transit rider or on foot, none of these trips were induced.

Table 23: Mode of Access for All Exiting Trips, Morning Peak Period

Mode of Access	All Exiting Trips (N=2,828)		
	Induced (N=97)	Internal (N=799)	External (N=2,029)
Auto Driver	13.5%	51.4%	28.5%
Auto Passenger	16.7	6.3	0.5
Transit	0.0	0.6	0.0
Walk	0.0	2.1	0.0
None (On-Site Resident)	69.8	35.9	53.0
None (On-Site Hotel Guest)	0.0	2.8	17.7
No Response	0.0	0.9	0.2
Note: Columns may not equal 100 percent due to rounding.			

Office Trips

Analysis of the travel survey data indicated that a total of 695 trip ends during the morning peak period involved the offices at Legacy Town Center, with 596 trips (85.8 percent) entering an office and 99 trips (14.3 percent) exiting an office. Out of 596 trips entering the offices, 117 trips (19.6 percent) had their origin internal to Legacy Town Center (see Table 24). The most frequent origin land use for internal trips entering the office properties was the restaurant, accounting for 7.4 percent of all entering trips. Other sources of a significant internal percentage of trips entering the offices were the on-site residences, retail shops, and other offices. The analysis identified 20 induced trips entering the offices, representing 3.4 percent of all trips entering the offices and 17.3 percent of all trips entering the offices from other locations in Legacy Town Center. However, none of the induced trip percentages for trips entering the offices at Legacy Town Center from individual land uses were computed to be significant.

Table 24: Origins of All Trips Entering Offices, Morning Peak Period

Origin Land Use	All Trips Entering Offices (N=596)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	1.7	**3.4**	0.500
Retail	0.0	**4.0**	0.000
Restaurant	0.7	**7.4**	0.095
Residential	0.8	**4.9**	0.163
Hotel	0.0	0.0	N/A
Other	N/A	0.0	N/A
All Internal Origins	**3.4**	**19.6**	0.173
Note: 80.4% of Trips Entering Offices had an External Origin Figures shown in bold had a margin of error less than 10% and were significantly different than zero (α=0.1).			

Of the 99 trips exiting the offices, 49 trips (49.5 percent) had their destination internal to Legacy Town Center (see Table 25). The most frequent destination land use for internal trips exiting the offices was other offices, accounting for 33.3 percent of all trips exiting offices. The analysis identified 17 induced trips exiting the offices, representing 17.2 percent of all trips exiting the offices and 34.7 percent of all trips exiting the offices with destinations internal to Legacy Town Center. All of the induced trips exiting the offices had a destination of other on-site offices. None of the induced or internal trip percentages for trips exiting the offices at Legacy Town Center were computed to be significant.

Table 25: Destinations of All Trips Exiting Offices, Morning Peak Period

Destination Land Use	All Trips Exiting Offices (N=99)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	17.2	33.3	0.516
Retail	N/A	0.0	N/A
Restaurant	0.0	8.1	0.000
Residential	0.0	8.1	0.000
Hotel	N/A	0.0	N/A
Other	N/A	0.0	N/A
All Internal Destinations	17.2	49.5	0.347
Note: 50.5% of Trips Exiting Offices had an External Destination Figures shown in bold had a margin of error less than 10% and were significantly different than zero (α=0.1).			

For both directions of travel, approximately half of the trips between two internal office properties were induced. These findings indicate that travel between two internal offices, trips entering the offices from the on-site restaurants, and trips entering the offices from the on-site residential units were land-use pairs where some amount of new trip generation was occurring.

Retail Trips

Analysis of the travel survey data indicated that total of 241 trip ends during the morning peak period involved the retail shops at Legacy Town Center, with 128 trips (53.1 percent) entering a retail establishment and 113 trips (46.9 percent) exiting a retail establishment. Of the 128 trips entering retail shops, 80 trips (62.5 percent) had their origin internal to Legacy Town Center (see Table 26). The most frequent origin land use for internal trips entering the retail shops was the residences, accounting for 56.3 percent of all trips entering the retail shops at Legacy Town Center. The analysis identified eight induced trips entering the retail shops, representing 6.3 percent of all trips entering the retail shops and 10.1 percent of all trips entering the retail shops from other locations in Legacy Town Center.

Table 26: Origins of All Trips Entering Retail, Morning Peak Period

Origin Land Use	All Trips Entering Retail (N=128)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	N/A	0.0	0.000
Retail	N/A	0.0	N/A
Restaurant	0.0	6.3	0.000
Residential	6.3	56.3	0.112
Hotel	N/A	0.0	N/A
Other	N/A	0.0	N/A
All Internal Origins	6.3	62.5	0.101
Note: 37.5% of All Trips Entering Retail had an External Origin Figures shown in bold had a margin of error less than 10% and were significantly different than zero (α=0.1).			

Of the 113 trips exiting the retail shops, 44 trips (38.9 percent) had their destination internal to Legacy Town Center (see Table 27). The most frequent destination land use for internal trips exiting the retail shops was the on-site offices, accounting for 19.5 percent of all trips exiting the retail shops at Legacy Town Center. The only internal trip percentage for trips exiting the retail shops at Legacy Town Center that was computed to be significant was the

percentage of internal trips from the retail shops to the on-site residences. The analysis identified four induced trips exiting the retail shops, representing 3.5 percent of all trips exiting the retail shops and 9.0 percent of trips exiting the retail shops with destinations internal to Legacy Town Center.

Table 27: Destinations of All Trips Exiting Retail, Morning Peak Period

Destination Land Use	All Trips Exiting Retail (N=113)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	0.0	19.5	0.000
Retail	N/A	0.0	N/A
Restaurant	3.5	8.0	0.438
Residential	0.0	**11.5**	0.000
Hotel	N/A	0.0	N/A
Other	N/A	0.0	N/A
All Internal Destinations	3.5	38.9	0.090
Note: 61.1% of Trips Exiting Retail had an External Destination Figures shown in bold had a margin of error less than 10% and were significantly different than zero (α=0.1).			

For both travel directions, the percentage of internal trips that were induced was approximately 10 percent. A majority of the retail establishments that were open during the morning peak period were service-oriented businesses such as a convenience store or dry cleaners. Based on these findings, one could speculate that travelers leaving a residence may stop at one of these establishments, then travel to either an on-site office, on-site restaurant, or off-site (presumably to a place of employment). It was also found that nearly half of the internal trips from the retail establishments to the restaurants were induced, suggesting that the ability to stop off at one of the on-site restaurants actually generated new trips between these two land uses. However, none of the induced trip percentages in either travel direction at the retail shops were computed to be significantly different than zero.

Restaurant Trips

Analysis of the travel survey data indicated that a total of 1,150 trip ends during the morning peak period involved the restaurants at Legacy Town Center, with 597 trips (51.9 percent) entering a restaurant and 553 trips (48.1 percent) exiting a restaurant. Of the 597 trips entering a restaurant, 205 trips (34.3 percent) had their origin internal to Legacy Town Center

(see Table 28). The most frequent origin land use for internal trips entering the restaurants was the residences, accounting for 26.8 percent of all trips entering restaurants. The percentage of trips entering restaurants from the on-site hotel was also computed to be significant. The analysis identified 17 induced trips entering the restaurants, representing 2.8 percent of all trips entering the restaurants and 8.2 percent of all trips entering the restaurants from origins internal to Legacy Town Center. All of these induced trips originated at an on-site residence, representing approximately 10 percent of the internal trips from the residences to the restaurants.

Table 28: Origins of All Trips Entering Restaurants, Morning Peak Period

Origin Land Use	All Trips Entering Restaurants (N=597)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	0.0	1.0	0.000
Retail	0.0	1.8	0.000
Restaurant	N/A	0.0	N/A
Residential	2.8	**26.8**	0.104
Hotel	0.0	**4.7**	0.000
Other	N/A	0.0	N/A
All Internal Origins	2.8	**34.3**	0.082
Note: 65.7% of Trips Entering Restaurants had an External Origin Figures shown in bold had a margin of error less than 10% and were significantly different than zero (α=0.1).			

Of the 553 trips exiting a restaurant, 98 trips (17.7 percent) had their destination internal to Legacy Town Center (see Table 29). The most frequent destination land use for internal trips exiting the restaurants was the on-site offices, accounting for 8.9 percent of all trips exiting a restaurant. The percentage of trips exiting restaurants with an on-site residence as their destination was also computed to be significant. The analysis identified ten induced trips exiting the restaurants, representing 1.8 percent of all trips exiting the restaurants and 17.7 percent of all trips exiting the restaurants with destinations internal to Legacy Town Center.

Table 29: Destinations of All Trips Exiting Restaurants, Morning Peak Period

Destination Land Use	All Trips Exiting Restaurants (N=553)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	0.9	**8.9**	0.101
Retail	0.0	2.0	0.000
Restaurant	N/A	0.0	N/A
Residential	0.0	**4.0**	0.000
Hotel	0.9	0.9	1.000
Other	0.0	2.0	0.000
All Internal Destinations	1.8	**17.7**	0.102
Note: 82.3% of Trips Exiting Restaurants had an External Destination Figures shown in bold had a margin of error less than 10% and were significantly different than zero (α=0.1).			

In both directions of travel, about 10 percent of the internal trips were induced. Approximately 10 percent of the internal trips exiting the restaurants with a destination of an on-site office were induced. Another finding of interest from Table 29 was that 100 percent of the internal trips exiting the restaurant traveling to the hotel were induced. The finding that all of the induced trips exiting the restaurant traveled to the office or the hotel was surprising as one might expect to find very few induced trips to these locations. As with trips at the retail shops, none of the induced trip percentages at the restaurants were found to be significantly different than zero.

Residential Trips

Analysis of the travel survey data indicated that a total of 2,335 trip ends during the morning peak period involved the residential units at Legacy Town Center, with 672 trips (28.8 percent) entering a residence and 1,663 trips (71.2 percent) exiting a residence. Of the 672 trips entering a residence, 336 (50.0 percent) had their origin internal to Legacy Town Center (see Table 30). The most frequent origin land use for internal trips entering the residences was other residences, accounting for 25.0 percent of all trips entering a residence. However, the percentage of all trips entering the residences with an origin of an internal restaurant was the only percentage in Table 30 computed to be significant. The analysis identified 42 induced trips entering the residences, representing 6.3 percent of all trips entering the residences and 12.6 percent of all trips entering the residences from other locations internal to Legacy Town Center. Approximately one-third of the trips entering the residences from the on-site retail shops were induced.

Table 30: Origins of All Trips Entering Residences, Morning Peak Period

Origin Land Use	All Trips Entering Residences (N=672)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	0.0	3.1	0.000
Retail	3.1	9.4	0.329
Restaurant	0.0	**12.5**	0.000
Residential	3.1	25.0	0.124
Hotel	N/A	0.0	N/A
Other	N/A	0.0	N/A
All Internal Origins	6.3	50.0	0.126
Note: 50.0% of Trips Entering Residences had an External Origin Figures shown in bold had a margin of error less than 10% and were significantly different than zero (α=0.1).			

Of the 1,663 trips exiting the residences, 571 trips (34.3 percent) had their destination internal to Legacy Town Center (see Table 31). The most frequent destination land use for internal trips exiting the residences was the restaurants, accounting for 14.4 percent of all trips exiting a residence. With the exception of trips to the hotel, each of the five land uses (including other residences) were destinations of a significant percentage of trips exiting the residences. The analysis identified 66 induced trips exiting the residences, representing 4.0 percent of all trips exiting the residences and 34.3 percent of all trips exiting the residences with destinations internal to Legacy Town Center. Trips exiting the residences had at least some induced travel to every on-site destination except for the hotel (although only trips to the restaurant had a significant induced percentage).

Table 31: Destinations of All Trips Exiting Residences, Morning Peak Period

Destination Land Use	All Trips Exiting Residences (N=1,663)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	0.5	**3.0**	0.166
Retail	1.0	**9.0**	0.111
Restaurant	**1.5**	**14.4**	0.104
Residential	0.5	**4.0**	0.125
Hotel	0.0	0.5	0.000
Other	0.5	**3.5**	0.143
All Internal Destinations	**4.0**	**34.3**	0.116
Note: 65.7% of Trips Exiting Residences had an External Destination Figures shown in bold had a margin of error less than 10% and were significantly different than zero (α=0.1).			

For both directions of travel, approximately one-eighth of the internal trips at the residences were induced, as was about one-eighth of the travel between two on-site residences. The percentage of trips exiting residences with internal destinations that were induced ranged from 10 percent to the restaurants to 17 percent to the offices, meaning that between 10 and 17 percent of trips exiting the residences with a destination internal to Legacy Town Center were not replacing trips on the external street network.

Hotel Trips

Analysis of the travel survey data indicated that a total of 587 trip ends during the morning peak period involved the hotel at Legacy Town Center, with 187 trips (31.9 percent) entering the hotel and 400 trips (68.1 percent) exiting the hotel. Of the 187 trips entering the hotel, 34 trips (18.2 percent) had their origin internal to Legacy Town Center (see Table 32). The only origin land uses for internal trips entering the hotel were restaurants and residences (each 9.1 percent of all entering trips, neither significant). The analysis identified 17 induced trips entering the hotel, representing 9.1 percent of all trips entering the hotel and 50.0 percent of all trips entering the hotel from other locations in Legacy Town Center. This was a result of all of the internal trips entering the hotel from the on-site restaurants and none of the trips entering the hotel from the on-site residences being induced.

Table 32: Origins of All Trips Entering the Hotel, Morning Peak Period

Origin Land Use	All Trips Entering the Hotel (N=187)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	N/A	0.0	N/A
Retail	N/A	0.0	N/A
Restaurant	9.1	9.1	1.000
Residential	0.0	9.1	0.000
Hotel	N/A	0.0	N/A
Other	N/A	0.0	N/A
All Internal Origins	9.1	18.2	0.500
Note: 81.8% of Trips Entering the Hotel had an External Origin Figures shown in bold had a margin of error less than 10% and were significantly different than zero (α=0.1).			

Of the 400 trips exiting the hotel, 37 trips (9.3 percent) had their destination internal to Legacy Town Center (see Table 33). The only destination land use for internal trips exiting the

hotel was the restaurants (9.3 percent of all exiting trips, significant). None of the trips exiting the hotel were found to be induced.

Table 33: Destinations of All Trips Exiting the Hotel, Morning Peak Period

Destination Land Use	All Trips Exiting the Hotel (N=400)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	N/A	0.0	N/A
Retail	N/A	0.0	N/A
Restaurant	0.0	**9.3**	0.000
Residential	N/A	0.0	N/A
Hotel	N/A	0.0	N/A
Other	N/A	0.0	N/A
All Internal Destinations	0.0	**9.3**	0.000
Note: 90.7% of Trips Exiting the Hotel had an External Destination Figures shown in bold had a margin of error less than 10% and were significantly different than zero (α=0.1).			

Automobile Trips

Analysis of the travel survey data indicated that a total of 4,181 trips during the morning peak period at Legacy Town Center were made in an automobile, either as a driver or a passenger, with 1,843 trips (44.1 percent) entering buildings at Legacy Town Center and 2,338 trips (55.9 percent) exiting buildings at Legacy Town Center. Collectively, trips made by automobile drivers and automobile passengers represented 83.5 percent of the trips made during the morning peak period at Legacy Town Center. Automobile drivers accounted for 3,903 of these trips (93.3 percent) while passengers accounted for the remaining 278 trips (6.7 percent). The percentage of trips entering buildings at Legacy Town Center made in an automobile that were induced and internal, by destination land use, is shown in Table 34. For trips made in an automobile that were entering buildings at Legacy Town Center, 448 trips (26.4 percent) had an origin that was located internal to Legacy Town Center. The analysis identified 35 induced trips entering buildings at Legacy Town Center made in an automobile, representing 1.9 percent of all trips entering buildings at Legacy Town Center and 7.2 percent of all trips entering buildings at Legacy Town Center with an origin somewhere on the site.

Table 34: Destinations of Entering Trips (via Automobile), Morning Peak Period

Destination Land Use	All Entering Trips (via Automobile, N=1,843)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	1.8	14.2	0.127
Retail	3.8	53.8	0.071
Restaurant	0.0	29.9	0.000
Residential	4.5	36.4	0.124
Hotel	0.0	10.0	0.000
All Internal Destinations	1.9	26.4	0.072

The percentage of trips exiting buildings at Legacy Town Center made in an automobile that were induced and internal, by the land use of their destination, is shown in Table 35. For trips made in an automobile that were exiting buildings at Legacy Town Center, 519 trips (22.2 percent) had a destination located inside Legacy Town Center. The analysis identified 32 induced trips exiting buildings at Legacy Town Center made in an automobile, representing 1.4 percent of all trips exiting buildings at Legacy Town Center and 6.3 percent of all trips exiting buildings at Legacy Town Center with a destination internal to the site.

Table 35: Origins of Exiting Trips (via Automobile), Morning Peak Period

Origin Land Use	All Exiting Trips (via Automobile, N=2,338)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	9.8	40.2	0.244
Retail	0.0	27.4	0.000
Restaurant	0.0	11.6	0.000
Residential	1.7	25.7	0.066
Hotel	0.0	15.6	0.000
All Internal Origins	1.4	22.2	0.063

In terms of the percentage of internal trips that were induced, the offices, the residences, and trips entering the retail stores all had some induced travel as a percentage of their internal trips that were made in an automobile. The remaining land uses had no induced trip ends where the trip was made by an automobile driver or passenger. These findings are important, because they suggest that while automobile users contributed to internal travel at Legacy Town Center, a majority would have traveled to a similar destination outside of the site, indicating that most automobile trips within Legacy Town Center were replacing automobile trips external to the site.

Walking Trips

Analysis of the travel survey data indicated that a total of 587 trips during the morning peak period at Legacy Town Center were made on foot, with 288 trips (49.1 percent) entering and 299 trips (50.9 percent) exiting. Walking trips represented 11.7 percent of all person-trips at Legacy Town Center during the morning peak period. For walking trips entering buildings at Legacy Town Center, 288 trips (100 percent) had an origin that was located inside Legacy Town Center (see Table 36). The analysis identified 69 induced trips made on foot entering buildings at Legacy Town Center, representing 24.0 percent of all trips made on foot entering buildings at Legacy Town Center and 24.0 percent of all trips made on foot entering buildings at Legacy Town Center with an origin internal to the site.

Table 36: Destinations of Entering Trips (via Walking), Morning Peak Period

Destination Land Use	All Entering Trips (via Walking, N=288)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	25.0	100.0	0.250
Retail	16.7	100.0	0.167
Restaurant	43.6	100.0	0.436
Residential	12.5	100.0	0.125
Hotel	100.0	100.0	1.000
All Internal Destinations	24.0	100.0	0.240

For walking trips exiting buildings at Legacy Town Center, 277 trips (92.6 percent) had a destination located inside the site (see Table 37). Only travelers exiting the restaurants and residences made walking trips external to Legacy Town Center. The analysis identified 63 induced trips made on foot, representing 21.1 percent of all trips made on foot exiting buildings at Legacy Town Center and 22.8 percent of all trips made on foot exiting buildings at Legacy Town Center with a destination internal to the site.

Table 37: Origins of Exiting Trips (via Walking), Morning Peak Period

Origin Land Use	All Exiting Trips (via Walking, N=299)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	47.1	100.0	0.471
Retail	23.5	100.0	0.235
Restaurant	24.4	87.8	0.278
Residential	18.3	92.4	0.198
Hotel	N/A	0.0	N/A
All Internal Origins	21.1	92.6	0.228

Given the accessibility concerns at Legacy Town Center (specifically, a lack of off-site trip generators within a reasonable walking distance), it was not surprising that nearly all of the trips made on foot had both trip ends internal to the site. As a percentage of the internal trips, the findings indicate that nearly one-quarter of the trips made on foot during the morning peak period were induced, not replacing trips external to Legacy Town Center. For every land use where an internal trip end took place on foot, at least one-eighth of the internal trip ends were induced. The ratio of induced to internal ranged from 0.125 for walking trips entering the residences to 1.000 for walking trips entering the hotel, indicating that between 12.5 and 100 percent of walking trips internal to Legacy Town Center were additional trips made within the site, and not replacements for external travel.

Traveler Characteristics

The morning peak period induced and internal trip characteristics for all trips at Legacy Town Center, by mode of access, are shown in Table 38 for trips entering buildings at Legacy Town Center and Table 39 for trips exiting buildings at Legacy Town Center. Travelers accessing the site as an automobile driver remained internal to the site at a rate of 23.5 percent for trips entering buildings at Legacy Town Center and 41.6 percent for trips exiting buildings at Legacy Town Center. Travelers stating that they had accessed the site using modes where external travel may not have been easily facilitated, such as automobile passenger, transit, or walking, traveled within the site at a higher rate than the automobile drivers.

Table 38: Characteristics of Entering Trips by Mode of Access, Morning Peak Period

Access Mode	All Entering Trips (N=2,180)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Auto Driver	0.6	23.5	0.026
Auto Passenger	5.3	41.5	0.128
Transit	0.0	100.0	0.000
Walk	0.0	100.0	0.000
None (On-Site Resident)	27.4	79.5	0.345
None (On-Site Hotel Guest)	0.0	100.0	0.000

However, the induced travel profile by mode of access was slightly more complex. Induced trips made by automobile drivers were approximately three percent of the internal trips made by this group of travelers. By contrast, travelers accessing the site as automobile passengers made induced trips at a rate of 5.3 percent (entering trips) and 26.2 percent (exiting trips), representing 12.8 percent and 32.0 percent of the internal trips made by these travelers, respectively. No induced trips were made in either travel direction by travelers accessing the site as transit riders or pedestrians, implying that internal trips made by these travelers were replacing trips external to the site. The travel patterns of on-site residents are discussed in greater detail below.

Table 39: Characteristics of Exiting Trips by Mode of Access, Morning Peak Period

Access Mode	All Exiting Trips (N=2,828)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Auto Driver	1.3	41.6	0.031
Auto Passenger	26.2	82.0	0.320
Transit	0.0	100.0	0.000
Walk	0.0	100.0	0.000
None (On-Site Resident)	5.0	21.1	0.237
None (On-Site Hotel Guest)	0.0	5.6	0.000

The morning peak period induced and internal trip percentages, classified by the traveler's stated ability to access an automobile for their trip, are shown in Table 40 for trips entering buildings at Legacy Town Center and Table 41 for trips exiting buildings at Legacy Town Center. To avoid potential bias, these percentages were derived from trips made by travelers accessing the site by all modes except for automobile driver, and also excluded trips

made by on-site residents. Presumably, a traveler that had access to an automobile would make less induced trips, since travel to an off-site destination could be easily facilitated with access to an automobile. Travelers not accessing the site in an automobile, but with an automobile available, remained internal to the site at a rate of 29.2 percent (entering trips) and 17.0 percent (exiting trips), while those travelers without an automobile available remained internal to the site at a rate of 77.4 percent (entering) and 16.8 percent (exiting).

Table 40: Characteristics of Entering Trips by Auto Availability, Morning Peak Period

Auto Availability	Entering Trips (Non-Auto Driver, Non-Resident; N=262)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Auto Available	5.6	29.2	0.192
No Auto Available	0.0	77.4	0.000

Travelers with access to an automobile for their trip were found to make induced trips at a rate of 5.6 percent (entering) and 8.5 percent (exiting). However, it was found that travelers without an automobile available for their trip did not make any induced trips at all during the morning peak period.

Table 41: Characteristics of Exiting Trips by Auto Availability, Morning Peak Period

Auto Availability	Exiting Trips (Non-Auto Driver, Non-Resident; N=473)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Auto Available	8.5	17.0	0.500
No Auto Available	0.0	16.8	0.000

The morning peak period induced and internal travel characteristics for a very important segment of travelers, residents of Legacy Town Center's on-site apartments and townhomes, are shown in Table 42 for all trips by residents entering buildings at Legacy Town Center and Table 43 for all trips by residents exiting buildings at Legacy Town Center. On-site residents accounted for 33.6 percent of all morning peak period trips, a majority of the induced trips, and about one-third of the internal trips made at Legacy Town Center during the morning. Trips by on-site residents were internal to Legacy Town Center at a rate of 79.5 percent (all entering trips) and 21.1 percent (all exiting trips). The only land use where on-site residents were entering that

did not have 100 percent of their origins within the site was the on-site residences, where 62.5 percent of the entering trips made by on-site residents had internal origins.

Table 42: Characteristics of Entering Trips by On-Site Residents, Morning Peak Period

Destination Land Use	All Entering Trips (Residents; N=307)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	0.0%	100.0%	0.000
Retail	33.3	100.0	0.333
Restaurant	19.3	100.0	0.193
Residential	25.0	62.5	0.400
Hotel	100.0	100.0	1.000
All Internal Destinations	27.4	79.5	0.345

Internal trips were made by on-site residents exiting every land use except for the offices and the hotel. All the trips exiting the retail shops made by on-site residents had destinations internal to the study site.

Table 43: Characteristics of Exiting Trips by On-Site Residents, Morning Peak Period

Origin Land Use	All Exiting Trips (Residents; N=1,353)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	N/A	N/A	N/A
Retail	100.0	100.0	1.000
Restaurant	8.5	44.1	0.193
Residential	4.5	19.8	0.227
Hotel	N/A	N/A	N/A
All Internal Origins	5.0	21.1	0.237

Induced trips accounted for 34.5 percent of the internal trips (entering) and 23.7 percent of the internal trips (exiting). There were no induced trips made by on-site residents entering the offices, but every other land use had some percentage of their entering trips that were made by on-site residents induced. For trips exiting buildings at Legacy Town Center made by on-site residents, induced trips represented at least 19.3 percent of the internal trips, including all of the trips made by on-site residents originating at retail shops.

AFTERNOON PEAK PERIOD ANALYSIS

Analysis of the travel survey data indicated that a total of 9,719 person-trips occurred during the afternoon peak period (3:00 PM to 7:00 PM), of which 5,699 (58.6 percent) were internal to the site. Of these internal trips, 2,358 (24.3 percent) were found to be induced, meaning that 41.4 percent of the internal trips during the afternoon peak period were additional trips and not replacements for external trips. Of the total person-trips during the afternoon, 5,052 (52.0 percent) were entering buildings at Legacy Town Center and 4,667 (48.0 percent) were exiting buildings at Legacy Town Center.

For trips entering buildings at Legacy Town Center, it was found that 3,391 trips (67.1 percent) had their origin internal to Legacy Town Center and 1,408 (27.9 percent) were induced, meaning that 41.6 percent of the internal trips entering buildings at Legacy Town Center were induced. The destination land use for all entering trips of each classification (induced, internal, and external) is shown in Table 44. A majority of the induced and internal trips entering buildings at Legacy Town Center had either a restaurant or a residence as their destination. A majority of the trips entering buildings at Legacy Town Center from external locations had the destination of an on-site restaurant.

Table 44: Destination Land Use of All Entering Trips, Afternoon Peak Period

Destination Land Use	All Entering Trips (N=5,052)		
	Induced (N=1,408)	Internal (N=3,391)	External (N=1,661)
Office	1.6%	2.5%	0.7%
Retail	14.8	13.9	22.5
Restaurant	43.0	39.4	43.2
Residential	37.5	39.5	10.6
Cinema	0.0	1.0	11.2
Hotel	3.1	3.6	11.9
Note: Columns may not equal 100 percent due to rounding.			

For trips exiting buildings at Legacy Town Center, it was found that 2,308 trips (49.5 percent) had their destination internal to Legacy Town Center and 950 trips (20.4 percent) were induced, meaning that 41.2 percent of the internal trips exiting buildings at Legacy Town Center were induced. The origin land use for all exiting trips of each classification (induced, internal, and external) is shown in Table 45. A majority of the induced and internal trips in both

directions of travel were focused at the retail, restaurant, and residential land uses. For external travelers, the most frequent origin and destination was a restaurant, which was not surprising, considering the number and variety of restaurants to patronize at Legacy Town Center.

Table 45: Origin Land Use of All Exiting Trips, Afternoon Peak Period

Origin Land Use	All Exiting Trips (N=4,667)		
	Induced (N=950)	Internal (N=2,308)	External (N=2,359)
Office	0.0%	3.0%	19.0%
Retail	36.7	24.8	13.9
Restaurant	20.6	30.0	32.3
Residential	29.6	34.7	24.8
Cinema	2.4	2.1	2.5
Hotel	10.6	5.4	7.5
Note: Columns may not equal 100 percent due to rounding.			

The mode split for each classification of trip is shown in Table 46 for entering trips and Table 47 exiting trips. During the afternoon peak period, walking was the dominant mode of travel for trips within Legacy Town Center. For induced trips, 71.1 percent of the entering trips and 80.0 percent of the exiting trips were made on foot; most of the remaining induced trips were made in an automobile, as a driver or a passenger. For all internal trips, walking accounted for 63.6 percent of the entering trips and 70.9 percent of the exiting trips.

Table 46: Mode of Travel for All Entering Trips, Afternoon Peak Period

Mode of Travel	All Entering Trips (N=5,032)		
	Induced (N=1,408)	Internal (N=3,391)	External (N=1,661)
Auto Driver	24.7%	33.9%	79.2%
Auto Passenger	3.0	2.1	10.5
Taxi	N/A	0.0	4.0
Transit	1.0	0.4	0.7
Walk	71.1	63.6	5.7
No Response	N/A	0.0	0.0
Note: Columns may not equal 100 percent due to rounding.			

As with the morning peak period, most trips external to Legacy Town Center during the afternoon peak period were made in an automobile (as a driver or a passenger, approximately

90.0 percent in each direction). There was also a small share of trips external to Legacy Town Center made on foot during the afternoon.

Table 47: Mode of Travel for All Exiting Trips, Afternoon Peak Period

Mode of Travel	All Exiting Trips (N=4,667)		
	Induced (N=950)	Internal (N=2,308)	External (N=2,359)
Auto Driver	17.4%	30.3%	89.7%
Auto Passenger	1.9	1.0	6.2
Taxi	N/A	0.0	0.8
Transit	0.6	0.3	0.0
Walk	80.0	70.9	3.3
No Response	N/A	0.0	0.0
Note: Columns may not equal 100 percent due to rounding.			

The mode of access for each classification of trip is shown in Table 48 for trips entering buildings at Legacy Town Center and Table 49 for trips exiting buildings at Legacy Town Center. No trips made by travelers accessing the site on a bicycle were obtained from the travel survey. A majority of the induced and internal trips at Legacy Town Center were made by travelers accessing the site as an automobile driver. On-site residents accounted for about one-third of the induced and internal trips entering buildings at Legacy Town Center.

Table 48: Mode of Access for All Entering Trips, Afternoon Peak Period

Mode of Access	All Entering Trips (N=5,302)		
	Induced (N=1,408)	Internal (N=3,391)	External (N=1,661)
Auto Driver	50.4%	51.3%	75.2%
Auto Passenger	6.1	4.9	9.7
Taxi	3.8	1.9	3.7
Transit	1.0	0.4	0.7
Walk	0.8	0.3	0.0
None (On-Site Resident)	33.2	38.2	0.9
None (On-Site Hotel Guest)	3.8	2.6	2.0
No Response	1.0	0.4	0.0
Note: Columns may not equal 100 percent due to rounding.			

A very limited share of the afternoon peak period trips were made by travelers accessing the site as a taxi passenger, transit rider, or pedestrian. As expected, a majority of the external

trips in both travel directions were made by travelers stating that they had accessed the site as an automobile driver.

Table 49: Mode of Access for All Exiting Trips, Afternoon Peak Period

Mode of Access	All Exiting Trips (N=4,667)		
	Induced (N=950)	Internal (N=2,308)	External (N=2,359)
Auto Driver	49.8%	53.2%	73.5%
Auto Passenger	4.0	3.5	5.8
Taxi	3.1	1.4	1.0
Transit	0.6	0.3	0.0
Walk	2.5	1.0	0.5
None (On-Site Resident)	35.3	37.8	18.0
None (On-Site Hotel Guest)	3.1	2.3	1.0
No Response	1.5	0.6	0.2
Note: Columns may not equal 100 percent due to rounding.			

Office Trips

Analysis of the travel survey data indicated that a total of 615 trip ends during the afternoon peak period involved the office properties at Legacy Town Center, with 97 trips (15.8 percent) entering an office and 518 trips (84.2 percent) exiting an office. Out of 97 trips entering the offices, 86 trips (88.7 percent) had their origin internal to Legacy Town Center (see Table 50). The most frequent origin land use for internal trips entering the office properties was the residences, which accounted for 44.3 percent of all trips entering an office. Additional trips entering the offices from internal origins included other offices, retail shops, and restaurants, although none of these percentages were significant. The analysis identified 22 induced trips entering the offices, representing 22.7 percent of all trips entering the offices and 25.6 percent of all trips entering the offices from other locations in Legacy Town Center. The two sources of induced trips entering the offices were the restaurants and the residences. However, none of the induced trip rates for trips entering the offices at Legacy Town Center were computed to be significant.

Table 50: Origins of All Trips Entering Offices, Afternoon Peak Period

Origin Land use	All Trips Entering Offices (N=97)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	0.0	11.3	0.000
Retail	0.0	11.3	0.000
Restaurant	11.3	21.6	0.523
Residential	11.3	44.3	0.255
Cinema	N/A	0.0	N/A
Hotel	N/A	0.0	N/A
Other	N/A	0.0	N/A
All Internal Origins	22.7	88.7	0.256
Note: 11.3% of All Trips Entering Offices had an External Origin Figures shown in bold had a margin of error less than 10% and were significantly different than zero (α=0.1).			

Of the 518 trips exiting the offices, 70 trips (13.5 percent) had their destination internal to Legacy Town Center (see Table 51). The most frequent destination land use for internal trips exiting the office properties was the restaurants, which accounted for 5.6 percent of all trips exiting an office. Trips exiting the offices also traveled to these internal destinations, but only the percentage of internal trips to the restaurants and residences was significant. During the afternoon peak period, there are generally more travelers exiting offices than entering (this was observed at Legacy Town Center). Consequently, the induced and internal trip percentages for trips exiting offices play a greater role in the potential for reducing traffic than the corresponding percentages for trips entering offices during this time period. The analysis identified no induced trips exiting the offices at Legacy Town Center during the afternoon peak period, meaning that all trips made from the office to another on-site land use were replacing trips external to Legacy Town Center.

Table 51: Destinations of All Trips Exiting Offices, Afternoon Peak Period

Destination Land Use	All Trips Exiting Offices (N=518)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	0.0	1.2	0.000
Retail	0.0	2.3	0.000
Restaurant	0.0	**5.6**	0.000
Residential	0.0	**3.3**	0.000
Cinema	N/A	0.0	N/A
Hotel	0.0	1.2	0.000
Other	N/A	0.0	N/A
All Internal Destinations	0.0	**13.5**	0.000
Note: 86.5% of All Trips Exiting Offices had an External Destination Figures shown in bold had a margin of error less than 10% and were significantly different than zero (α=0.1).			

Retail Trips

Analysis of the travel survey data indicated that a total of 1,764 trip ends during the afternoon peak period involved the retail shops at Legacy Town Center, with 847 trips (48.5 percent) entering the retail shops and 899 trips (51.5 percent) exiting the retail shops. Of the 847 trips entering the retail shops at Legacy Town Center, 473 trips (55.8 percent) had their origin internal to Legacy Town Center (see Table 52). The most frequent origin land use for internal trips entering the retail shops was other retail shops, which accounted for 19.5 percent of all trips entering the retail shops at Legacy Town Center. Other significant sources of internal trips entering the retail shops were the restaurants, residences, and the cinema. The analysis identified 209 induced trips entering the retail shops, representing 24.7 percent of all trips entering the retail shops and 44.3 percent of all trips entering the retail shops from other locations in Legacy Town Center. The only land use contributing a significant percentage of induced trips entering the retail shops was other retail shops.

Table 52: Origins of All Trips Entering Retail, Afternoon Peak Period

Origin Land Use	All Trips Entering Retail (N=847)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	0.0	2.6	0.000
Retail	**10.4**	**19.5**	0.533
Restaurant	2.6	**11.7**	0.222
Residential	3.9	**13.0**	0.300
Cinema	3.9	**5.2**	0.750
Hotel	0.0	3.9	0.000
Other	0.0	0.0	N/A
All Internal Origins	**24.7**	**55.8**	0.443
Note: 44.2% of All Trips Entering Retail had an External Origin Figures shown in bold had a margin of error less than 10% and were significantly different than zero (α=0.1).			

Of the 899 trips exiting the retail shops, 572 trips (63.6 percent) had their destination internal to Legacy Town Center (see Table 53). The most frequent destination land uses for internal trips exiting the retail shops were other retail shops and the residences, each accounting for 19.5 percent of all trips exiting the retail shops at Legacy Town Center. Other significant internal destinations for trips exiting retail shops were the on-site residences and the cinema. The analysis identified 349 induced trips exiting the retail shops, representing 38.8 percent of all trips exiting the retail shops and 61.0 percent of all trips exiting the retail shops with destinations internal to Legacy Town Center. Significant percentages of induced trips leaving the retail shops had a destination of another retail shop, a restaurant, or an on-site residence.

Table 53: Destinations of All Trips Exiting Retail, Afternoon Peak Period

Destination Land Use	All Trips Exiting Retail (N=899)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	0.0	1.3	0.000
Retail	**10.3**	**19.5**	0.528
Restaurant	**13.0**	**19.5**	0.667
Residential	**10.3**	**14.2**	0.725
Cinema	N/A	0.0	N/A
Hotel	2.6	**5.2**	0.500
Other	2.6	3.9	0.667
All Internal Destinations	**38.8**	**63.6**	0.610
Note: 36.4% of All Trips Exiting Retail had an External Destination Figures shown in bold had a margin of error less than 10% and were significantly different than zero (α=0.1).			

Every land use at Legacy Town Center had an interaction with the on-site retail shops in one or both directions during the afternoon period. Significant internal travel percentages were found for trips between the retail shops and the restaurants. At a minimum, these results imply that a substantial amount of activity between the retail shops and other on-site land uses at Legacy Town Center was induced and not replacing travel external to the site.

Restaurant Trips

Analysis of the travel survey data indicated that a total of 3,508 trip ends during the afternoon peak period involved the restaurants at Legacy Town Center, with 2,053 trips (58.5 percent) entering the restaurants and 1,455 trips (41.5 percent) exiting the restaurants. Of the 2,053 trips entering a restaurant, 1,336 trips (65.1 percent) had their origin internal to Legacy Town Center (see Table 54). The most frequent origin land use for internal trips entering the restaurants was the residences, which accounted for 19.9 percent of all entering trips. Every defined land use at Legacy Town Center was an origin of a significant percentage of trips entering the restaurants. The analysis identified 605 induced trips entering the restaurants, representing 29.5 percent of all trips entering the restaurants and 45.3 percent of all trips entering restaurants from origins internal to Legacy Town Center. All internal origin land uses except for the offices had at least 30 percent of their internal trips to the restaurants induced.

Table 54: Origins of All Trips Entering Restaurants, Afternoon Peak Period

Origin Land Use	All Trips Entering Restaurant (N=2,053)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	0.0	**3.4**	0.000
Retail	**6.9**	**10.3**	0.700
Restaurant	**2.7**	**8.9**	0.303
Residential	**6.2**	**19.9**	0.312
Cinema	**4.8**	**10.3**	0.466
Hotel	**8.9**	**11.6**	0.767
Other	0.0	0.7	0.000
All Internal Origins	**29.5**	**65.1**	0.453
Note: 34.9% of All Trips Entering Restaurants had an External Origin Figures shown in bold had a margin of error less than 10% and were significantly different than zero (α=0.1).			

Of the 1,455 trips exiting a restaurant, 692 trips (47.6 percent) had their destination internal to Legacy Town Center (see Table 55). The most frequent destination land use for internal trips exiting the restaurants was other restaurants, which accounted for 12.6 percent of all exiting trips. Trips exiting the restaurants demonstrated a significant internal interaction with every other land use except for the office and the hotel. The analysis identified 196 induced trips exiting the restaurants, representing 13.5 percent of all trips exiting the restaurants and 28.4 percent of all trips exiting the restaurants with a destination internal to Legacy Town Center. There were induced trips being made from restaurants to every on-site land use except for the cinema. The percentage of all outbound internal trips that were induced ranged from 16.4 percent traveling to the residences to 52.6 percent traveling to the offices. However, only the percentage induced trips exiting the restaurants at Legacy Town Center with a destination of other restaurants or "other" destinations was computed to be significant.

Table 55: Destinations of All Trips Exiting Restaurants, Afternoon Peak Period

Destination Land Use	All Trips Exiting Restaurant (N=1,455)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	1.0	1.9	0.526
Retail	1.9	**8.7**	0.218
Restaurant	**3.8**	**12.6**	0.302
Residential	1.9	**11.6**	0.164
Cinema	0.0	**4.9**	0.000
Hotel	1.0	2.9	0.345
Other	**3.8**	**4.9**	0.776
All Internal Destinations	**13.5**	**47.6**	0.284
Note: 52.4% of All Trips Exiting Restaurants had an External Destination Figures shown in bold had a margin of error less than 10% and were significantly different than zero (α=0.1).			

The significant interaction among the restaurants at Legacy Town Center was most likely due to travel between two different types of restaurants (for example, a sit-down meal followed by coffee or dessert). Similar to the retail shops, the travelers at the restaurants exhibited a significant amount of interaction with every other land use at Legacy Town Center.

Residential Trips

Analysis of the travel survey data indicated that a total of 2,903 trip ends during the afternoon peak period involved the residential units at Legacy Town Center, with 1,516 trips (52.2 percent) entering the residences and 1,387 trips (47.8 percent) exiting the residences. Of the 1,516 trips entering a residence, 1,340 trips (88.4 percent) had their origin internal to Legacy Town Center (see Table 56). The most frequent origin land use for internal trips entering the residences was the restaurants, which accounted for 27.9 percent of all trips entering a residence. None of the internal trip percentages for trips entering the residences were computed to be significant. The analysis identified 528 induced trips entering the residences, representing 34.8 percent of all trips entering the residences and 39.4 percent of all trips entering residences from other locations internal to Legacy Town Center. Significant percentages of trips entering residences originated from the on-site retail shops and other residences. It should be noted that the results shown in Table 56 are based primarily on travelers stating that an on-site residence was their destination during an exit interview at another land use. Therefore, the only way to identify trips that were entering residences from external locations was if a person was interviewed exiting a residence during the afternoon and provided information about their trip from a previous location that was external to Legacy Town Center. Consequently, very few trips entering a residence from an external location were identified in the data set, resulting in a bias towards trips entering a residence that originated internal to the study site. This bias could have been mitigated by administering travel survey interviews with travelers entering residences during the afternoon. However, the management entities of the residential properties at Legacy Town Center were not willing to allow entrance interviews to be administered to travelers entering the residences.

Table 56: Origins of All Trips Entering Residences, Afternoon Peak Period

Origin Land Use	All Trips Entering Residences (N=1,516)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	0.0	7.0	0.000
Retail	**18.6**	25.6	0.727
Restaurant	4.6	27.9	0.165
Residential	**11.6**	25.6	0.453
Cinema	0.0	2.3	0.000
Hotel	N/A	0.0	N/A
Other	N/A	0.0	N/A
All Internal Origins	34.8	**88.4**	0.394
Note: 11.6% of All Trips Entering Residences had an Internal Origin Figures shown in bold had a margin of error less than 10% and were significantly different than zero (α=0.1).			

Of the 1,340 trips exiting the residences, 801 trips (57.8 percent) had their destination internal to Legacy Town Center (see Table 57). The most frequent destination land use for internal trips exiting the residences was also the restaurants (23.6 percent of all exiting trips). The fact that a significant percentage of trips exiting the residences had a destination of an on-site restaurant during the afternoon peak period (3:00 PM to 7:00 PM) was not surprising, considering that an evening meal is generally consumed during this time period. A significant percentage of trips exiting the residences had a destination at every on-site land use except for the cinema and the hotel; 12.2 percent of the trips exiting residences identified their internal destination as "other," which was generally a trip to exercise, walk a pet, or visit the park located inside Legacy Town Center. All non-zero internal trip percentages for trips exiting the residences were significant, except for trips made to the cinema. The analysis identified 281 induced trips exiting the residences, representing 20.3 percent of all trips exiting the residences and 35.1 percent of all trips exiting the residences with destinations internal to Legacy Town Center. Significant percentages of induced trips exiting the residences had destinations of retail shops, restaurants, other residences, and "other" locations.

Table 57: Destinations of All Trips Exiting Residences, Afternoon Peak Period

Destination Land Use	All Trips Exiting Residences (N=1,340)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	0.8	**3.2**	0.250
Retail	**2.5**	**8.1**	0.309
Restaurant	**7.3**	**23.6**	0.309
Residential	**4.0**	**8.9**	0.450
Cinema	N/A	0.0	N/A
Hotel	0.8	1.7	0.471
Other	**4.9**	**12.2**	0.402
All Internal Destinations	**20.3**	**57.8**	0.351
Note: 42.2% of All Trips Exiting Residences had an External Destination Figures shown in bold had a margin of error less than 10% and were significantly different than zero (α=0.1).			

These results were not consistent with what was expected at a residence; it was assumed that there would be little induced activity to the residences, since one would presume that trips to a person's home would be made regardless of where their residence was located. One possible explanation for the intra-residential induced travel was that these travelers were visiting friends, a visit that might not have been made if the friends lived off-site. The significant percentages of induced trips exiting residences suggested that these travelers made extra trips simply because the destinations were conveniently located inside Legacy Town Center.

Cinema Trips

Analysis of the travel survey data indicated that a total of 328 trip ends during the afternoon peak period involved the cinema at Legacy Town Center, with 221 trips (67.4 percent) entering the cinema and 107 trips (32.6 percent) exiting the cinema. Of the 221 trips entering the cinema, 35 trips (15.8 percent) had their origin internal to Legacy Town Center (see Table 58). The only origin land use for internal trips entering the cinema was the restaurants, which accounted for 15.8 percent of all entering trips (significant). The analysis identified no induced trips entering the cinema. The finding that there were no induced trips entering the cinema is not surprising, considering that the cinema at Legacy Town Center showed films that were not shown in mainstream theaters and would most likely not have attracted the average traveler.

Table 58: Origins of All Trips Entering the Cinema, Afternoon Peak Period

Origin Land Use	All Trips Entering the Cinema (N=221)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	N/A	0.0%	N/A
Retail	N/A	0.0	N/A
Restaurant	0.0	**15.8**	0.000
Residential	N/A	0.0	N/A
Cinema	N/A	0.0	N/A
Hotel	N/A	0.0	N/A
Other	N/A	0.0	N/A
All Internal Origins	0.0	**15.8**	0.000
Note: 84.2% of All Trips Entering the Cinema had an External Origin Figures shown in bold had a margin of error less than 10% and were significantly different than zero (α=0.1).			

Of the 107 trips exiting the cinema, 49 trips (45.8 percent) had their destination internal to Legacy Town Center (see Table 59). The most frequent destination land use for internal trips exiting the cinema was the restaurants, which accounted for 29.0 percent of all exiting trips. Other significant internal destinations for trips exiting the cinema included the retail shops and "other" locations. The analysis identified 23 induced trips exiting the cinema, which represented 21.5 percent of all trips exiting the cinema and 46.9 percent of all the trips exiting the cinema with a destination internal to Legacy Town Center. Destinations for induced trips exiting the cinema included 74.7 percent of all internal trips to the retail stores and 48.3 percent of all internal trips to the restaurants (both significant). The significant interaction between the cinema and the on-site restaurants was not surprising, since the land-use combination has a logical interaction (i.e. "dinner and a movie").

Table 59: Destinations of All Trips Exiting the Cinema, Afternoon Peak Period

Destination Land Use	All Trips Exiting the Cinema (N=107)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	N/A	0.0%	N/A
Retail	**5.6**	**7.5**	0.747
Restaurant	**14.0**	**29.0**	0.483
Residential	0.0	1.9	0.000
Cinema	N/A	0.0	N/A
Hotel	0.0	1.9	0.000
Other	1.9	**5.6**	0.339
All Internal Destinations	**21.5**	**45.8**	0.469
Note: 54.2% of All Trips Exiting the Cinema had an External Destination Figures shown in bold had a margin of error less than 10% and were significantly different than zero (α=0.1).			

Hotel Trips

Analysis of the travel survey data indicated that a total of 619 trip ends during the afternoon peak period involved the hotel at Legacy Town Center, with 318 trips (51.4 percent) entering and the hotel 301 trips (48.6 percent) exiting the hotel. Of the 318 trips entering the hotel, 121 trips (38.1 percent) had their origin internal to Legacy Town Center (see Table 60). The most frequent origin land use for internal trips entering the hotel was the retail stores, which accounted for 13.8 percent of all entering trips. However, none of the internal trip percentages for trips entering the hotel from individual land uses were computed to be significant. The analysis identified 44 induced trips entering the hotel, representing 13.8 percent of all trips entering the hotel and 36.2 percent of all trips entering the hotel from other locations in Legacy Town Center. None of the induced trip percentages entering the hotel were computed to be significant.

Table 60: Origins of All Trips Entering the Hotel, Afternoon Peak Period

Origin Land Use	All Trips Entering the Hotel (N=318)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	0.0	3.5	0.000
Retail	6.9	13.8	0.500
Restaurant	3.5	10.4	0.337
Residential	3.5	6.9	0.507
Cinema	0.0	3.5	0.000
Hotel	N/A	0.0	N/A
Other	N/A	0.0	N/A
All Internal Origins	13.8	38.1	0.362
Note: 61.9% of All Trips Entering the Hotel had an External Origin Figures shown in bold had a margin of error less than 10% and were significantly different than zero (α=0.1).			

Of the 301 trips exiting the hotel, 124 trips (41.2 percent) had their destination internal to Legacy Town Center (see Table 61). The most frequent destination land use for internal trips exiting the hotel was the restaurants, which accounted for 33.2 percent of all exiting trips. The significant percentage of trips exiting the hotel traveling to a restaurant in Legacy Town Center was most likely indicative of hotel guests seeking a restaurant for an evening meal. The analysis identified 101 induced trips exiting the hotel, representing 33.6 percent of all trips exiting the hotel and 81.6 percent of all trips exiting the hotel with a destination internal to Legacy Town Center; this included all of the internal trips to retail and 77.1 percent of the internal trips to restaurants. These findings suggest that very few internal trips exiting the hotel during the afternoon peak period were actually "captured" internally; rather, they were additional trips made to internal destinations.

Table 61: Destinations of All Trips Exiting the Hotel, Afternoon Peak Period

Destination Land Use	All Trips Exiting the Hotel (N=301)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	N/A	0.0	N/A
Retail	6.0	6.0	1.000
Restaurant	**25.6**	**33.2**	0.771
Residential	N/A	0.0	N/A
Cinema	N/A	0.0	N/A
Hotel	N/A	0.0	N/A
Other	2.0	2.0	1.000
All Internal Destinations	33.6	**41.2**	0.816
Note: 58.8% of All Trips Exiting the Hotel had an External Destination Figures shown in bold had a margin of error less than 10% and were significantly different than zero (α=0.1).			

Automobile Trips

Analysis of the travel survey data indicated that a total of 5,626 trips during the afternoon peak period at Legacy Town Center were made in an automobile, either as a driver or a passenger, with 2,696 trips (47.9 percent) entering buildings at Legacy Town Center and 2,930 trips (52.1 percent) exiting buildings at Legacy Town Center. Collectively, automobile drivers and automobile passengers represented 57.9 percent of the afternoon peak period trips. Automobile drivers accounted for 5,215 of these trips (92.7 percent) while passengers accounted for the remaining 411 trips (7.3 percent). The percentage of trips entering buildings at Legacy Town Center made in an automobile that were induced and internal, by destination land use, is shown in Table 62. For trips (made in an automobile) entering buildings at Legacy Town Center, 1,221 trips (45.3 percent) had an origin that was located internal to Legacy Town Center. The analysis identified 390 induced trips made by automobile, representing 14.5 percent of all trips (made in an automobile) entering buildings at Legacy Town Center. These induced trips made in an automobile represented 32.0 percent of all trips (made in an automobile) entering buildings at Legacy Town Center with an origin somewhere internal to the site.

Table 62: Destinations of Entering Trips (via Automobile), Afternoon Peak Period

Destination Land Use	All Entering Trips (via Automobile, N=2,696)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	0.0	66.7	0.000
Retail	2.4	31.0	0.077
Restaurant	14.8	38.2	0.387
Residential	28.5	80.9	0.352
Cinema	N/A	0.0	N/A
Hotel	0.0	15.4	0.000
All Internal Destinations	14.5	45.3	0.320

The percentage of trips exiting buildings at Legacy Town Center made in an automobile that were induced and internal, by origin land use, is shown in Table 63. For trips (made in an automobile) exiting buildings at Legacy Town Center, 657 trips (22.8 percent) had a destination located inside Legacy Town Center. The analysis identified 184 induced trips made by automobile, representing 6.3 percent of all trips (made in an automobile) exiting buildings at Legacy Town Center and 27.6 percent of all trips (made in an automobile) exiting buildings at Legacy Town Center with a destination located inside Legacy Town Center.

Table 63: Origins of Exiting Trips (via Automobile), Afternoon Peak Period

Origin Land Use	All Exiting Trips (via Automobile, N=2,930)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	0.0	9.3	0.000
Retail	17.1	31.7	0.539
Restaurant	1.5	22.4	0.067
Residential	6.2	27.3	0.227
Cinema	0.0	9.4	0.000
Hotel	20.8	23.8	0.874
All Internal Origins	6.3	22.8	0.276

Automobile trips entering and exiting the office, entering the hotel, and exiting the cinema contained no induced component in their internal trips; at these locations, automobile trips internal to Legacy Town Center were replacing automobile trips external to the site. At the other locations, some of the automobile trips internal to Legacy Town Center were new trips that were not “captured” from the external street network.

Walking Trips

Analysis of the travel survey data indicated that a total of 3,965 trips during the afternoon peak period at Legacy Town Center were made on foot, with 2,249 trips (56.7 percent) entering buildings at Legacy Town Center and 1,716 trips (43.3 percent) exiting buildings at Legacy Town Center. Walking trips represented 40.8 percent of all person trips during the afternoon peak period. For walking trips entering buildings at Legacy Town Center, 2,156 trips (95.9 percent) had an origin that was located inside Legacy Town Center (see Table 64). The analysis identified 1,001 induced trips made on foot entering buildings at Legacy Town Center, representing 44.5 percent of all trips made on foot entering buildings at Legacy Town Center and 46.4 percent of all trips made on foot entering buildings at Legacy Town Center with an origin internal to the site. The percentage of walking trips that were induced and internal, by direction and land use, is shown in Table 65.

Table 64: Destinations of Entering Trips (via Walking), Afternoon Peak Period

Destination Land Use	All Entering Trips (via Walking, N=2,249)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	33.8	100.0	0.338
Retail	52.9	88.2	0.600
Restaurant	46.6	98.4	0.474
Residential	40.9	95.5	0.428
Cinema	0.0	100.0	0.000
Hotel	44.4	100.0	0.444
All Internal Destinations	44.5	95.9	0.464

As with the morning peak period, it was not surprising that a vast majority of all trips taken on foot had both trip ends internal to the site. The lowest internal capture rate for trips made on foot was inbound trips to the retail stores, with 88.2 percent of the walking trip ends originating internally.

Table 65: Origins of Exiting Trips (via Walking), Afternoon Peak Period

Origin Land Use	All Exiting Trips (via Walking, N=1,716)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	0.0	100.0	0.000
Retail	63.4	100.0	0.634
Restaurant	35.8	94.5	0.379
Residential	36.9	93.0	0.397
Cinema	53.5	100.0	0.535
Hotel	68.8	92.2	0.746
All Internal Origins	44.4	95.4	0.465

Concerning the induced nature of these walking trips, the percentage of induced trips was nearly equal in both directions (44.5 percent inbound, 44.4 percent outbound). The percentage of internal trips that were induced was also approximately equal in both directions (46.4 percent inbound, 46.5 percent outbound). No induced trip ends made on foot were recorded exiting the offices or entering the cinema. For the other land use-travel direction combinations, between 33.8 percent (inbound office trips) and 74.6 percent (outbound hotel trips) of the walking trips internal to Legacy Town Center were induced and not replacing external trips.

Traveler Characteristics

The afternoon peak period induced and internal trip characteristics for all trips at Legacy Town Center, by mode of access to the site, are shown in Table 66 for all trips entering buildings at Legacy Town Center and Table 67 for all trips exiting buildings at Legacy Town Center. For all access modes, at least half of the trips entering buildings at Legacy Town Center had their origin somewhere in the site. All of the trips entering buildings at Legacy Town Center made by travelers accessing the site on foot originated internally.

Table 66: Characteristics of Entering Trips by Mode of Access, Afternoon Peak Period

Access Mode	All Entering Trips (N=5,052)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Auto Driver	23.7	58.1	0.408
Auto Passenger	26.2	50.9	0.515
Taxi	42.1	50.8	0.829
Transit	56.0	56.0	1.000
Walk	100.0	100.0	1.000
None (On-Site Resident)	32.5	89.9	0.362
None (On-Site Hotel Guest)	43.4	73.0	0.595

For all trips exiting buildings at Legacy Town Center, travelers that accessed the site as automobile passengers had the lowest percentage of destinations internal to the site. All of the trips exiting buildings at Legacy Town Center made by travelers that accessed the site using transit had their destinations internal to the site. With respect to induced trips, it was found that all of the internal trips made by travelers accessing the site on transit or on foot were induced. Also, travelers accessing the site in a taxi were found to have most of their internal trips induced. On-site hotel guests were found to have about 60 percent of their internal trips induced. The travel patterns of on-site residents are discussed in greater detail below.

Table 67: Characteristics of Exiting Trips by Mode of Access, Afternoon Peak Period

Access Mode	All Exiting Trips (N=4,667)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Auto Driver	16.0	41.4	0.386
Auto Passenger	17.5	36.9	0.474
Taxi	53.6	57.1	0.939
Transit	100.0	100.0	1.000
Walk	68.6	68.6	1.000
None (On-Site Resident)	26.0	67.2	0.387
None (On-Site Hotel Guest)	39.0	68.8	0.567

The afternoon peak period induced and internal trip percentages, classified by the traveler's ability to access an automobile for their trip, are shown in Table 68 for trips entering buildings at Legacy Town Center and Table 69 for trips exiting buildings at Legacy Town Center. In a similar manner as the morning peak period analysis, the percentages shown were derived from trips made by travelers accessing the site by all modes except for automobile driver

and on-site residents. For trips entering buildings at Legacy Town Center, the percentage of all trips originating on-site for those travelers with an automobile available was nearly equal to the internal percentage for those travelers without an automobile available. However, for trips in the reverse direction, travelers with no access to an automobile remained internal to the site at a rate nearly 30 percentage points higher than those with access to an automobile. For travelers with access to an automobile, 27.3 percent of the trips entering buildings at Legacy Town Center and 21.4 percent of the trips exiting Legacy Town Center were induced.

Table 68: Characteristics of Entering Trips by Auto Availability, Afternoon Peak Period

Auto Availability	Entering Trips (Non-Auto Driver, Non-Resident; N=612)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Auto Available	27.3	59.9	0.456
No Auto Available	39.9	60.1	0.664

Travelers without access to an automobile for their trip made induced trips at a higher rate (39.9 percent of entering trips, 43.9 percent of exiting trips) than travelers with access to an automobile for their trip. As a percentage of the internal trips, travelers lacking access to an automobile had approximately two-thirds of their internal trips induced, higher than those with automobile access.

Table 69: Characteristics of Exiting Trips by Auto Availability, Afternoon Peak Period

Auto Availability	Exiting Trips (Non-Auto Driver, Non-Resident; N=409)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Auto Available	21.4	38.6	0.554
No Auto Available	43.9	64.2	0.684

The afternoon peak period induced and internal travel characteristics for a very important segment of travelers, residents of Legacy Town Center's on-site apartments and townhomes, are shown in Table 70 for all trips by on-site residents entering buildings at Legacy Town Center and Table 71 for all trips by residents exiting buildings at Legacy Town Center. On-site residents accounted for 28.1 percent of all afternoon peak period trips and approximately one-third of the induced and internal trips. Travel by on-site residents was internal to Legacy

Town Center at a rate of 89.9 percent (all entering trips) and 67.2 percent (all exiting trips). The two on-site land uses where no on-site residents were involved with trips in either direction were the cinema and the hotel.

Table 70: Characteristics of Entering Trips by On-Site Residents, Afternoon Peak Period

Destination Land Use	All Entering Trips (Residents; N=1,437)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	25.6	100.0	0.256
Retail	33.3	89.9	0.370
Restaurant	37.2	92.6	0.402
Residential	30.8	88.4	0.348
Cinema	N/A	N/A	N/A
Hotel	N/A	N/A	N/A
All Internal Destinations	32.5	89.9	0.362

All trips made by on-site residents involving the offices and trips exiting retail shops remained internal to the study site. Concerning induced trips made by on-site residents, about three out of every eight internal trips made by an on-site resident were induced. However, no more than half of the internal trips made by on-site residents from any land use were induced, indicating that at least some of the internal trips made by on-site residents were replacing trips external to Legacy Town Center.

Table 71: Characteristics of Exiting Trips by On-Site Residents, Afternoon Peak Period

Origin Land Use	All Exiting Trips (Residents; N=1,297)		
	Induced Trips (%)	Internal Trips (%)	Ratio
Office	0.0	100.0	0.000
Retail	50.0	100.0	0.500
Restaurant	23.0	77.0	0.298
Residential	24.5	62.2	0.394
Cinema	N/A	N/A	N/A
Hotel	N/A	N/A	N/A
All Internal Origins	26.0	67.2	0.387

DISCUSSION OF FINDINGS

Having presented the results of the travel survey analysis for each study period, the next task was to identify and discuss the contribution of these findings towards accomplishing the stated research objectives. The specific objectives of this investigation were to determine the percentage of induced trips at Legacy Town Center, identify potential factors that influenced the nature and extent of induced travel, and evaluate the impacts of induced travel on the site planning process for proposed mixed-use developments. A discussion of the analysis findings as they relate to each research objective is provided in the paragraphs below. First, the relevant induced trip percentages identified at Legacy Town Center are summarized. Next, the potential factors that influenced the induced travel percentages identified in the analysis are discussed in greater detail. The discussion concludes with an overview of current site planning techniques used to analyze the traffic impacts of proposed mixed-use developments and how the results of this investigation may be incorporated into these processes.

Induced Travel

The first and primary objective of this investigation was to determine if travelers responded to potential travel cost savings in the mixed-use environment by making additional "induced" trips. Analysis of the travel survey data clearly indicated that there was induced travel occurring at Legacy Town Center during the study periods. During the morning peak period (6:00 AM to 10:00 AM), it was found that about four percent of the person-trips at Legacy Town Center were induced (4.8 percent of all entering trips, 3.4 percent of all exiting trips). Induced trips during the morning peak period represented about one-eighth of all the internal trips at the site. A majority of these induced trips were made on foot by residents of the on-site apartments and townhomes at Legacy Town Center. During the afternoon peak period (3:00 PM to 7:00 PM), it was found that 24.3 percent of the person-trips at Legacy Town Center were induced (27.9 percent of all entering trips, 49.5 percent of all exiting trips). These induced trips represented about 40 percent of all the internal trips at the site during the afternoon peak period. A majority of these induced trips were made on foot by travelers accessing Legacy Town Center as an automobile driver. The practical implication of these findings is that during both study periods, a percentage of trips that had both trip ends inside Legacy Town Center were not "captured" internally, but represented new trip generation, most likely as a result of travel cost savings in the mixed-use environment.

Influences of Induced Travel

The second objective of this investigation was to identify the various factors that may have exerted an influence on the induced travel characteristics of Legacy Town Center. At the outset of this Chapter, some thoughts on the potential influences of induced travel were provided. Based on the analysis of the travel survey data, several potential influencing factors were identified, including the time of day, trip end characteristics, travel mode, and traveler characteristics. Each factor is discussed in greater detail below.

In decomposing the data set for analysis by time period, it was acknowledged that the induced travel profile for the two study periods was sufficiently different to justify the separation. As expected, the afternoon peak period had a higher percentage of induced trips than the morning peak period (24.3 percent in the afternoon against 4.0 percent in the morning). The finding that the induced travel percentage for the afternoon was higher than the induced travel percentage for the morning indicates that the marginal cost of making additional trips in the morning was higher than what travelers were willing to pay during that time period. In other words, travelers in the morning had other activities that they needed (or wanted) to do besides make additional trips at Legacy Town Center.

One factor expected to exert a major influence on the induced travel characteristics of the site was the land use at each end of the induced trip. In the morning peak period, most of the travel activity involved trips exiting residential units and trips entering offices. Trips exiting the residences during the morning peak period with the destination of an on-site restaurant were induced at a rate of 1.5 percent, representing the only land-use pair during the morning peak period with a significant percentage of induced activity. By contrast, the induced travel activity during the afternoon peak period was primarily located at the three land uses that composed the mixed commercial core of Legacy Town Center, the retail shops, restaurants, and the cinema. The influence of land use on induced travel at Legacy Town Center is summarized as follows:

- **Office:** Very little induced travel activity was identified at the offices. While there was a significant amount of internal travel activity at the offices during both study periods (entering during the morning, exiting in the afternoon), very few trips at the office were induced. This finding suggests that internal trips made by office travelers were substitutes for trips that would have been made externally if the other end of the trip was

not located inside Legacy Town Center, supporting the prevailing mindset that mixing land uses "captures" trips within a development.

- **Retail:** The influence of the retail component of Legacy Town Center on the induced travel profile varied by study period. In the morning, no significant induced travel percentages were identified between the retail shops and the other on-site land uses. However, during the afternoon, a significant percentage of induced travel occurred between the retail shops and other retail shops, restaurants, and the residences. These interactions accounted for at least half of the internal trips between these on-site land uses, implying that some of the retail trips during the afternoon represented new trips that were not replacements for travel external to the site.
- **Restaurant:** The restaurants at Legacy Town Center influenced induced travel in a similar manner as the retail stores. In the morning, none of the trips entering or exiting the restaurants had a significant induced percentage. During the afternoon, however, nearly 30 percent of all trips entering the on-site restaurants were induced from another on-site origin, accounting for about 45 percent of the internal trips entering restaurants. As with the retail shops, not all of the internal trips entering the restaurants were "captured" from external locations.
- **Residential:** During both study periods, a significant percentage of trips exiting the residences remained internal to Legacy Town Center. In the morning, a significant percentage of trips from the residences to on-site restaurants were induced. In the afternoon, a significant share of trips from the residences to the retail shops and restaurants were induced. Travelers exiting the residences during this time were also induced to make trips to "other" locations, such as the on-site park, walking pets, or exercising. In total, about 35 percent of the internal trips exiting residences in the afternoon were induced trips, and not replacing trips to external locations. A possible bias in the survey design was identified that influenced the findings for travelers entering the residences during the afternoon peak period.
- **Cinema:** The only significant amount of induced travel that occurred at the cinema was trips exiting the cinema traveling to on-site retail and restaurant, totaling 21.5 percent of all trips exiting the cinema and 46.9 percent of all trips exiting the cinema with internal destinations. Trips entering the cinema exhibited very little interaction with the other

land uses at the site, except for restaurant. No induced trips were identified among the trips entering the cinema from internal origins, most likely a result of the type of films shown at the cinema.

- **Hotel:** Travelers at the on-site hotel were found to interact with the on-site restaurants, but had a limited amount of interaction with the other land uses at the site. In the morning, internal trips from the hotel to the restaurants did not contain an induced component, implying that these internal trips replaced trips off-site. In the afternoon, however, about 77 percent of the internal trips from the hotel to on-site restaurants were induced and not substitutes for off-site travel.

In summary, the only land use where most travelers were found to be replacing external trips with internal trips was the office. A portion of the internal trips at the remaining five land uses at Legacy Town Center were induced. These trips were not replacing external travel, but generating new trips within the site.

One of the primary travel cost-saving elements in the mixed-use environment is the ability to walk for some trips within the development. Thus, it was assumed that many of the trips made as a result of the travel cost savings (that is, induced trips) would be made on foot. In the travel survey analysis, the travel characteristics of trips made in an automobile (as a driver or as a passenger) and trips made on foot were reported. For both study periods, trips made on foot had higher internal and induced trip percentages than trips made in an automobile. In the morning, nearly all of the internal trips made in an automobile, but only three-quarters of the internal trips made on foot, were found to be replacements for travel external to the site. In the afternoon, about 30 percent of the automobile trips and 45 percent of the walking trips internal to Legacy Town Center were induced and not replacing trips external to the site. Given the accessibility concerns at Legacy Town Center (specifically, limited off-site trip generators within a reasonable walking distance), it could be safely assumed that the walking trips within the site that were found to be replacing external trips (75 percent in the morning, 55 percent in the afternoon) would most likely have been made in an automobile if the off-site travel was required. Thus, it could be said that the pedestrian-friendly mixed-use environment of Legacy Town Center was able to remove at least some vehicular traffic from the external street network.

Although no formal statistical analyses were conducted for the mode of travel analysis, its findings can be used to perform a “back of the envelope” calculation of vehicle-miles traveled

(VMT), which is a measure of great importance to regional planning efforts. The VMT contribution of Legacy Town Center consisted of external trips (most of which were made in an automobile) and internal trips (some percentage of which were made in an automobile, and included trips that replaced external trips and trips that were induced). If these same trips had occurred at a conventional, single-land use development, the VMT contribution would have consisted of the external trips and all trips that were internal to Legacy Town Center that were found to be replacing external trips. Assuming that, on the average, vehicle-trips inside Legacy Town Center were one-quarter mile in length and trips outside Legacy Town Center were all vehicle-trips five miles in length, the convenience of multiple land uses in the pedestrian-friendly environment of Legacy Town Center resulted in a VMT savings of 21.9 percent during the morning and 26.1 percent in the afternoon, as shown in Table 72.

Table 72: VMT Comparison: Legacy Town Center and a Conventional Development

Time Period	VMT Existing (Legacy Town Center)	VMT Alternate (Conventional Development)	Percent Difference
Morning Peak Period	7,505.12	9,605.43	21.9
Afternoon Peak Period	8,809.95	11,918.32	26.1

For a VMT reduction to occur, the assumed length of all external vehicle-trips could be as little as 0.27 miles in the morning peak period and 0.44 miles in the afternoon peak period. In the morning peak period, the minimum assumed external vehicle-trip length for a VMT reduction was nearly equal to the assumed length of internal vehicle-trips because there were very few induced vehicle-trips during this time. In the afternoon peak period, the minimum assumed external vehicle-trip length for a VMT reduction was less than one-half mile primarily because many of the internal trips (replacements or induced) during this time were made on foot, which reduced the number of vehicle-trips (thus reducing the VMT). Based on these calculations, it is evident that VMT savings are realized at the Legacy Town Center mixed-use development in spite of the VMT contribution of induced vehicle-trips.

Traveler characteristics were also investigated to determine any potential influences on induced travel. Specifically, the induced and internal travel characteristics of all travelers by mode of access to Legacy Town Center, the traveler's ability to access an automobile for his or her trip, and the on-site residents were examined. In the morning peak period, travelers that

accessed Legacy Town Center as a transit rider or pedestrian appeared to have a higher percentage of internal travel than automobile users, but a lower percentage of induced travel, suggesting that the internal trips made by these travelers were replacing off-site trips. In complete contrast, the afternoon peak period analysis indicated that nearly all of the internal trips made by travelers accessing the site as a taxi passenger, transit rider, or pedestrian were induced, suggesting that these trips were not substitutes for external travel. It should be noted these findings were based on the travel survey responses of travelers that accessed the site as a transit rider or pedestrian, which represented a small component of the entire travel at the site due to the limited accessibility of Legacy Town Center. A similar mixed outcome between the two study periods was also noted when analyzing the impact of automobile availability on the induced trip percentage. In the morning, travelers without an automobile available made no induced trips; in the afternoon, these travelers had a higher percentage of induced trips than those with access to an automobile. Approximately 30 percent of on-site residents' trips remained internal to Legacy Town Center with about 30 percent of those internal trips being induced. This finding indicated that some trips made by on-site residents were new trips and not "captured" from the external street network.

With respect to traveler characteristics and their impact on induced travel, it should also be noted that there were no opportunities in the travel survey to evaluate the role of travelers self-selecting into the mixed-use environment. For example, transit riders may have chosen to travel to Legacy Town Center instead of another destination because they wished to take full advantage of the lower travel costs associated with multiple trip origins and destinations in a pedestrian-friendly environment. Occupants of the on-site apartments and townhomes may have selected Legacy Town Center as their place of residence because they could easily access their workplace or the enjoyed the convenience of the variety of retail shops and restaurants within walking distance of their residence.

Site Planning Applications

The final objective of this investigation was to examine ways that the analysis results could be incorporated into the mixed-use development site planning process. In the site planning process (also called a traffic impact analysis), the planner estimates the number of trips for a proposed development (using the *Trip Generation* report (ITE 2003) or another approved methodology) and applies this estimate to the remaining steps of what is essentially a "four-step"

planning model for a microscopic (site) level of detail. The results of this process are used to identify infrastructure and traffic control needs in the transportation network adjacent to the proposed site. Accurately estimating trip generation as part of the site planning process is important, since underestimation may lead to a congested transportation network around the site and overestimation may result in unnecessary infrastructure and traffic control investments. Estimating trip generation as part of a traffic impact analysis for a single land-use site is a fairly straightforward process performed by entry-level planners and engineers on a daily basis. For proposed developments with multiple on-site land uses, the process is similar except that some allowances may be included for the potential capture of trips within to the site. One procedure used to account for internal travel, an ITE recommended practice, involves estimating the number of trips for each component land use as a single-use, free-standing site, then applying internal trip capture percentages to the entering and exiting trip estimates for each land use (ITE 2004). This process was discussed in greater detail in Chapter II. The availability of local data on internal trip percentages may compel some reviewing agencies to establish their own internal capture rates to be used in the development of traffic impact studies; other agencies may use a "rule of thumb" or an across-the-board reduction (i.e. a 5% or 10% reduction of the entire site trip generation estimate). Other reviewing agencies, wishing to lean on the side of a conservative trip generation estimate for new developments, may not allow any reduction in trips for mixed-use development sites.

Regardless of the approach that is taken by any particular reviewing agency, the basic process for estimating trips at mixed-use developments remains essentially the same: estimate trip generation for each component of the site from single-use site data, then apply an adjustment (if permitted) at some level of detail (productions/attractions for each land use, or a reduction for the entire site) during the process. The premise of this adjustment (no matter how it is applied) is that trips between two on-site land uses are being "captured" from the external street network, that is, replacing trips between the proposed site and other locations in the community. Based on the analysis and findings in this Chapter, it is evident that at least some internal trips at mixed-use developments are not replacing external trips, but rather are additional trips, induced by the travel cost-saving elements of the mixed-use environment. Therefore, a preliminary examination of approaches to incorporating induced travel into the various techniques used by planners to evaluate the traffic impact of proposed mixed-use developments is necessary.

The selection of appropriate numerical values to be applied to trip generation estimates to account for induced trips is based on the ratio of the percentage of induced trips to the percentage of internal trips for the appropriate stratification of interest. This ratio, which was reported for the various stratifications of interest throughout this Chapter, represents the percentage of internal trips that were induced, and not captured from the external street network. Using this ratio instead of another measure also allows the results to be applied to any of the approaches taken by reviewing agencies described above independent of the actual numerical values that are assumed for the internal trip percentages that are permitted by the reviewing agencies. It is recommended that analysts wishing to incorporate the results of this investigation into their traffic impact analyses do so by applying this ratio as a percent reduction in the number of internal trips estimated for the level of detail in the process that is permitted by the reviewing agency with jurisdiction over the proposed mixed-use development project. With this approach, ratios of induced to internal trips that were close to zero will have more internal trips "captured" and the full trip reduction allowed by the reviewing agency for internal trips will be applied. By contrast, those stratifications where the ratio was closer to one will have very few trips reduced, since these trips were not "captured" internally from the external street network.

For example, this investigation found that approximately 10 percent of all internal trips in the morning and approximately 40 percent of all internal trips in the afternoon were induced. If a reviewing agency allows a rule-of-thumb or across-the-board reduction in the number of trips estimated at a proposed mixed-use development, then the internal trips estimated through that process could be reduced by 10 percent for morning analyses and 40 percent for afternoon analyses. For approaches that estimate internal trips on a greater level of detail, such as the *Trip Generation Handbook* methodology (ITE 2004), the analyst is advised to consult the appropriate table in this Chapter to determine what percentage of internal trips were induced and apply this number as a percentage reduction in the number of internal trips estimated for the level of detail being examined. It should be noted that the results of this study were reported as person-trips; if vehicle-trips are used in the analysis, an appropriate conversion is required[5]. The analyst is advised to use caution when applying the results of this investigation that were found to not be statistically significant and is reminded that this research only studied one mixed-use

[5] The vehicle occupancy (persons per vehicle) is used to convert vehicle-trips to person-trips. The observed vehicle occupancies at Legacy Town Center can be found in Table 11 for the morning peak period/peak hour and Table 12 for the afternoon peak period/peak hour.

development site, Legacy Town Center, with the characteristics discussed in Chapter III. While Legacy Town Center had several characteristics that emulated current mixed-use development design trends, caution is advised when applying these results to traffic studies for proposed mixed-use developments with characteristics that deviate substantially from those of Legacy Town Center. Also, it should be noted that the process described in this paragraph should be independent of other reductions for mixed-use developments that may be allowed by a reviewing agency, such as reductions for pass-by trips or to account for transit service at a proposed site. Even if the results of this investigation are not directly applied to the site planning process, the findings clearly indicate that the planner should consider the potential for induced travel as a result of travel cost savings in the mixed-use environment when conducting traffic impact studies for proposed mixed-use developments.

CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

The model of personal travel as a consumer good provides engineers, planners, and economists with powerful tools to evaluate the impact of supply changes in the transportation system on the quantity of travel demanded. In this model, a decrease in the costs of travel will shift the travel supply curve, resulting in an increase in the quantity of travel demanded. This new quantity consists of two distinct groups: travelers that were in the system prior to the cost decrease, and travelers who were previously unwilling to pay for travel, but are now willing to as a result of the decrease in travel costs (Cervero 2003). The latter of these two groups is generally considered to be the "induced" component of the travel demand.

In this investigation, these concepts were used to examine the potential for induced travel at mixed land-use developments. Specifically, it was proposed that certain elements of the mixed-use environment caused the curve defining the relationship between the quantity of travel supplied and the cost of travel to shift to the right, supplying more travel at a given cost level than a single-use, free-standing development. Proponents claim that mixed-use developments will reduce traffic by mixing a variety of trip origins and destinations in the same development (allowing travelers to accomplish multiple trip purposes at the same site) and providing a pedestrian-friendly environment (allowing travelers to walk for these trips instead of driving). In urban areas that are struggling with traffic congestion and air quality conformance, planners, policy makers, and politicians are quick to embrace anything that has the potential to reduce the regional vehicle-miles traveled and solve the aforementioned issues, including adopting land-use policies that encourage high-density, pedestrian-friendly mixed-use development.

However, the very elements of the mixed-use environment that are touted in the name of solving urban traffic ills may also increase certain trips. Consider the idea that travelers in the mixed-use environment experience a savings in their cost of travel because of the ability to remain internal to the site for some trips (eliminating the cost of off-site travel) and the ability to walk for those trips (which generally costs less than driving for short distances). It could be argued, then, that instead of mixed-use developments reducing travel, their characteristics simply shift the supply curve to the right (since more travel can be supplied at a mixed-use development for the cost, as compared to a single-use, free-standing development), thereby increasing the total

amount of travel generated by the site. The idea that mixed-land use developments with pedestrian-friendly characteristics could actually generate more traffic instead of less was first proposed by Crane (1996), who presented an economics-based framework in support of the argument that the traffic benefits of these developments may be overstated.

If all the additional travel at mixed-use developments remains internal to the site (given the nature of the travel cost savings, this is a reasonable assumption), it would appear that the impacts of induced travel at mixed-use developments are minimal, due to the fact that these extra trips never enter the external transportation network. While the induced trips do not impact the external transportation system, the more pressing issue is the way they are accounted for in the trip generation estimating process. Analysis techniques used to evaluate the traffic impacts of proposed mixed-use development sites, such as the practice recommended by ITE (2004), assume that all travel between two on-site land uses at a mixed-use development is replacing or "capturing" travel between the proposed site and external locations. However, internal travel between two on-site land uses at the mixed-use development site is comprised of both existing travelers and new "induced" travelers. Thus, there was a theoretical basis to explore the possibility that some internal trips are "induced" and not being "captured" from the external transportation network.

The objective of this research was to conduct a survey of travelers at a mixed-use development site, specifically asking the traveler about the induced nature of their trip, to determine the extent of induced travel at the study site. The mixed-use development site that was studied in this investigation was named Legacy Town Center, a suburban infill mixed-use development located in Plano, Texas. The 75-acre site contained 310,764 occupied square feet of office, 196,264 occupied square feet of retail, 69,318 occupied square feet of restaurants, 1,360 occupied residential units, a five-screen cinema, and a 400-room conference hotel. In addition to mixing land uses, design elements were employed at the site to provide a pedestrian-friendly internal street network. The diverse, interactive land use mix, grid-style street layout, pedestrian-oriented street design, and the use of parks and open space to develop a sense of place and community were all attributes of Legacy Town Center that made it an ideal study site for this investigation. The only drawback of Legacy Town Center as a study site was a general inability to access the site by any mode other than an automobile, due to infrequent bus transit service and the lack of available trip generators within walking distance.

The data collection elements of this investigation included a travel survey, as well as counts of the person-trips entering and exiting buildings on the site and a multimodal site cordon count. The travel survey was designed as an interview, administered by temporary labor employees to travelers as they exited certain buildings at the study site. The interview gathered information about the origin and destination of two trips made by the respondent, as well as whether the trip made at the time of the interview was induced or not. A trip was determined to be induced if the respondent was not willing to travel outside of Legacy Town Center to reach their destination. A total of 846 travel survey interviews were administered to travelers at Legacy Town Center during the morning peak period (6:00 AM to 10:00 AM) and the afternoon peak period (3:00 PM to 7:00 PM) during four weekdays in late May 2007. A total of 1,288 trips were obtained from these travel surveys for analysis. Since the trips obtained from the travel surveys represented a sample of all trip activity at Legacy Town Center, the survey results were weighted to reflect sampling rates and unsurveyed areas of the site.

RELEVANT FINDINGS

The most relevant finding of this investigation was that during both study periods, there was a share of the internal trips at Legacy Town Center that were induced, which meant that some of the internal trips were not "capturing" external trips, but represented additional travel within the site. In the morning, four percent of all trips were induced; in the afternoon, about one-quarter of all trips were induced. A majority of the induced trips during each study period were made on foot, a finding that was expected given the nature of the travel cost savings in the mixed-use environment. As a percentage of all the internal trips at Legacy Town Center, induced trips accounted for about one out of every eight internal trips during the morning study period and about four out of every ten internal trips during the afternoon study period. The implication of these findings is that during both study periods, not all of the internal trips at Legacy Town Center were "captured" from the external street system; some were new trips generated as a result of travel cost savings realized in the mixed-use environment. In terms of the land-use influences on induced travel, the only land use where no significant percentages of trips were induced was the office, where all internal trips were found to be replacing trips external to the site. In addition to mixing land uses, the ability to walk for trips internal to mixed-use developments instead of drive presents another opportunity for travel cost savings in that environment. Examining the mode of travel for induced trips found that most automobile

trips were replacements for off-site travel while most trips made on foot were induced. Another significant finding was that the walking trips that were replacing trips external to the site (75 percent of walking trips in the morning, 55 percent in the afternoon) were most likely replacing automobile trips, since there were no off-site trip generators within a reasonable walking distance from the site. This finding is extremely relevant as it supports the claim that walking trips at mixed-use sites are replacing driving trips on the external street network. It was also demonstrated that, even though some induced travel took place in an automobile, the Legacy Town Center mixed-use development could, theoretically, contribute to a reduction in overall VMT on the order of 21.9 percent in the morning and 26.1 percent in the afternoon (assuming an internal vehicle-trip length of one-quarter mile and an external vehicle-trip length of five miles). For a VMT reduction to be realized, the assumed length of all external vehicle-trips at Legacy Town Center could be as little as 0.27 miles in the morning peak period and 0.44 miles in the afternoon peak period.

RECOMMENDATIONS

Based on this investigation of traveler behavior at the Legacy Town Center mixed-use development, it is evident that at least some of the internal trips at mixed-use developments are not "captured" from the external street network, but represent additional trips, induced by the travel cost-saving opportunities in the mixed-use environment. It should be emphasized that the existence of induced travel in the mixed-use environment is not necessarily a bad thing; after all, what's wrong with building places that provide a vibrant pedestrian atmosphere and the opportunity for travelers to get out of their cars? Induced travel certainly benefits the developers and tenants, who appreciate the extra traffic and revenue potential. If properly designed and implemented, mixed-use developments have the potential to create positive change in many important aspects of modern life.

As a result of the findings of this investigation, there are three basic recommendations. First, in their quest to find the answer to urban traffic congestion and air quality woes, planners, policy makers, and elected officials should include policies that encourage pedestrian-friendly, mixed-land use developments in their toolbox of possible solutions, with the caveat that the transportation benefits of this style of development may not be completely as advertised. Second, practicing engineers and planners that are tasked with conducting a traffic impact analysis for a proposed mixed-use development project are strongly encouraged to consider the

results of this investigation, in tandem with other studies of travel behavior at mixed-use developments and their own professional judgment, to develop a trip generation estimate for the proposed site that includes the possibility of induced trips as a result of travel cost savings realized in the mixed-use environment. Finally, it is recommended that engineers and planners consider the implications of proposed transportation projects from an economic perspective, which provides powerful insights into impacts that might not be easily recognized otherwise.

FUTURE RESEARCH DIRECTIONS

Given the number of variables that could impact travel patterns at mixed-use development sites and the limited amount of data that are currently available, the potential for future research work in this area is boundless. In addition to the need for more site-specific travel surveys similar to the one conducted in this investigation, travel surveys investigating the impacts of such variables as the proximity between on-site land uses or the quality of the pedestrian connections at a mixed-use development site would provide much-needed insights into the impacts of certain design features on travel behavior. Also, given the popularity of transit-oriented mixed-use developments, additional studies on the travel behavior and patterns of transit riders would add value to regional- or site-level planning activities. Adding a question about the respondent's home zip code to the travel survey used in this investigation would allow for a more accurate assessment of the VMT implications of mixed-use developments; for example, are travelers actually traveling more miles to visit places like Legacy Town Center, where many walking trips can be chained together with a single vehicle-trip? Another future research topic with great significance is an evaluation of residents or other types of travelers self-selecting into the mixed-use environment. Any additional data on the travel activity and patterns of mixed-use developments would also greatly enhance the site planning techniques used to evaluate the traffic impacts of proposed mixed-use development projects.

The induced travel aspect of mixed-use development planning research is also worthy of future study. One element of experimental design that was not included in this study but recommended for future efforts is a conventional development control site against which the findings of the mixed-use site could be compared, providing a better understanding of the differences between the two forms of development. Another topic for future study in this area is the relationship between induced travel and a component of traditional regional transportation planning studies, the traveler's stated trip purpose (as opposed to the trip origin and destination,

which was studied in this investigation). Future study may also examine in greater detail the economic aspects of induced travel at mixed-use developments, such as defining the actual travel cost for a particular quantity of travel at a mixed-use development. Future studies in these areas will no doubt be able to advance the work of this investigation; until then, the planning community must approach mixed-use developments in a very deliberate and comprehensive manner to ensure that the transportation impacts of these developments are properly identified.

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APPENDIX A

TRAVEL SURVEY INTERVIEW FORM

LEGACY TOWN CENTER

As persons DEPART intercept as they leave a specific entrance

Interviewer Name:____________________ **Phone #:** _________ **Building:** _______________ **Date:** _________ **Start Time:** ______ **am pm**

→→ Hello. May I please have a moment of your time to ask you a couple of questions for a Legacy Town Center travel survey?

Building Entrance	Time	**Where are you headed?**		**How are you going to get there?**	**If trip within Legacy Town Center: Would you be making this trip if you had to travel outside Legacy Town Center?**	**Where did you come from before you came to [name place being exited]**		**How did you travel from there?**	**What time did you arrive there?**	**How did you initially travel to Legacy Town Center today?**	
		1. Within Legacy Town Center 2. Outside Legacy Town Center	1. Office 2. Retail 3. Restaurant 4. Residential 5. Medical office 6. Cinema 7. Hotel/motel 8. Other (specify)	1. Auto Driver 2. Auto Passenger 3. Taxi 4. Bus 5. Walk 6. Bicycle	1. Yes 2. No	1. Within Legacy Town Center 2. Outside Legacy Town Center	1. Office 2. Retail 3. Restaurant 4. Residential 5. Medical office 6. Cinema 7. Hotel/motel 8. Other (specify)	1. Auto Driver 2. Auto Passenger 3. Taxi 4. Bus 5. Walk 6. Bicycle		1. Auto driver 2. Auto passenger 3. Taxi 4. Bus 5. Walk 6. Bicycle 7. Live On-Site 8. Staying In On-Site Hotel	If not as driver, did you have an auto available for your trip here?
			Specify business/building				Specify business/building				1. Yes 2. No

APPENDIX B

INSTITUTIONAL REVIEW BOARD APPROVAL

TEXAS A&M UNIVERSITY
VICE PRESIDENT FOR RESEARCH - OFFICE OF RESEARCH COMPLIANCE

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Institutional Biosafety Committee | Institutional Animal Care and Use Committee | Institutional Review Board

DATE: 07-May-2007

MEMORANDUM

TO: BOCHNER, BRIAN S
TTI (00220)

FROM: Office of Research Compliance
Institutional Review Board

SUBJECT: Initial Review

Protocol Number:	2007-0291
Title:	Internal Trip Capture and Induced Travel at the Legacy Town Center Mixed-use Development
Review Category:	Exempt from IRB Review

The Institutional Review Board (IRB) has determined that the referenced protocol application meets the criteria for exemption and no further review is required. However, any amendment or modification to the protocol must be reported to the IRB and reviewed before being implemented to ensure the protocol still meets the criteria for exemption.

This determination was based on the following Code of Federal Regulations:
(http://www.hhs.gov/ohrp/humansubjects/guidance/45cfr46.htm)

45 CFR 46.101(b)(2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior, unless: (a) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (b) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

Provisions:

This electronic document provides notification of the review results by the Institutional Review Board.

APPENDIX C

ANALYSIS TABLES

Table C-1: Analysis Table (All Entering Trips, Morning Peak Period)

Destination Land Use	Survey Data (Trip Origins)								
	Office	Retail	Restaurant	Residential	Cinema	Hotel	Other	External	Total
Office	4	5	9	6	0	0	0	98	122
Retail	0	0	2	18	0	0	0	12	32
Restaurant	1	2	0	29	0	5	0	71	108
Residential	1	3	4	8	0	0	0	16	32
Cinema	0	0	0	0	0	0	0	0	0
Hotel	0	0	1	1	0	0	0	9	11
All Destinations	6	10	16	62	0	5	0	206	305
Destination Land Use	Weighted Survey Data (Trip Origins)								
	Office	Retail	Restaurant	Residential	Cinema	Hotel	Other	External	Total
Office	20	24	44	29	0	0	0	479	596
Retail	0	0	8	72	0	0	0	48	128
Restaurant	6	11	0	160	0	28	0	392	597
Residential	21	63	84	168	0	0	0	336	672
Cinema	0	0	0	0	0	0	0	0	0
Hotel	0	0	17	17	0	0	0	153	187
All Destinations	47	98	153	446	0	28	0	1408	2180

Table C-2: Analysis Table (Induced Entering Trips, Morning Peak Period)

Destination Land Use	Survey Data (Trip Origins)								
	Office	Retail	Restaurant	Residential	Cinema	Hotel	Other	External	Total
Office	2	0	1	1	0	0	0	0	4
Retail	0	0	0	2	0	0	0	0	2
Restaurant	0	0	0	3	0	0	0	0	3
Residential	0	1	0	1	0	0	0	0	2
Cinema	0	0	0	0	0	0	0	0	0
Hotel	0	0	1	0	0	0	0	0	1
All Destinations	2	1	2	7	0	0	0	0	12
Destination Land Use	Weighted Survey Data (Trip Origins)								
	Office	Retail	Restaurant	Residential	Cinema	Hotel	Other	External	Total
Office	10	0	5	5	0	0	0	0	20
Retail	0	0	0	8	0	0	0	0	8
Restaurant	0	0	0	17	0	0	0	0	17
Residential	0	21	0	21	0	0	0	0	42
Cinema	0	0	0	0	0	0	0	0	0
Hotel	0	0	17	0	0	0	0	0	17
All Destinations	10	21	22	51	0	0	0	0	104

Table C-3: Analysis Table (All Exiting Trips, Morning Peak Period)

Origin Land Use	Survey Data (Trip Destinations)								
	Office	Retail	Restaurant	Residential	Cinema	Hotel	Other	External	Total
Office	4	0	1	1	0	0	0	6	12
Retail	5	0	2	3	0	0	0	16	26
Restaurant	9	2	0	4	0	1	2	84	102
Residential	6	18	29	8	0	1	7	132	201
Cinema	0	0	0	0	0	0	0	0	0
Hotel	0	0	5	0	0	0	0	49	54
All Origins	24	20	37	16	0	2	9	287	395
Origin Land Use	Weighted Survey Data (Trip Destinations)								
	Office	Retail	Restaurant	Residential	Cinema	Hotel	Other	External	Total
Office	33	0	8	8	0	0	0	50	99
Retail	22	0	9	13	0	0	0	69	113
Restaurant	49	11	0	22	0	5	11	455	553
Residential	50	149	240	66	0	8	58	1092	1663
Cinema	0	0	0	0	0	0	0	0	0
Hotel	0	0	37	0	0	0	0	363	400
All Origins	154	160	294	109	0	13	69	2029	2828

Table C-4: Analysis Table (Induced Exiting Trips, Morning Peak Period)

Origin Land Use	Survey Data (Trip Destinations)								
	Office	Retail	Restaurant	Residential	Cinema	Hotel	Other	External	Total
Office	2	0	0	0	0	0	0	0	2
Retail	0	0	0	1	0	0	0	0	1
Restaurant	1	0	0	0	0	1	0	0	2
Residential	1	2	3	1	0	0	1	0	8
Cinema	0	0	0	0	0	0	0	0	0
Hotel	0	0	0	0	0	0	0	0	0
All Origins	4	2	3	2	0	1	1	0	13
Origin Land Use	Weighted Survey Data (Trip Destinations)								
	Office	Retail	Restaurant	Residential	Cinema	Hotel	Other	External	Total
Office	17	0	0	0	0	0	0	0	17
Retail	0	0	0	4	0	0	0	0	4
Restaurant	5	0	0	0	0	5	0	0	10
Residential	8	17	25	8	0	0	8	0	66
Cinema	0	0	0	0	0	0	0	0	0
Hotel	0	0	0	0	0	0	0	0	0
All Origins	30	17	25	12	0	5	8	0	97

Table C-5: Analysis Table (All Entering Trips, Afternoon Peak Period)

Destination Land Use	Survey Data (Trip Origins)								
	Office	Retail	Restaurant	Residential	Cinema	Hotel	Other	External	Total
Office	1	1	2	4	0	0	0	1	9
Retail	2	15	9	10	4	3	0	34	77
Restaurant	5	15	13	29	15	17	1	51	146
Residential	3	11	12	11	1	0	0	5	43
Cinema	0	0	5	0	0	0	0	27	32
Hotel	1	4	3	2	1	0	0	18	29
All Destinations	12	46	44	56	21	20	1	136	336
Destination Land Use	Weighted Survey Data (Trip Origins)								
	Office	Retail	Restaurant	Residential	Cinema	Hotel	Other	External	Total
Office	11	11	21	43	0	0	0	11	97
Retail	22	165	99	110	44	33	0	374	847
Restaurant	70	211	183	408	211	239	14	717	2053
Residential	106	388	423	388	35	0	0	176	1516
Cinema	0	0	35	0	0	0	0	186	221
Hotel	11	44	33	22	11	0	0	197	318
All Destinations	220	819	794	971	301	272	14	1661	5052

Table C-6: Analysis Table (Induced Entering Trips, Afternoon Peak Period)

Destination Land Use	Survey Data (Trip Origins)								
	Office	Retail	Restaurant	Residential	Cinema	Hotel	Other	External	Total
Office	0	0	1	1	0	0	0	0	2
Retail	0	8	2	3	3	3	0	0	19
Restaurant	0	10	4	9	7	13	0	0	43
Residential	0	8	2	5	0	0	0	0	15
Cinema	0	0	0	0	0	0	0	0	0
Hotel	0	2	1	1	0	0	0	0	4
All Destinations	0	28	10	19	10	16	0	0	83
Destination Land Use	Weighted Survey Data (Trip Origins)								
	Office	Retail	Restaurant	Residential	Cinema	Hotel	Other	External	Total
Office	0	0	11	11	0	0	0	0	22
Retail	0	88	22	33	33	33	0	0	209
Restaurant	0	141	56	127	98	183	0	0	605
Residential	0	282	70	176	0	0	0	0	528
Cinema	0	0	0	0	0	0	0	0	0
Hotel	0	22	11	11	0	0	0	0	44
All Destinations	0	533	170	358	131	216	0	0	1408

Table C-7: Analysis Table (All Exiting Trips, Afternoon Peak Period)

Origin Land Use	Survey Data (Trip Destinations)								
	Office	Retail	Restaurant	Residential	Cinema	Hotel	Other	External	Total
Office	1	2	5	3	0	1	0	77	89
Retail	1	15	15	11	0	4	3	28	77
Restaurant	2	9	13	12	5	3	5	54	103
Residential	4	10	29	11	0	2	15	52	123
Cinema	0	4	15	1	0	1	3	28	52
Hotel	0	3	17	0	0	0	1	30	51
All Origins	8	43	94	38	5	11	27	269	495
Origin Land Use	Weighted Survey Data (Trip Destinations)								
	Office	Retail	Restaurant	Residential	Cinema	Hotel	Other	External	Total
Office	6	12	29	17	0	6	0	448	518
Retail	12	175	175	128	0	47	35	327	899
Restaurant	28	127	184	169	71	42	71	763	1455
Residential	45	113	327	124	0	23	169	586	1387
Cinema	0	8	31	2	0	2	6	58	107
Hotel	0	18	100	0	0	0	6	177	301
All Origins	91	453	846	440	71	120	287	2359	4667

Table C-8: Analysis Table (Induced Exiting Trips, Afternoon Peak Period)

Origin Land Use	Survey Data (Trip Destinations)								
	Office	Retail	Restaurant	Residential	Cinema	Hotel	Other	External	Total
Office	0	0	0	0	0	0	0	0	0
Retail	0	8	10	8	0	2	2	0	30
Restaurant	1	2	4	2	0	1	4	0	14
Residential	1	3	9	5	0	1	6	0	25
Cinema	0	3	7	0	0	0	1	0	11
Hotel	0	3	13	0	0	0	1	0	17
All Origins	2	19	43	15	0	4	14	0	97
Origin Land Use	Weighted Survey Data (Trip Destinations)								
	Office	Retail	Restaurant	Residential	Cinema	Hotel	Other	External	Total
Office	0	0	0	0	0	0	0	0	0
Retail	0	93	117	93	0	23	23	0	349
Restaurant	14	28	56	28	0	14	56	0	196
Residential	11	34	101	56	0	11	68	0	281
Cinema	0	6	15	0	0	0	2	0	23
Hotel	0	18	77	0	0	0	6	0	101
All Origins	25	179	366	177	0	48	155	0	950

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