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16. Abstract
In 2004 the Texas Department of Transportation (TxDOT) funded the Center for Transportation Research at The University of Texas at Austin to develop a methodology to evaluate the environmental justice (EJ) impacts of toll roads given four scenarios: (a) the construction of new toll road(s), (b) converting existing non-toll roads to toll roads, (c) the tolling of capacity enhancements (e.g., additional main lanes or frontage roads to existing facilities), and (d) the conversion of planned non-toll roads to toll roads upon completion. This report documents the research performed in developing the EJ evaluation methodology to identify, measure, and mitigate disproportionately high or adverse impacts imposed on minority and low-income (EJ) communities by toll roads compared to non-toll roads.

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Identifying, Measuring, and Mitigating Environmental Justice Impacts of Toll Roads

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Chapter 1. Introduction

Road infrastructure is a key component of any state's transportation system. It allows unprecedented levels of mobility, accessibility, and economic growth. Texas has 79,297 miles of state highways (including the Interstates), 138 miles of toll roads, and 221,646 miles of local roadways. Slightly over 70 percent of the state's annual 214.8 billion vehicle miles traveled (VMT) occur on state highways, with the balance of 62.1 billion VMT occurring on local roads and streets (Pocket Facts, 2002). As in much of the rest of the United States, VMT in Texas has been growing faster than the population. Between 1994 and 1999, VMT in Texas increased from 178 billion to 211 billion—almost 19 percent (U.S. Department of Transportation: National Highway Traffic Safety Administration). Increasingly, traditional funding sources are inadequate to maintain and modernize the state's infrastructure to ensure mobility, accessibility, and reasonable travel times. Studies by the Texas Department of Transportation (TxDOT) project a shortfall of $60 billion over the next 10 years (Texas Department of Transportation, 2001).

One option to address this funding shortfall is to finance new roads and the rebuilding and modernizing of existing roads in rural and urban areas through investments that can be recovered from tolls charged to users. A preliminary literature review revealed that more than 26 U.S. states have expanded or modernized their road infrastructure through tollways (BTS, 2004). Tolls are thus becoming an increasingly popular method for state Departments of Transportation (DOTs) to alleviate some of the cost burden of maintaining and building transportation-related infrastructure.

Toll equity and Regional Mobility Authorities (RMAs) are voter-approved financial tools to leverage limited state transportation funds and are considered key tools by Governor Rick Perry to build needed transportation infrastructure in Texas sooner. Potential benefits for TxDOT include fiscal savings as RMAs take responsibility for developing infrastructure projects, reduced maintenance expenditures associated with reduced traffic on department facilities, and supplementary revenue sources (TxDOT, Regional Mobility Authorities: Proposed Preamble). In line with the Governor's vision and given the fiscal constraints of traditional roadway funding sources, the Texas Transportation Commission unanimously approved on December 16, 2003 a policy that directed the TxDOT, RMAs, private developers, counties, and regional toll authorities to evaluate the feasibility of tolling all controlled-access mobility projects in any phase of development or construction (TxDOT, 2004). This directive pertained to the following: new facilities, increased capacity (for example, adding frontage roads to existing main lanes), the conversion of existing non-toll roads to toll roads, and the conversion of planned non-toll roads to toll roads. This action fulfills the requirements of Texas House Bill 3588 passed during the 78th Legislature in May of 2003 (see text box) (Krusee, 2003), but it has also raised some questions about environmental justice and how that relates to tolling.

> **Texas House Bill 3588**
>
> Texas House Bill 3588 addresses the transportation funding shortfall in the State of Texas and expanded the ability of RMAs to construct, maintain, and operate various transportation projects. It also gave TxDOT, RMAs and counties flexibility in deciding whether to develop a non-toll highway as a tolled facility.

Inherently, transportation investments almost always create a disparate impact in that benefits are not equally distributed to all communities affected by the investments. Assessing the equity of transportation investments requires the examination of a myriad of issues, including determining who benefits and who is burdened by the proposed transportation projects. Environmental Justice (EJ) becomes an issue when minority or low-income communities (referred to as EJ communities) receive fewer benefits and either are or may be disproportionately burdened by transportation investments. The burdens may be the result of negative social, economic, or environmental impacts placed on those living in the affected toll project areas. It is foreseeable that toll road projects could hold additional benefits as well as burdens for EJ communities compared to non-toll road projects. To date, however, very little guidance exists on how to assess the additional benefits and burdens imposed by toll roads compared to non-toll roads, and how to mitigate any negative impacts.

In August 2004, TxDOT contracted with the Center for Transportation Research (CTR) at The University of Texas at Austin to develop an approach for the effective identification, evaluation, and mitigation of disproportionately high or adverse impacts imposed on minority and low-income communities (EJ communities) by toll roads relative to non-toll roads. The four toll scenarios considered were:

- the conversion of existing non-toll roads into toll roads;
- the construction of new toll roads;
- the conversion of planned non-toll roads into toll roads prior to the opening of the road to the public; and
- the conversion of existing non-toll roads into toll roads by (a) tolling the existing lanes and adding adjacent frontage roads as *free alternatives* or (b) tolling the new capacity (i.e., building the toll lanes in the grass median) and keeping the existing lanes as *free alternatives*.

This research has culminated in this report. The report is structured as follows. Chapter 2 highlights key findings of the literature review regarding the regulations that established the requirement for EJ analysis, the definitions for EJ populations, the documented concerns associated with transportation investments, and the socio-demographic characteristics of toll road users. Chapter 3 presents background material from the literature review and the proposed methodology for identifying, measuring, and mitigating the potential additional EJ impacts associated with the four toll road scenarios relative to non-toll roads. Chapter 4 presents the main conclusions of this research and recommends future research that will enhance the methodology proposed in this report.

Chapter 2. Background

The requirement for environmental justice (EJ) forms part of many laws, regulations, and policies, including: (a) Title VI of the Civil Rights Act of 1964, (b) the National Environmental Policy Act of 1969, (c) Section 109(h) of Title 23, (d) the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (URA), as amended, (e) the Transportation Equity Act for the 21st Century (TEA-21), and (f) numerous U.S. DOT statutes. An in-depth literature review was conducted of the laws, regulations, and policies that establish the requirement for EJ analysis of a transportation investment, the definitions for EJ individuals and communities, the documented EJ concerns pertinent to transportation investments, and the socio-demographic characteristics of toll road users. This chapter of the document provides the overall background for Chapter 3, which details the proposed approach for identifying, measuring, and mitigating EJ concerns associated with toll roads as compared to non-toll roads. For a detailed review of the legal framework for addressing EJ, see related publication 0-5208-P1, entitled "Toll Roads and Environmental Justice: Preliminary Guidance."

2.1. Environmental Justice: A Legal Requirement and Administrative Directive

Title VI of the Civil Rights Act states that "[no] person in the United States shall, on the ground of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance" (U.S. Department of Justice, 1998). The Civil Rights Restoration Act of 1987 amended Title VI to require that all activities of federal aid recipients have to comply with this non-discriminatory requirement—not just those programs or activities that receive direct Federal aid. Thus, even highway projects that are entirely funded by state or local governments have to comply with this requirement if these agencies receive any federal funding. The U.S. DOT has developed Title VI regulations to ensure that transportation agencies comply with this mandate. An administrative enforcement procedure exists to address any concerns about discrimination in violation of Title VI. Title VI may, however, also be enforced in court (ICF Consulting 2003). The interpretation of EJ concerns has thus been the subject of a number of court decisions. The most important EJ criteria that emerged from Title VI litigation are that plaintiffs should demonstrate intentional discrimination (not only disparate impacts) and be in a position to suggest a reasonable non-discriminatory alternative (Hicks & Company and Rust Environment & Infrastructure, 1997). Box 2.1 highlights an earlier lawsuit against the Los Angeles Metropolitan Transit Authority that claimed both disparate and intentional discrimination as well as three court decisions that seemed to have limited the ability of private parties to prevent environmental injustices by invoking Title VI against government actions that cause "disparate impacts" (ICF Consulting 2003). It has, however, to be emphasized that these court decisions do not affect a private individual's ability to file an administrative complaint with U.S. DOT, who has—as stated earlier—adopted regulations that prohibit funding programs or projects that have racially discriminatory impacts (i.e., funding can be stopped even when discrimination is unintended).

Box 2.1 Recent Title VI Environmental Justice (EJ) Cases

Los Angeles Metropolitan Transit Authority (MTA) Lawsuit

In Los Angeles, a coalition of EJ advocates alleged that the MTA did not provide low-income people and minorities with an equitable share of the transit system's services. The advocates presented evidence that MTA spent a substantial proportion of its budget on rail projects and suburban buses that served primarily upper-income whites. In 1996, a federal district court ruled in favor of the 350,000 Los Angeles bus riders in a historic civil rights class action. A consent decree resulted from the case, in which MTA agreed to invest over one billion dollars in bus system improvements over 10 years. This was the first time that Title VI was successfully used to challenge the spending priorities of a major transit agency (ICF Consulting, 2003).

Coalition of Concerned Citizens Against I-670 v. Damian

This case involved the construction of a freeway through minority (50 to 90 percent) neighborhoods. The plaintiffs charged that the siting of the freeway had a discriminatory impact on minorities and that public input was insufficient in the early planning stages of the highway. The court ruled that the defendants "*met their burden of justifying the location of I-670 by articulating legitimate non-discriminatory reasons for the location.*" The court ruled that an effort was made to minimize the impacts upon minority communities by avoiding most of the neighborhoods where 90 percent of the population was from a racial minority group. The court also found that no other reasonable alternative existed to achieve the defendant's objective. The Damian ruling thus states that a state agency's actions could have disproportionate impacts and still comply with Title VI if it could be justified as the only reasonable alternative. Finally, the court ruled in favor of the plaintiffs that there was insufficient public input at the beginning of the project (Hicks & Company and Rust Environment & Infrastructure, 1997).

Alexander v. Sandoval Decision

On April 24, 2001, the U.S. Supreme Court issued an historic 5-4 decision in Alexander v. Sandoval. The case stemmed from Alabama's decision to administer state driver's license exams only in English. The majority opinion was that Congress did not intend for private individuals to bring suits to enforce discriminatory (or disparate) impact under Title VI, but rather *"intentional discrimination"* (ICF Consulting, 2003).

South Camden Decision

It is, however, unclear whether private plaintiffs can bring the equivalent of Title VI disparate-impact claims under a separate statute, 42 U.S.C. §1983. In South Camden Citizens in Action v. New Jersey Department of Environmental Protection, citizens were suing over a decision to permit a cement mixing facility in a racially diverse community, where there were existing manufacturing facilities. The court ruled that citizens could pursue Title VI discrimination under 42 U.S.C §1983. The U.S. Court of Appeals, however, overturned this decision in 2002 (ICF Consulting, 2003).

On February 11, 1994 President Clinton signed Presidential Executive Order 12898, which requires federal agencies to "make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high human health or environmental effects of its programs, policies, and activities on minority populations and low income populations." Executive Order (EO) 12898 (1994) thus requires "that minority and low-income populations not receive disproportionately high and adverse human health or environmental impacts." Specifically, the EO pointed agencies to the existing regulations contained in the National Environmental Policy Act (NEPA) of 1969,[1] Title VI of the Civil Rights Act of 1964[2] (441 U.S. 677, 1979), and the laws that require public input and access to information (Hicks & Company and Rust Environment & Infrastructure, 1997). EO 12898 and the accompanying presidential memorandum called for specific actions during the NEPA process, including (Questions and Answers on Environmental Justice and Title VI, 2002):

- analyzing environmental effects (e.g., human health, economic, and social) on minority and low-income populations;
- ensuring that mitigation measures outlined or analyzed in the environmental documents address the disproportionately high and adverse environmental effects of the proposed actions on minority and low-income populations; and
- providing opportunities for community input in the NEPA process by facilitating the attendance of EJ community members to public meetings, providing official documents and notices to affected communities, and by identifying potential effects and mitigation measures in consultation with affected communities.

EO 12898 is, however, an administrative directive and does not create any new legal rights and is not enforceable in court (Hicks & Company and Rust Environment & Infrastructure, 1997).

In response to EO 12898, the U.S. DOT issued DOT Order 5610.2 entitled "Department of Transportation Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" (February 3, 1997). The U.S. DOT order stated that

> "an adverse impact is disproportionately high and adverse on a low-income or minority population when (a) the adverse impact is predominantly borne by a minority population and/or low-income population, or (b) the adverse impact that will be suffered by the minority population and/or low-income population is more severe or greater in magnitude than the adverse impact that will be suffered by the non-minority population and/or non-low-income population" (Novak and Joseph, 1996).

Like EO 12898, the DOT order is not a new requirement, but is intended to reinforce the requirements of the existing legal framework as provided by NEPA and Title VI.

In December 1998, the FHWA issued its own order on EJ—"FHWA Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" (DOT Order 6640.23)—that requires the implementation of the principles of EO 12898 and DOT Order

1 The NEPA process sets policy goals for the protection, maintenance, and enhancement of the environment.

2 Title VI prohibits discrimination on the basis of race, color, or national origin in programs and activities that receive federal funding.

5610.2. The FHWA order specifically stated that the following information needs to be collected and analyzed when considering EJ in terms of FHWA activities: (a) the race/national origin and income of those served and/affected, (b) the proposed steps to protect the identified minorities from disproportionately high or adverse effects, and (c) proposed membership of the identified minorities on any planning or advisory body. The FHWA undertook to follow the following steps with regards to its programs, policies and activities to prevent disproportionately high and adverse impacts on environmental justice populations: (a) identify and evaluate the environmental, health, social, and economic effects, (b) propose measures to avoid, minimize, and mitigate disproportionately high and adverse effects, and to provide offsetting benefits and opportunities, (c) consider alternatives, and (d) provide public involvement opportunities (ICF Consulting, 2003).

The discussed orders (i.e., EO 12898, DOT Order 5610.2, and DOT Order 6640.23) encouraged agencies to address EJ under the NEPA. In essence, NEPA requires that the responsible federal agency must evaluate the environmental impacts of every *"major federal action significantly affecting the quality of the human environment"*. This requirement applies to both projects that receive federal funding or require a type of federal permit. The NEPA statute specifically requires that State DOTs address the following:

- identify social, economic, and environmental effects,
- consider alternatives and mitigation options,
- involve the public and other agencies, and
- use a systematic interdisciplinary approach (ICF Consulting, 2003).

Since the NEPA statute does not explicitly state how EJ impacts should be addressed under the NEPA process, two federal documents (developed by the Council on Environmental Quality (CEQ) and the FHWA Western Resource Center) have attempted to provide guidance for public agencies considering EJ under NEPA. The CEQ provides definitions (i.e., for minority individuals, minority populations, low-income populations) that can be used in assessing EJ, and offers some broad guidance to determine high and adverse impacts. No definite guidance is, however, provided to many of the analytical questions faced by planners. The Interim Guidance on addressing EJ under NEPA developed by the FHWA Western Resource Center provides guidance (a) on appropriate definitions, (b) as to where in the Environmental Impact Assessment (EIA)/Environmental Impact Statement (EIS) to discuss how minority and low-income groups will be impacted and how they were involved in the decision-making process, (c) in identifying adverse impacts, and (d) as to what defines a disproportionately high and adverse effect. The latter was stated as *"... appreciably more severe or greater in magnitude on minority or low-income populations than the adverse effect suffered by the non-minority or non-low-income populations after taking offsetting benefits into account"* (ICF Consulting, 2003).

Finally, the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Section 109 (h) of the Federal Highway Act, and both ISTEA and TEA-21 have aspects that aim to promote EJ. The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 aims to ensure uniform and impartial treatment of people and businesses that are displaced by federally assisted programs. Section 109(h) of the Federal Highway Act states

> "that the appropriate state and federal officials assure that possible adverse economic, social, and environmental effects related to any proposed project on any Federal-aid

system have been fully considered in developing the project, and that the final decision on the project is made in the best overall public interest" (Novak and Joseph, 1996).

Finally, both ISTEA and TEA-21 require strong public participation with Native American Tribal Governments when conducting transportation planning.

2.2. Environmental Justice Population Groups

The terms "minority" and "low-income" were initially defined by the Interagency Working Group (IWG), led by the U.S. Environmental Protection Agency (EPA), which was created to implement the requirements of EO 12898. These definitions were subsequently incorporated in the U.S. DOT and FHWA policies. The definitions have essentially remained unchanged since their inception. In the FHWA policy, the terms are defined as follows:

- *Minority* describes a person who is Black, Hispanic, Asian American, American Indian or Alaskan Native;
- *Minority Population* is "any readily identifiable groups of minority persons who live in geographic proximity, and if circumstances warrant, geographically dispersed/transient persons (such as migrant workers or Native Americans);" (FHWA, 1998)
- *Low-Income Person* describes an individual with a "household income at or below the Department of Health and Human Services poverty guidelines;" (FHWA, 1998) and
- *Low-Income Population* is "any readily identifiable group of low-income persons who live in geographic proximity, and, if circumstances warrant, geographically dispersed/transient persons (such as migrant workers or Native Americans) who would be similarly affected by a proposed FHWA program, policy, or activity" (FHWA, 1998)

According to the FHWA (Cambridge Systematics, Inc., 2002), the terms minority and low-income populations "should not be presumptively combined" when analyzing EJ issues. There are minority populations of all income levels, while low-income populations may be minority, non-minority, or a mix in a given area. This research thus analyzes these two population groups separately.

2.3. Environmental Justice Concerns Pertinent to Transportation Projects

The impacts pertaining to highway projects have been well documented in the literature. Table 2.1 summarizes the most pertinent impacts associated with highway projects categorized as follows: (1) physical environmental quality effects, (2) mobility and safety effects, (3) socio-economic effects, and (4) cultural effects. These categories relate to aspects of the transportation system and the natural environment that are particularly important to NEPA participants. These impacts are not necessarily negative. For example, a new highway may have a positive or negative impact on air quality, access to jobs, and land and housing property values. In Chapter 3 and Appendix F, this broad list of impacts was examined to determine the potential additional impacts imposed by toll roads. Ultimately, however, the list of impacts needs to be finalized in consultation with the affected communities. Finally, when conducting EJ analysis, the distribution of the additional benefits and burdens across income and racial groups needs to be critically reviewed.

Table 2.1. Potential Impacts of Highway Projects

Physical Environmental Quality Effects	
Air Quality	Effects of pollutants (e.g., public health, land use)
	Regional compliance with Clean Air standards and conformity
	Reduction in single-occupant vehicle (SOV) use
Noise	Effects on sensitive site noise contour levels (e.g., public health, land use)
Water Resources	Effects on surface water quality (e.g., drainage characteristics)
	Effects on ground-water quality
	Effects on flood plains (e.g., flood characteristics)
	Effects on wetlands
Ecosystems	Destruction or disruption of natural resources (e.g., vegetation, wildlife, and threatened and endangered species)
Soil Resources	Effects on prime farmland (e.g., soil contamination)
Hazardous Materials	Influences of existing/abandoned landfill sites
	Influences of known/potential hazardous materials sites
Mobility and Safety Effects	
Highway/Roadway	Effects on travel patterns (e.g., decreased mode choice, route assignment)
	Effects on service (e.g., average travel/delay time, running speed)
	Effects on system capacity (person trips)
	Effects on vehicle occupancy
	Effects on accessibility (to work, to shop, etc.)
	Effects on safety
Transit Service	Effects on travel patterns (origin-destination transit patterns, transit routes)
	Effects on service (e.g., service coverage, travel times, service frequency)
	Effects on ridership
Other Forms of Transportation	Effects on bicycle use and safety
	Effects on pedestrian use and safety
Social and Economic Effects	
Neighborhood Effects	Displacements of residential property
	Effects on neighborhood cohesion, social interaction
	Visual intrusion or obstruction
	Effects on access to work, community facilities, and services
	Effects on access to sensitive sites (hospital, schools, etc.)
	Effects on recreational places (parks, water recreational resources, etc.)
	Effects on neighborhood traffic patterns
	Effects on land and residential property values
	Pedestrian and bicycle safety
	Cumulative effects on neighborhood quality/safety
Health Effects	Bodily impairment, infirmity, illness or death
Local Business Effects	Displacements of businesses/public properties
	Effects on employment
	Effects on business access and deliveries
	Effects on land and commercial property values
Economic Development Effects	Changes in available job types
	Changes in property values
	Land use impacts (effects on services and tax base)
	Delays in the receipt of benefits of DOT programs
Cultural Effects	
Archaeological, Historic and Cultural Resources	Effects on archaeological sites
	Effects on historic sites and landmarks

2.4. Socio-demographic Characteristics of Toll Road Users

Transportation pricing strategies, irrespective of the objectives—whether to reduce traffic congestion, protect the natural environment, increase transportation revenues, or facilitate the adding of capacity—generally raise equity concerns. For example, congestion pricing allows for the differentiation of tolls charged for traveling during the peak and non-peak hours. Commuters with a high value of time (VOT) are thus more likely to use the tolled facility and benefit from faster trip times than commuters who cannot afford the additional expense. The latter group of commuters may defer trips to off-peak periods, shift to transit, or alter their location choices of home, work, and other activities (Deakin and Pozdena, 1996).

An extensive literature review was conducted to determine whether tolling, per se, would exclude low-income and minority individuals from using, and thus sharing in the benefits of, toll roads. The literature review revealed the following interesting observations regarding the socio-demographic characteristics of toll road users in California:

- The user demographics of the variable-toll express lanes in the median of the Riverside Freeway (State Route 91) in Orange County, California, revealed that (1) high-income earners are more than twice as likely to use toll lanes compared to low-income earners (23 percent compared to 10 percent), and (2) low-income earners are more than twice as likely not to use toll lanes compared to high-income earners (37 percent compared to 73 percent) (Sullivan, 1998). This points to a strong correlation between income and the frequency of toll lane use.
- A public opinion survey of the dynamic priced[3] I-16 High Occupancy Toll (HOT) lanes in San Diego, California, revealed strong support across all income groups (The Fairfax Research Group, 2001). Counter-intuitively, the lowest income group expressed stronger support than the higher income group (80 percent compared to 70 percent). According to DeCorla-Souza and Skaer (2003), this strong support by the poor may be explained by the fact that while higher income earners generally have more flexible work schedules, poorer workers typically have either work schedules or childcare arrangements that require them to be on time. Tolled facilities thus allow them to bypass congestion and avoid severe consequences at work and childcare.
- A Southern California study showed that a 5¢ per mile road user fee would produce benefits to all residents by reducing congestion and air pollution (Cameron, 1994). Furthermore, it was concluded that the toll would mostly benefit the poorest residents, who tend to live near busy roads and therefore are most exposed to pollution.
- Finally, a California study that investigated five categories of transportation pricing measures in the Los Angeles, Bay Area, San Diego, and Sacramento metropolitan regions found that (1) the lowest income class made relatively little use of the highway system, (2) the lower middle class endured much of the impact of pricing policies, and (3) the distribution of impacts are more strongly correlated to income than to demographic characteristics (Deakin and Pozdena, 1996).

[3] Dynamic pricing means that the toll rate fluctuates according to the amount of traffic actually on the road during that particular time of day. Generally, electronic message boards are used to display user fares.

The literature reviewed revealed only one case study where a tolled facility had a perceived disproportionately high impact on a minority community. The equity analysis for converting the I-95 high occupancy vehicle (HOV) lane into a high occupancy toll (HOT) lane in South Florida disclosed a disproportionately high impact on members of the African American community who make short trips (i.e., trips less than 10 miles) (Cleland and Winters, 2000).[4]

2.5. Concluding Remarks

EJ requires that a transportation agency determine whether a program, policy, project or activity will impact minority or low-income populations disproportionately and ensure that these communities are:

- afforded an opportunity under Title VI to participate in the planning process to ensure a non-discriminatory process,
- involved in the identification of impacts associated with the project in an effort to determine if the effects suffered by these populations are disproportionately high, and
- involved in identifying mitigation and enhancement measures associated with a particular project (Novak and Joseph, 1996).

Very little guidance, however, exists specifically on **how** to identify and quantify the additional impacts of toll roads on low-income and disadvantaged communities or on how to establish whether an impact is disproportionately high or adverse. This is aggravated by the fact that EJ might have a different meaning for different population groups given their unique perspectives and timeframes (Cairns et al., 2003).

[4] Commuter acceptance and equity analysis of the HOT Lanes/Value Pricing concept for the I-95 in South Florida was tested through a telephone survey among residents of the three-county South Florida area (Palm Beach, Broward, and Miami-Dade counties).

Chapter 3. Proposed Methodology for Identifying, Measuring, and Mitigating EJ Concerns of Toll Roads

This chapter presents the proposed methodology for the identification, measurement, and mitigation of potential EJ impacts associated with four defined toll road scenarios relative to non-toll roads. The scenarios were conceptualized given the tolling policy adopted on December 16, 2003 by the Texas Transportation Commission. The proposed EJ evaluation methodology (EJEM) has two equally important components: an analysis/quantitative and an effective EJ participation component. This chapter provides background information and details each of the methodological steps required to apply the proposed methodology.

3.1. Toll Road Scenario Characteristics

It is generally argued that:

- toll roads have a disproportionate impact on lower-income commuters if their workplaces are not accessible by transit,
- the poor bear an unfair burden if they have to shift to congested roads to avoid the toll, and
- low-income drivers may be priced out of traveling for some discretionary trips (e.g., shopping trips and recreational trips) or be forced to use less attractive modes (e.g., transit, bicycling, or walking) to satisfy their transportation needs when charged a toll (Litman, 2004).

Whether a toll is regressive, however, is a function of how many lower-income drivers use the toll facility, how many are discouraged or prevented from using the toll facility, the quality of available alternative transportation modes, and how toll revenues are used (Litman, 2004; Litman, 1996; Giuliano, 1994). Contradictory reports regarding the ecological, social, and economic impacts of transportation pricing point to the fact that the EJ analysis of toll roads can be very complex. Table 3.1 summarizes the relevant features of a toll road that may potentially affect EJ outcomes.

Table 3.1. Toll Road Features Relevant for EJ Analysis

Features	Examples
Type of facility	Toll roads with adjacent frontage roads as “free alternatives”
Demographic characteristics of the commuter population	High percentage of low-income/minority travelers and low percentage of high-income travelers
Demographic characteristics of the neighborhood adjacent to the facility	Facility to divide low-income African American neighborhood
Corridor alternatives, including non-auto mode	No non-toll road available Non-toll roads available as “frontage roads” Low frequency of public transit service
Access control	Limited access to local minority neighborhoods Improved access to sensitive places (i.e., hospitals)
Toll pricing structure	Flat rate Dynamic rate Differential rate (e.g., low-income commuters pay less than high-income commuters)

Depending on the features of the toll road, distinct ecological, social, and economic impacts may result. For example, the conversion of an existing non-toll road into a toll road is more likely to have a disproportionate impact on a low-income community living adjacent to the road, especially if residents commute to work by car, than a new location facility. Given the cited features in Table 3.1, four toll road scenarios (see Table 3.2) were conceptualized considering the tolling policy adopted on December 16, 2003 by the Texas Transportation Commission. The Commission's tolling policy—aimed at addressing the shortfall in transportation funds in Texas— applies to new location facilities (Scenario 3), capacity enhancements (for example, additional main lanes or frontage roads to existing facilities—Scenario 4), the conversion of existing non-toll roads into toll roads (Scenario 1), and the conversion of planned non-toll roads to toll roads upon completion (Scenario 2). The pricing structure for all four scenarios assumed a flat rate (i.e., constant toll irrespective of the day of week, time of day, level of congestion, or number of passengers in the vehicle).

Table 3.2. Toll Road Scenario Characteristics

Scenario Characteristics	Scenario 1	Scenario 2
Funding	Federal funding	Federal funding
Location	Existing location (existing road)	New location (new road)
Alternative non-toll road within the same right-of-way	No	Not applicable
Planned/Constructed	As a non-toll road	As a toll road
Operated	Initially operated as a non-toll road. Non-toll road converted into a toll road after a period of time.	As a toll road
Scenario Characteristics	**Scenario 3**	**Scenario 4**
Funding	Federal funding	Federal funding
Location	New location (new road)	Existing location (existing road)
Alternative non-toll road within the same right-of-way	Not applicable	Yes (frontage roads)
Planned/Constructed	As a non-toll road	As a non-toll road
Operated	As a toll road	Initially operated as a non-toll road. After a period of time, (a) tolling the existing lanes and adding adjacent frontage roads as non-toll alternatives or (b) tolling the new lanes built in the grass median and keeping the existing lanes as non-toll alternatives. In both cases, the new capacity is provided within the same right-of-way.

Texas law prescribes that the Texas Transportation Commission cannot convert a segment of a non-toll road into a toll road unless the public has "a reasonable alternative non-tolled route" (Texas Transportation Code Ann. § 370.035(2), Vernon 1999 & Supp. 2004). Since it is still unclear what this provision entails, scenario 1 was conceptualized with no non-toll road alternatives within the same right-of-way. Scenario 4 assumes adjacent frontage roads as the non-toll alternative within the same right-of-way. Finally, this provision does not apply to scenarios 2 and 3 as these represent new facilities.

3.2. Environmental Justice Evaluation Methodology

In general, an EJ analysis is required when one of the following two conditions exists: (1) an EJ population is located in the impacted area, or (2) the adverse impacts caused by a transportation investment could affect the EJ population disproportionately. This requires that the scoping part of the NEPA process be expanded to ensure that low-income and minority populations participate in investment decisions and that opportunities are provided for them to become informed and voice their concerns. This research conceptualized an EJ evaluation methodology (EJEM) to evaluate the EJ concerns associated with four defined toll road scenarios. The proposed methodology has two equally important components: an analysis/quantitative and an effective EJ participation component (see Figure 3.1). The analysis component requires the analyst to:

1. identify the demographic profile and the spatial distribution of population groups within the impacted area,
2. identify the spatial concentrations of EJ communities in the impacted area,
3. determine the additional impacts of concern associated with the toll road relative to the non-toll road,
4. calculate the magnitude of the additional impacts,
5. determine whether zones with higher concentrations of EJ populations are disproportionately impacted by the toll road, and finally
6. identify and formulate effective mitigation options if it is found that the impacts suffered by zones with higher concentrations of EJ populations are appreciably more severe than the impacts suffered by zones with lower concentrations of EJ populations.

A key component of any EJ analysis should be the inclusion of low-income and minority populations in the planning process, in providing input in research and data collection needs, in project design, in determining the benefits and burdens of proposed facilities, and in identifying mitigation measures. The second component, EJ participation, aims to ensure that EJ communities are given the opportunity for meaningful participation. EJ community outreach efforts are thus foreseen during the various steps of the analysis to ensure that all the adverse impacts are known and that effective mitigation options are designed to lessen or offset the disproportionately high impacts. In this regard, public outreach techniques are important in facilitating the dialogue between the transportation agency and the impacted community while ensuring that the decision-making process surrounding the proposed toll road takes place in a cooperative environment. It is also very important that the chosen public outreach techniques expose core community concerns.

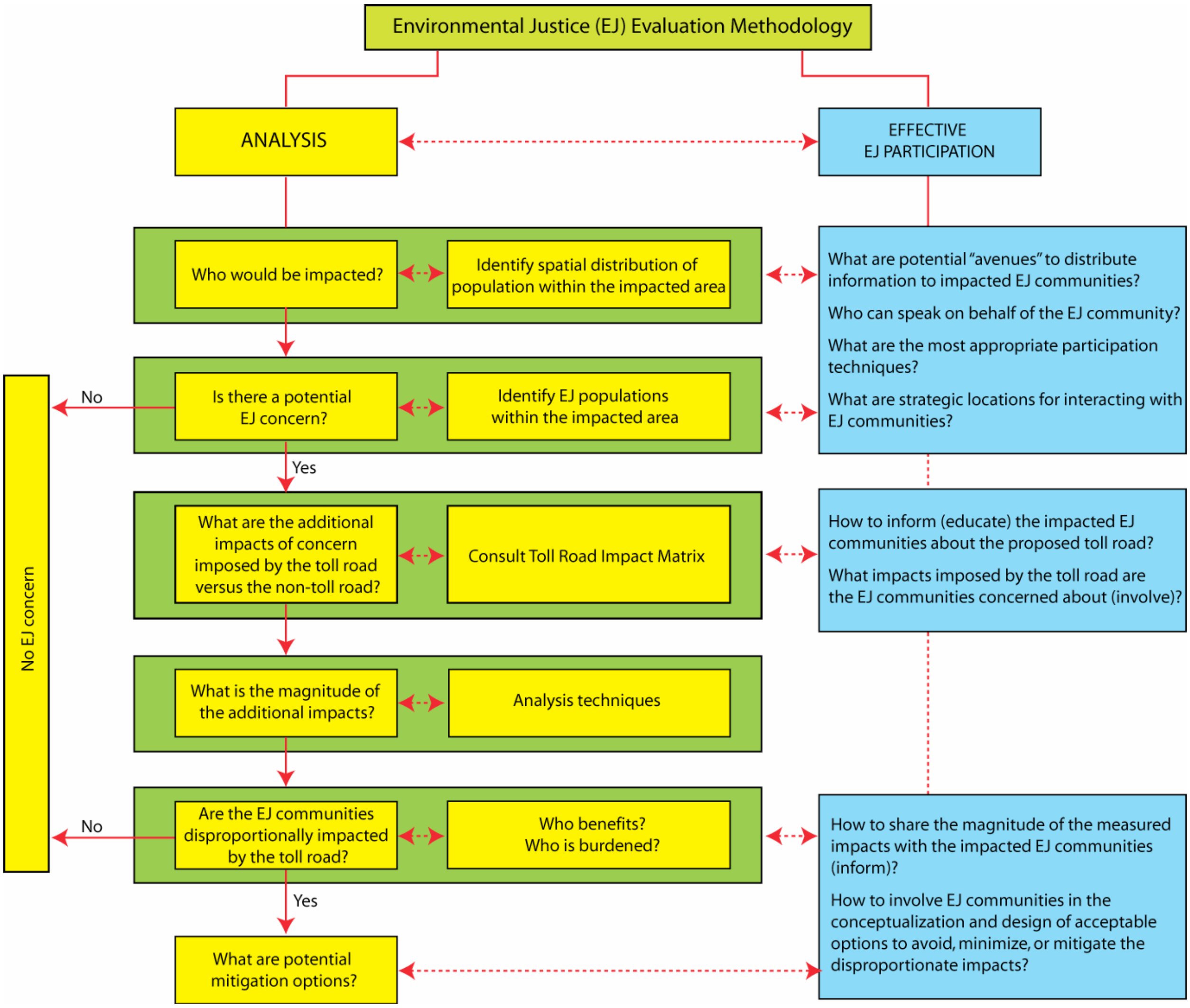


Figure 3.1. Environmental Justice Flowchart for Toll-Road Projects

3.2.1 Analysis/Quantitative Component

Who Would Be Impacted?

The first step in the analysis component of the EJEM is the identification of the population affected by the proposed toll road. The literature revealed that the greatest impacts are typically to those communities residing close to a roadway project, irrespective of whether it is a toll or a non-toll project. For example:

- Children living near busy roads are more likely to develop all types of cancer (Pearson et al., 2000).
- Pregnant women living near high traffic areas are more likely to have premature and low-birth weight babies (Wilhelm and Ritz, 2002).
- Motor vehicle air toxins cause high pollution levels inside homes (Buchan et al., 2003).

- Low-income persons tend to experience higher levels of pedestrian accidents and traffic pollution, because they often live adjacent to busy roads (Social Exclusion Unit, 2002).

In addition, toll roads may also impact the activity space where communities work, shop, and partake in other activities. Forkenbrock and Sheeley (2004) concluded that in order to assess the nature and magnitude of impacts that vary spatially throughout a community, it is first necessary to gain a sense of the geographic space within which population groups live and move (i.e., spatial activity). Figure 3.2 illustrates the elements required for identifying the spatial distribution of the impacted population groups at the corridor/project analysis level.

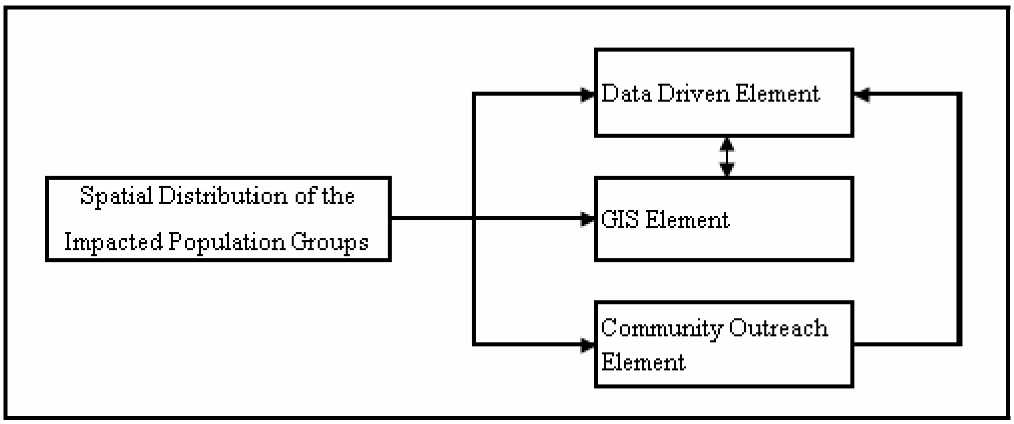
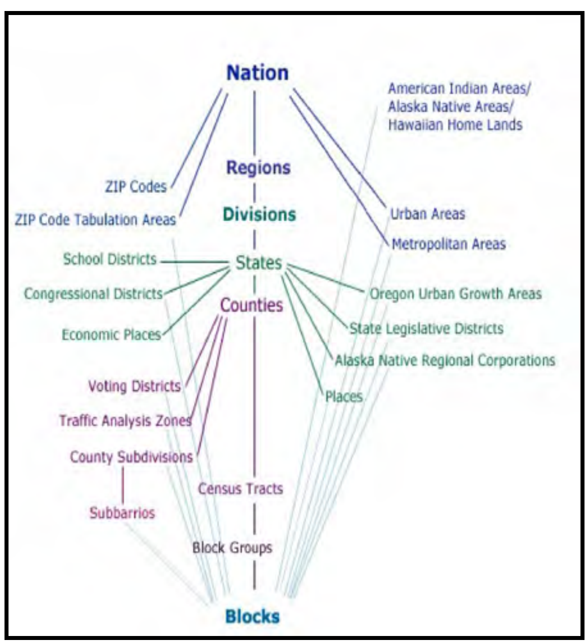


Figure 3.2. Elements for Identifying the Spatial Distribution of Impacted Population Groups

Since the 1990 and 2000 U.S. Census Data are reported at different geographic scales (see Figure 3.3), the data may be used for different levels of analysis.



Source: 2000 U.S. Census Data

Figure 3.3. Census Geographic Hierarchy

The U.S. Census Data and GIS-based techniques have thus proven to be very useful (see Table 3.3) in developing demographic profiles by allowing for spatial analyses at very disaggregate levels of geographic detail (e.g., census block, grids).

Table 3.3. Expertise Required for Developing Demographic Profiles

Method	Assessment Level	Appropriate uses	Use When	Data needs	Expertise required
Threshold Analysis	Screening/ Detailed	Regional Plans, STIP/TIP, Initial Corridor Assessment	Demographic patterns must be evaluated for large areas	Low	GIS, Census Data
Spatial Interpolation	Screening/ Detailed	Corridor/ Project Level	Demographic patterns must be evaluated for small areas or population patterns must be evaluated for finite areas of effect	Medium	GIS, Census Data
Population Surfaces	Detailed	Regional Plans/ Corridor/ Project Level	Scenario modeling or integration with grid-based modeling packages is required	High	GIS, Census Data
Environmental Justice Index	Screening/ Detailed	All	Combined analysis of multiple demographic factors is needed	Medium/ High	GIS, Census Data

Source: Adapted from Forkenbrock and Sheeley (2004)

When identifying impacted population groups at the project level, the scale of geographic analysis selected requires special consideration. The selected scale should provide detailed information about the population characteristics within the impacted area. According to a Cambridge Systematics, Inc. study (2002), counties and census tracts are usually employed for statewide planning; census tracts, census block groups, Traffic Analysis Zones (TAZs) and neighborhoods are used for metropolitan planning; and census block groups, census blocks, or individual households are used for project development. Box 3.1 summarizes the findings of a recent MPO survey regarding the scale of geographic analysis used by MPOS for EJ analysis for their Long-Range Transportation Plans (Lederer et al., 2005).

Box 3.1 Scale of Geographic Analysis Used by MPOs for EJ Analysis

A survey conducted from June to September 2003 of the EJ analysis methodologies used by MPOs for their Long-Range Transportation Plans provides insight into the scale of geographic analysis adopted by the 64 MPOs that responded. The responses, summarized in the table below, show that (1) there is no standard approach in terms of the scale of census data used for the identification of EJ communities, (2) smaller MPOs do not necessarily use the more aggregate geographic scale (i.e., census tracts), and (3) larger MPOs tend to use TAZs, because the output from their travel demand models allow them to determine the mobility and accessibility impacts on EJ communities at the TAZ level.

Geographic Scale	% of MPO responses		MPO Population Mean	
	For Identifying Minority Populations	For Identifying Low-income Populations	For Identifying Minority Populations (Million Inhabitants)	For Identifying Low-income Populations (Million Inhabitants)
Block	16	*	0.62	------
Block Group	21	34	1.10	0.93
Tracts	32	31	0.93	0.87
TAZ	17	20	2.50	2.40
Undefined	14	15		
TOTAL	100	100		

*Income or poverty data are not compiled at the census block level.
Source: Lederer et al (2005)

Forkenbrock and Sheeley (2004) recommended the following scale of geographic analysis when using U.S. Census Data:

- large-area census data (i.e., states, counties, and census tracts) for both the initial assessment of corridor studies and when the scale of effects is assumed to be uniform over the impacted area, and
- small-area census data (i.e., block, block group, and TAZs) for both detailed corridor-level and project-level assessment and when the scale of effects requires a high degree of demographic resolution because impacts are not uniform over the impacted area.

Appendix A demonstrates that the geographic scale adopted for identifying EJ communities (i.e., census tract, block, block group, and TAZs) could potentially affect the demographic profiles of the impacted area through the results of a *sensitivity analysis of different geographic scales*. The sensitivity analysis was conducted for a section of the SH 130 toll road in Travis County, Texas. First, the various EJ populations (identified from U.S. Census Data) were mapped at the different geographic scales using vector models. The vector models display the spatial distribution of the EJ and non-EJ population groups by dividing the study area into polygons (i.e., tracts, block groups, blocks, and TAZs). Tracts, block groups, blocks, and TAZs with minority/low-income populations greater than an established threshold were considered to have a target population group. On the other hand, tracts, block groups, blocks, and TAZs with minority/low-income populations lower than the established threshold were considered not to have a target population group. Second, statistical analyses were conducted to compare the proportions of EJ and non-EJ populations at the various study scales. Homogeneity tests were conducted to test whether the true proportions of the EJ and non-EJ populations were identical for the four study scales. The analysis revealed that the conventional approach, which classifies communities into target and non-target populations using threshold values, is sensitive to the geographic scale of analysis used. Figures 3.4 and 3.5 illustrate that the spatial distribution of target and non-target minority/low-income populations in the study area changed when the scale of geographic analysis (i.e., tracts, block groups, blocks, and TAZs) changed. In this regard, the analysis showed that the coarse scale of TAZs used in travel demand modeling might overlook smaller minority/low-income population groups and prevent local analysis (e.g., calculate access to sensitive sites). A more complete spatial distribution of the EJ communities was obtained at the block level, and it is therefore considered more appropriate to assess EJ concerns of toll-road projects with differential impacts on the impacted population. A very detailed scale of demographic analysis (i.e., block level) is thus recommended for toll road projects if (a) the impacts are not uniformly distributed over the impacted area, (b) there is a possibility that smaller low-income and minority communities might be overlooked at more aggregate levels of geographic analysis, and (c) the proposed toll project is perceived to be highly controversial.

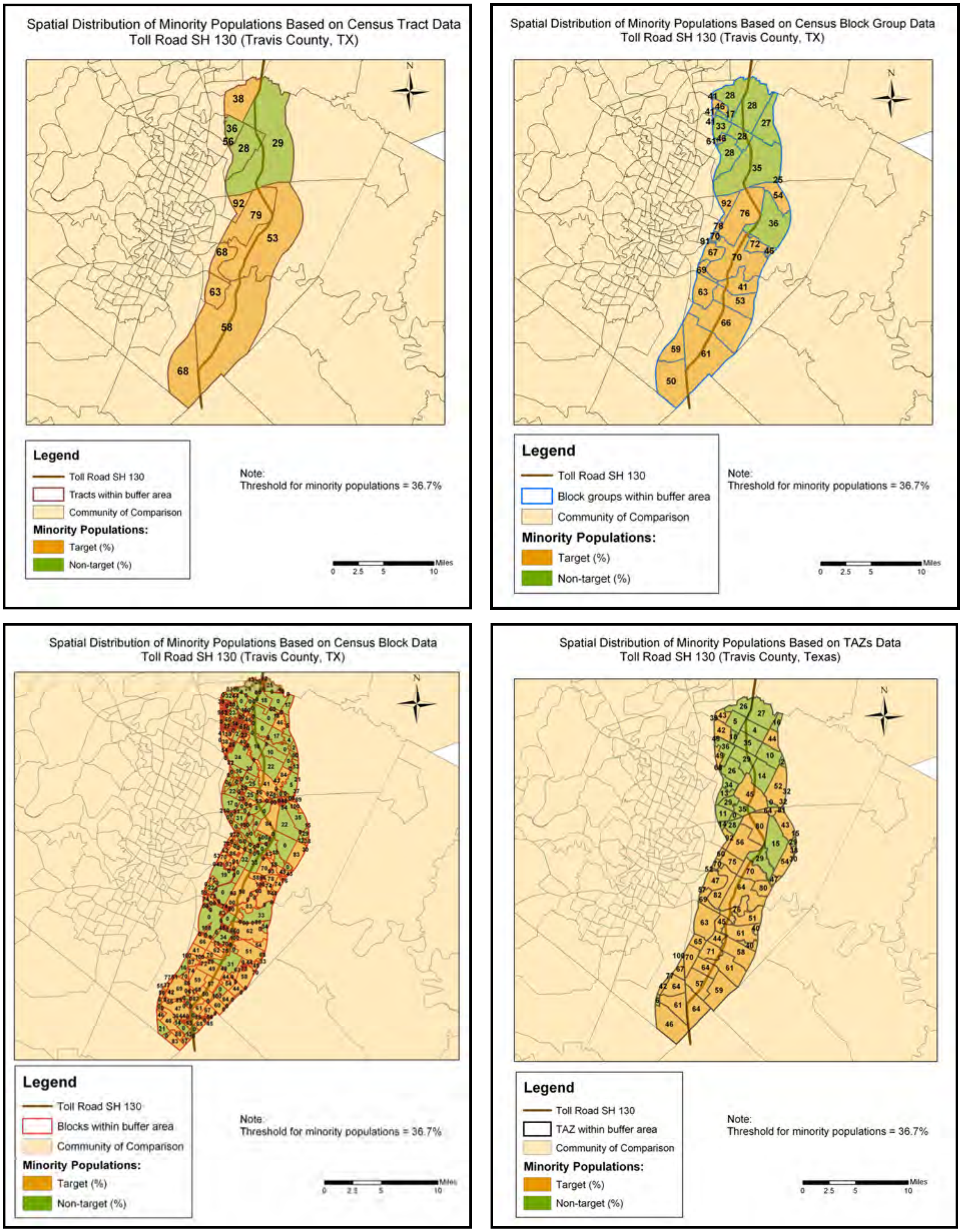


Figure 3.4. Spatial Distribution of Minority Populations Given Different Geographic Scales

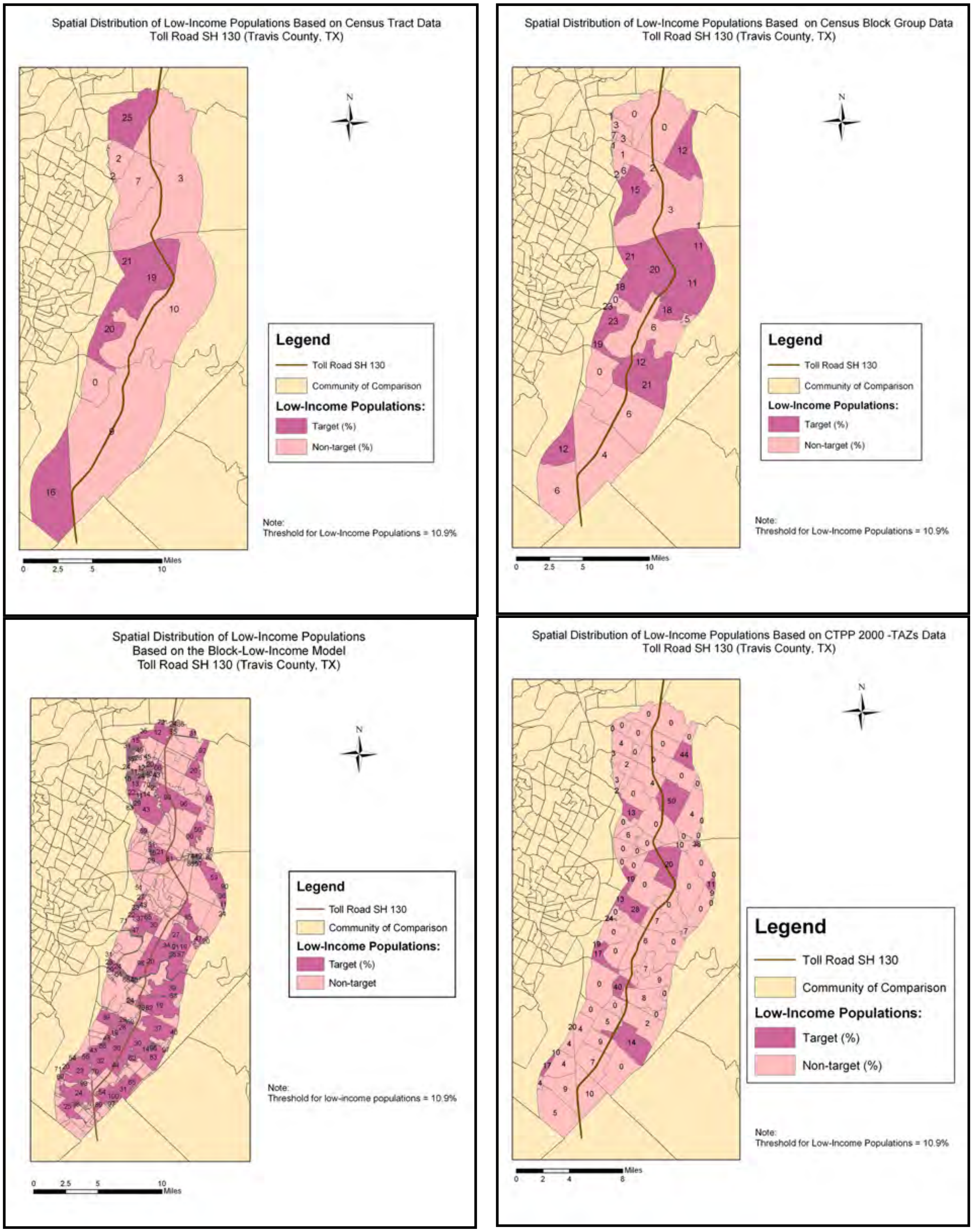


Figure 3.5. Spatial Distribution of Low-Income Populations Given Different Geographic Scales

Table 3.4 summarizes the geographic scales of the EJ data captured in the 2000 census products. Appendix B highlights the content and geographic scales of the census products and lists the variables included in the census data products that are relevant for EJ analysis.

Table 3.4. Race and Income Data Captured by the 2000 Census Products

Geographic Scale	Environmental Justice Data		Census Data Products
	Race	Income	
Census Block	Yes	No	Census 2000 Redistricting Data File (PL-94-171)* Summary File 1 (SF 1)
Census Block Group	Yes	Yes	Summary File 3 (SF 3)
Census Tracts	Yes	Yes	Summary File 3 (SF 3)
TAZ	Yes	Yes	Census Transportation Planning Package 2000 (CTPP 2000)

*A TAZ field included in the redistricting file allows users to aggregate blocks into TAZ summaries.

From Table 3.4, it is evident that income data is not available at the Census block level. An income model, the *block-low-income model*, was thus estimated to address this gap when conducting EJ analyses of toll-road projects that require a high degree of demographic resolution. The *block-low-income model* was estimated at the block group level, using available U.S. Census Data, to estimate low-income populations at the block level. This is possible because there is a perfect correlation between block groups and blocks (i.e., block groups are made up of blocks). The econometric approach to develop the *block-low-income model* is as follows: (a) the "best" ordinary least-square (OLS) model was estimated, (b) relevant analysis was undertaken to determine spatial dependence, and (c) if the latter existed, better estimates were constructed by incorporating spatial effects into the regression analysis. In this regard, two spatial econometric models were estimated (i.e., the spatial lag model and the spatial error model) because the OLS estimates are sensitive to (a) the spatial context of each observation and (b) the presence of estimation errors that are spatially correlated. Finally this approach was applied to data for SH 130 to test the validity of the methodology. Using the 2000 U.S. Census Data available, the "best" OLS model was estimated at the block group level for the impacted area of the section of the SH 130 toll road in Travis County, Texas. The empirical results disclosed that the "best" OLS model did not violate the assumptions of independently distributed observed values and residuals. Close examination of the OLS residuals, however, revealed that three blocks within the impacted area exhibited a significant cluster pattern. Two spatial models were estimated to improve the understanding of this spatial pattern. The spatial lag and spatial error models confirmed the insignificance of the spatial context of the data for the impacted area. The residuals of the spatial error model, however, presented marginally less correlation than the OLS residuals. In this particular case, the spatial distribution of the low-income population based on the "best" OLS model and the spatial error model presented a marginal difference. The results from the empirical application should, however, not be generalized to other study areas. On the contrary, the existence of a spatial pattern should be examined on a case-by-case basis. The empirical results and the relevant findings from the SH 130 case study are presented in Appendix C.

Is There a Potential EJ Concern?

The second step of the EJEM is the identification of EJ communities in the area impacted by the toll road. The Council on Environmental Quality (CEQ) guidelines (1997) states that an EJ community exists if one of the following conditions is present:

- The minority or low-income population exceeds 50 percent in the impacted area.
- The minority or low-income population percentage in the impacted area is "meaningfully greater" than the minority or low-income population in the general population or other appropriate geographic area.
- There is more than one minority or low-income group present and the minority or low-income percentage, as calculated by summing all minority or low-income persons, meets one of the thresholds presented above.

The USDOT and the FHWA require minority populations to be examined separately from low-income populations, but they do not specify specific thresholds for distinguishing minority or low-income communities. Although a low-income person is defined as an individual in a household whose median income is at or below the Department of Health and Human Service (HHS) poverty guidelines, [5] FHWA guidelines allow a state or region to adopt a higher income threshold only if it is not selectively implemented. It must also include all persons at or below the HHS poverty guidelines (FHWA and FTA, 2005).

Several state DOTs and MPOs have adapted the above-mentioned regulatory guidelines to reflect the local demographic characteristics and cost of living in their states and regions. For example, the EJ analysis of the Bay Area's Metropolitan Plan in California—a region with a high minority population and a much higher cost of living than the national average—identified "communities of concern" as zones with (1) more than 70 percent minority residents or (2) more than 30 percent residents with a household income twice the federal poverty level (ICF Consulting, 2003). Furthermore, the criteria used by 64 MPOs to distinguish minority and low-income communities are summarized in Tables 3.5 and 3.6, respectively (Lederer et al., 2005). Most of these MPOs use a threshold approach to identify EJ communities, comparing the demographics of the impacted area with the demographics of a more general area (referred to as the community of comparison or COC).

[5] Since the Department of Health and Human Service poverty guidelines are based on the U.S. Census poverty threshold, this is essentially the same definition as the "very low-income" under the National Guidance for Conducting Environmental Justice Analyses (EPA, 1998). The National Guidance defines the "very low-income" population as persons in households below the U.S. Census Bureau's poverty threshold.

Table 3.5. Criteria Used by MPOs to Distinguish Minority Areas

Criteria	MPO respondents (%)	Comment
Percentage of minority persons greater than the average percentage throughout the region*	65	Several MPOs with large minority populations applied a factor of 1.25 or 2.0 to increase the threshold (the average percentage throughout the region).
Percentage of minority persons greater than 50%*	15	CEQ guideline
Percentage of minority persons greater than absolute standards*	16	Some MPOs with large minority populations (that may actually constitute a majority of the population) adopted absolute standards that were as high as 70% and 90%.
Divide the region into minority quartiles and compare the impacts in the various groups	4	---
TOTAL =	100	

*Threshold approach
Source: Lederer et al. (2005)

Table 3.6. Criteria Used by MPOs to Distinguish Low-Income Areas

Criteria	MPO respondents (%)	Comment
Percentage of low-income persons greater than the average percentage throughout the region*	38	Based on HHS poverty guideline
Compare the average income with a specific income level*	25	Specific income level: HHS poverty level multiplied by a factor Average income of the region multiplied by a factor 65% of the statewide median 75% of the MPO median income level 80% of the median county family income 50% of the median household income
Percentage of low-income population greater than 50%*	14	CEQ guideline
Percentage of low-income persons greater than an absolute percentage*	10	20% or 30%
Divide the region into income quartiles and compare the impacts in the various groups	13	---
TOTAL =	100	

*Threshold approach
Source: Lederer et al. (2005)

It is important to emphasize that the use of thresholds for identifying EJ communities is a function of the geographic scale of analysis chosen, the socio-demographic characteristics of the COC, and ultimately the geopolitical unit chosen (e.g., state, county, etc.) for the COC. For example, using the Texas poverty rate as the threshold to identify EJ communities may overlook some EJ communities at the project level. From Table 3.7 it is evident that some of the most populous Texas counties, such as Harris and Dallas, have a lower estimated poverty rate than the state (U.S. Census Bureau, 2005a and 2005b), while several less-densely populated counties, such as Cameron and Hidalgo, have poverty rates almost at or above 35 percent. Using the state as the COC and thus the state poverty rate as the threshold value to identify EJ communities in an impacted area in Harris County, for argument's sake, could potentially overlook a number of low-income communities impacted by a toll project.

Table 3.7. Texas Poverty Facts (2002)

County	Estimated Poverty Rate (%)	Total Poor (Inhabitants)
Collin	5.2	28,967
Williamson	5.7	16,323
Fort Bend	7.2	28,285
Denton	7.3	34,869
Montgomery	7.4	24,007
Tarrant	11.6	173,307
Galveston	12.8	32,846
Harris	14.6	512,131
Travis	14.8	122,607
Dallas	15.2	341,573
Bexar	15.6	219,384
Nueces	23.1	71,233
El Paso	26.7	182,362
Cameron	34.8	121,577
Hidalgo	36.2	220,153
Texas (Total)	15.6	3.3 million

Appendix D proposes an innovative approach for identifying EJ communities impacted by a toll project. The approach uses U.S. Census Data, spatial autocorrelation measures, and GIS modeling in vector and raster data structures to categorize minority and low-income communities and to define zones with small, medium, high, and extremely high levels (concentrations) of EJ populations within the impacted area (see Figure 3.6 and Figure 3.7). This approach, therefore, overcomes some of the limitations of the threshold analysis that divides communities into two groups (i.e., target EJ population and non-target EJ population) and whose results depend on the community of comparison (COC) chosen and the geographic scale of analysis used. The described approach was tested using data for the section of the SH 130 toll road that traverses Travis County, Texas (see Appendix D). If notwithstanding the threshold approach is used, it is recommended that the COC specified is only one level more aggregate than the geopolitical unit chosen for developing the demographic profiles of the impacted area.

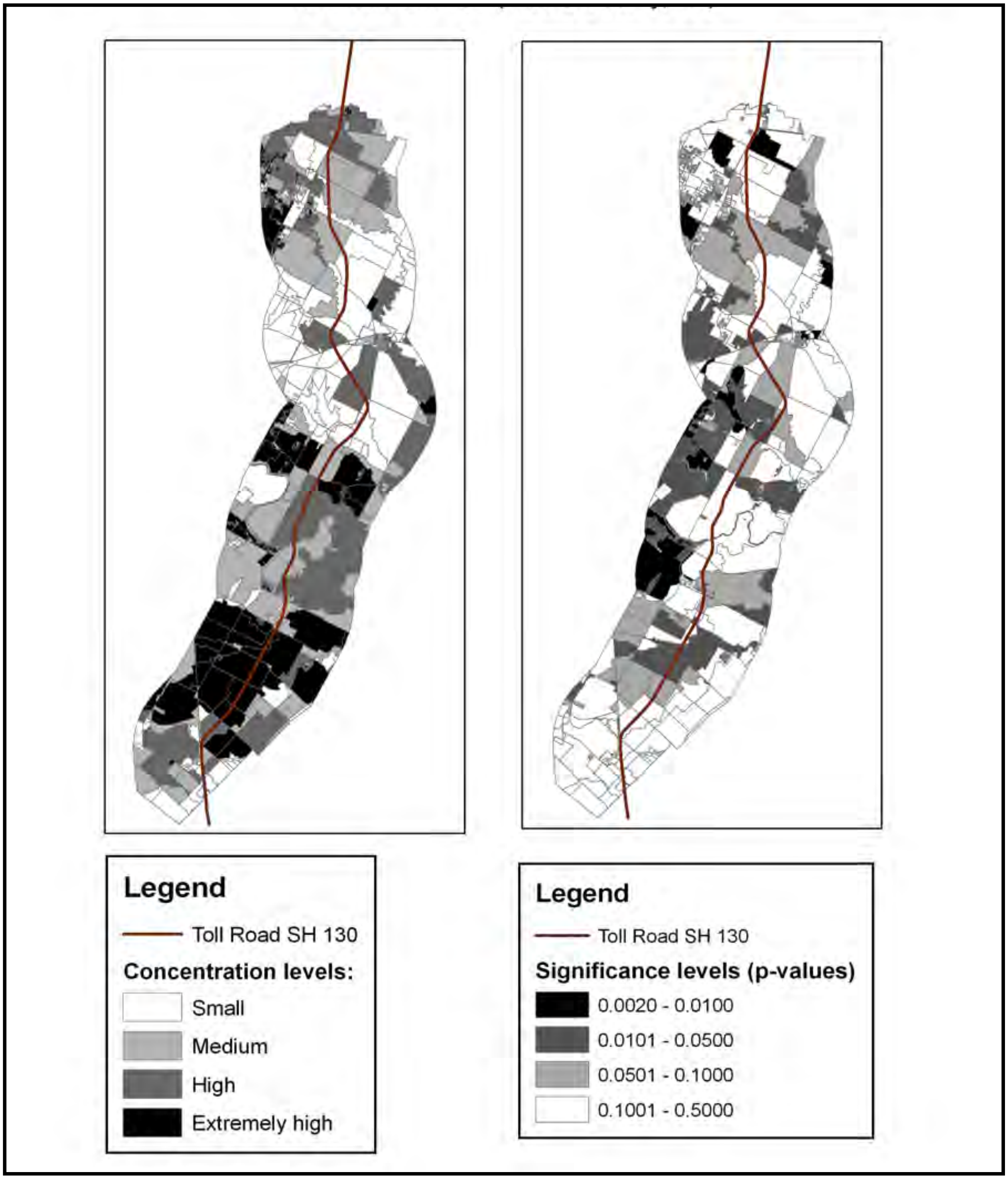


Figure 3.6. Minority Population Concentration Levels within the Impacted Area

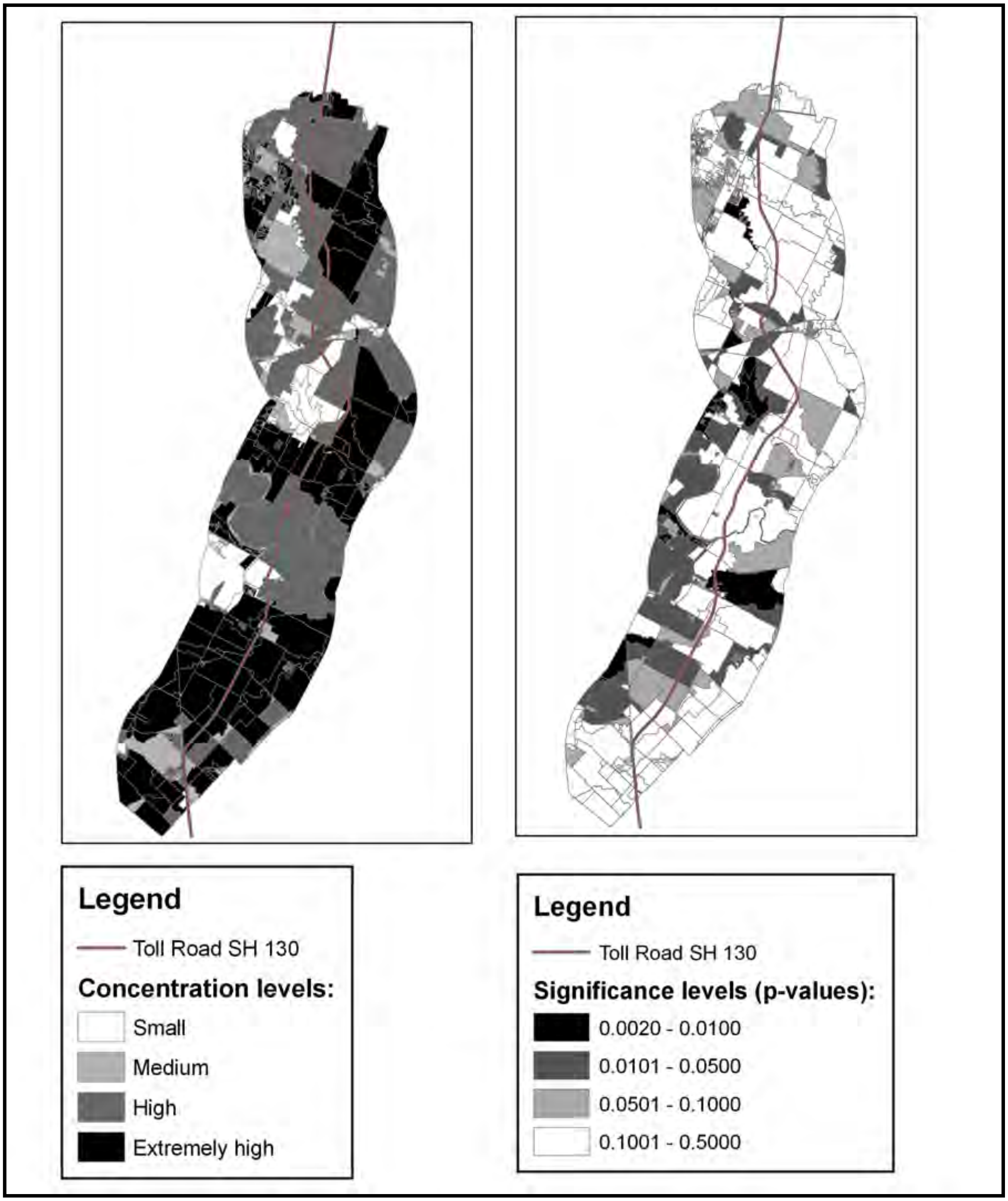


Figure 3.7. Low-Income Population Concentration Levels within the Impacted Area

What are the Additional Impacts of Concern Imposed by the Toll Roads versus the Non-Toll Roads?

The objective of step 3 of the EJEM is to determine the additional impacts of concern imposed by a toll road (alternative 2) compared to a non-toll road (alternative 1), given the four conceptualized scenarios (see Figure 3.8).

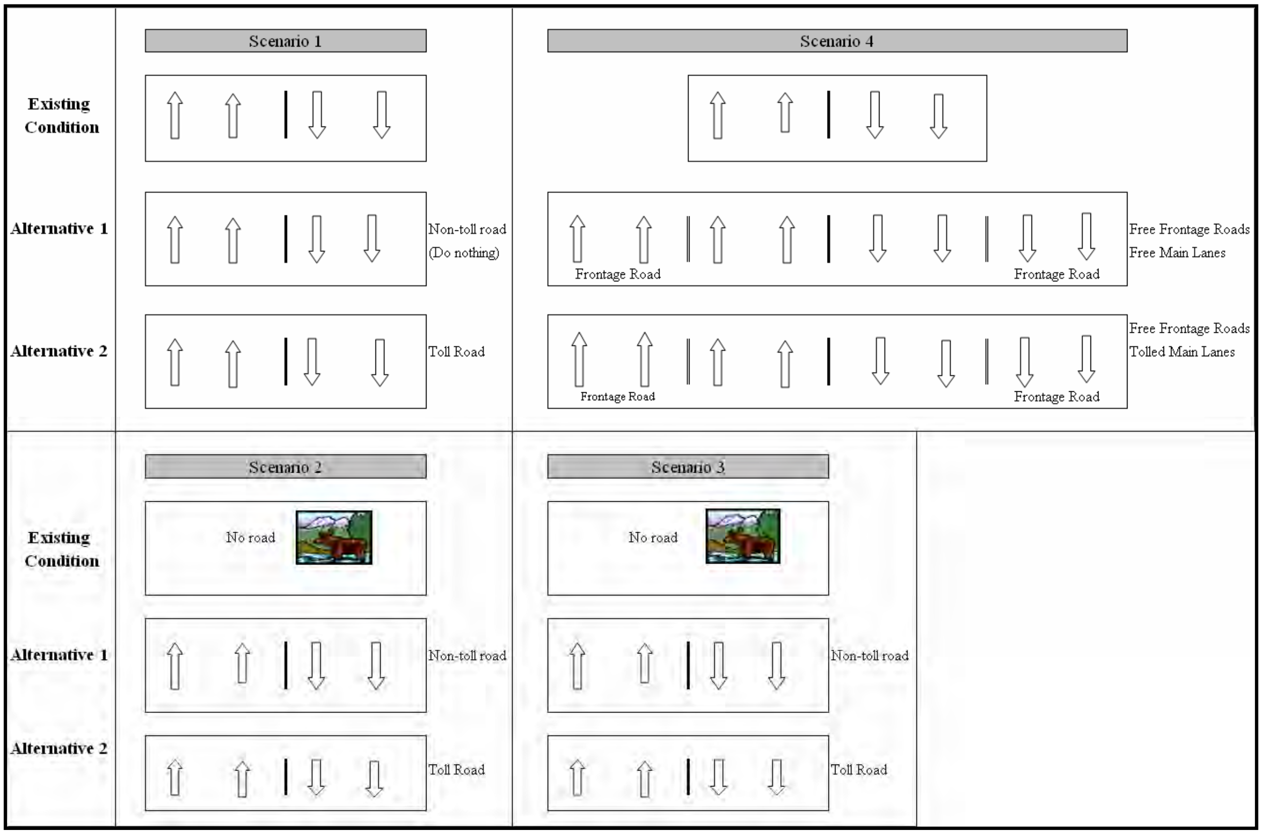


Figure 3.8. Schematic Representation of the Compared Alternatives Given the Four Studied Scenarios[6]

Persad et al. (2004) synthesized the impacts associated with tolled facilities in the U.S. and abroad (see Table 3.8) in a TxDOT technical report entitled "Impacts of Toll Projects and Simplified Methodology for Candidate Evaluation Road." The listed impacts were critically reviewed to identify the potential additional impacts of toll roads relative to non-toll roads on EJ communities.

[6] See Table 3.2 for an explanation of the toll scenarios.

Table 3.8. Potential Impacts of Toll Roads

Impact	Outcomes
Air quality (pollution)	If traffic is diverted through neighborhoods adjacent to toll roads, then these neighborhoods may experience higher levels of pollution.
Mobility (ability to move between different activity sites measured by average travel speed or time)	Because of significant travel speed improvements, significant time savings accrue to commuters who can afford the toll.
Accessibility (number of opportunities—also called activity sites—accessible within a certain distance, travel time or trip cost)	Toll roads improve the access of upper-income commuters. For lower-income commuters, the extra cost imposed by the toll may result in less access to services and opportunities.
Route and trip time shifting	Low-income commuters may be forced to change their trip times to avoid congestion on non-toll roads, or low-income shoppers may have to go to other shopping centers to avoid paying a toll.
Safety	Diverted traffic through neighborhoods adjacent to toll roads may pose a higher safety risk to residents, pedestrians, cyclists, and local drivers in these neighborhoods.
Property values and land use	Higher prices of housing units near toll nodes because of increased access to services and opportunities. Industries and businesses that value mobility and reliability tend to locate at nodes and along connectors, which in turn attract high-income developments and leisure businesses.
Social	For low-income individuals, tolls are an additional expense and therefore they may be forced to live and work close to non-toll roads. Since property values tend to be higher at toll road nodes, these areas may become unaffordable for low-income individuals. Toll roads thus have the potential to encourage segregation of population groups by income level.
Economic	Potential positive effects in terms of business relocations, increases in employment, and increased tax revenues.

Source: Adapted from Persad et al. (2004)

The following questions and examples of sub-questions were explored to determine the additional impacts (i.e., benefits and burdens) imposed by toll roads on EJ communities given each of the four toll road scenarios compared to non-toll roads:

- What are the additional physical environmental quality effects?
  - Will the toll road result in a substantial amount of traffic being diverted through an EJ community? If yes, what are the additional air pollution impacts? If yes, what are the additional noise impacts?
- What are the additional mobility and safety effects?
  - Will the toll result in low-income drivers being "priced out" of certain trips?
  - What reasonable alternative transportation modes are available to those who cannot afford the toll?
  - Will EJ individuals be forced to use less desirable (to them) modes or routes to satisfy their mobility needs?
  - Are there adequate reasonable non-tolled north/south and east/west corridors to serve as alternative roads?

- Will diverted traffic through EJ communities impose a higher safety risk to local pedestrians and bicyclists?
- How will the toll road impact transit (e.g., altered bus routes, transit routes/schedules)?

• What are the additional social and economic effects?
  - Will the non-toll alternatives be equitable in terms of travel time or distance?
  - How will the toll road impact business access for both customers and deliveries?
  - Will the toll road displace a larger number of residents and businesses compared to the non-toll roads?
  - How will the toll road impact (commercial versus residential) property values?
  - How will the toll road impact the access of EJ communities to work, schools, hospitals, etc.?

• What are the additional cultural effects?
  - How will the toll road impact access to cultural resources (e.g., discourage access to historic sites, historic landmarks, and recreational areas)?

The answers to these and other questions were based on an in-depth literature review of (1) the potential ecological, social, and economic impacts of highway investments, including priced facilities, and (2) the socio-demographic characteristics of the users of priced facilities. The outcome was a detailed *Toll Road Impact Matrix* (see Appendix E) that may be used by the transportation agency as a reference when identifying the additional benefits and burdens associated with toll roads (alternative 2) as compared to non-toll roads (alternative 1). The four columns of the matrix represent the four toll road scenarios and the rows represent potential toll project impacts. The entry cells provide examples of the potential additional benefits and burdens associated with the toll road relative to the non-toll road.

Finally, NEPA requires that the transportation agency distinguishes among and consider direct, indirect, and cumulative impacts associated with transportation investments, including toll roads. Box 3.2 provides the CEQ definitions for each of these types of impacts. The potential additional impacts included in the toll road impact matrix have to be reviewed in light of these definitions.

Box 3.2 Direct, Indirect and Cumulative Impacts Defined

"Effects" include:

(a) ***Direct effects*** [emphasis added], which are caused by the action and occur at the same time and place.
(b) ***Indirect effects*** [emphasis added], which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth-inducing effects and other effects related to induced changes in the patterns of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems." (Sec. 1508.8 Effects)

"***Cumulative impact***" [emphasis added] is the impact on the environment, which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time." (Sec. 1508.7 Cumulative impact)

What is the Magnitude of the Additional Impacts?

The objective of the EJEM is to determine whether a toll road would burden EJ populations disproportionately as compared to non-EJ populations. This requires the measurement of the additional impacts—both positive and negative—that minority and low-income populations are most likely to experience as a result of the proposed toll road. Step 4 of the EJEM thus requires the measurement of the additional impacts associated with toll roads relative to non-toll roads. A number of measures and analysis techniques have been identified for quantifying or qualitatively describing the EJ impacts (see Table 3.9).

Table 3.9. Measures and Analysis Techniques to Assess EJ Impacts at the Project Level

Impact	Measure	Type of Analysis
Ecological Impacts	Air quality	Quantitative
	Noise	Quantitative
Socio-economic Impacts	Accessibility to employment, shopping and community services	Quantitative and Qualitative
	Community cohesion	Quantitative and Qualitative
	Economic development	Qualitative
	Displacement	Quantitative
	Safety and security	Qualitative
	Aesthetics	Qualitative
	Percent of income spent on transportation	Qualitative

Source: Adapted from Cambridge Systematics, Inc. (2002)

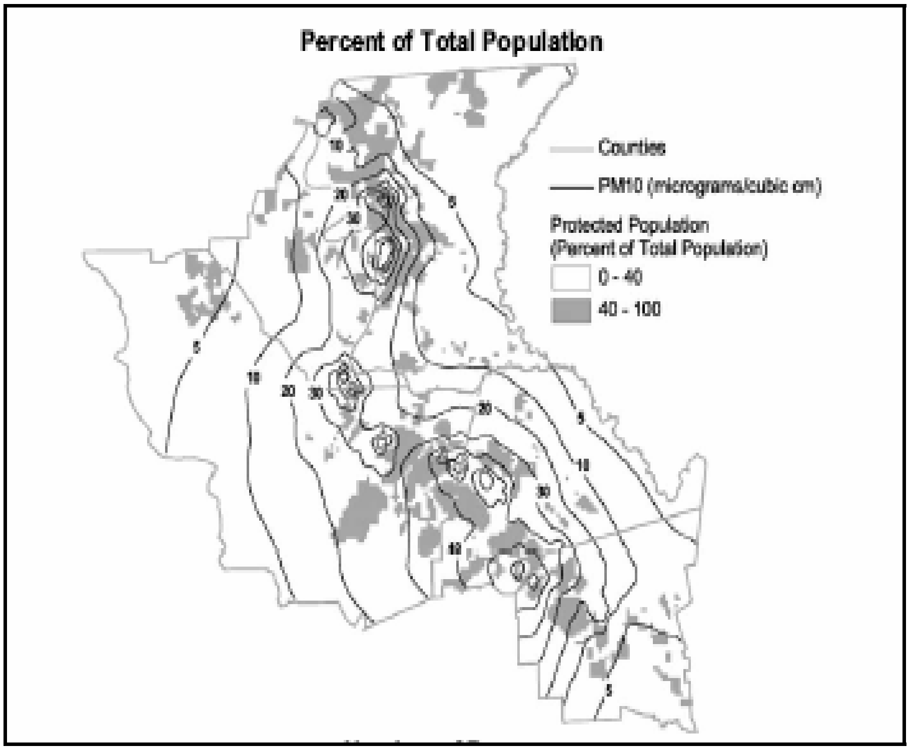
The literature review provided insights into the strengths and weaknesses of the traditional types of analysis tools and models available for measuring the ecological and socio-economic impacts of transportation projects among different population groups. The following paragraphs provide a brief overview of the strengths and weaknesses of some of these analysis methods.

Questions, Interviews, and Panels are useful techniques to identify and collect information on the social and environmental impacts associated with a particular project. Information can be gathered through key person interviews with opinion leaders, indigenous peoples, and technical experts (Executive Office of the President, 1997). For example, researchers tend to use surveys and focus groups to determine the impacts of proposed transportation projects on community cohesion. Neighborhood surveys, however, only measure community cohesion at a specific point in time. In other words, neighborhood surveys cannot be used to predict how cohesion might be affected by a significant change in the community. Focus groups can be used in situations where the views of a few knowledgeable participants are considered representative of the majority view, a technique recommended for use in small communities in which cohesion is weak to moderate or in medium-sized communities where cohesion is strong (Forkenbrock and Weisbrod, 2001).

Checklists detailing likely impacts associated with a particular project can provide a framework for analysis. This might prevent important impacts from being ignored. At the same time, checklists are repeatable, provide consistency when similar projects are evaluated, and can present information in a concise manner. Checklists might, however, be incomplete, list a number of irrelevant impacts, or double-count impacts (Executive Office of the President, 1997).

Modeling tools, such as air quality models and travel demand models, can be used to quantify the cause and effect relationships of specific projects. In addition, simulation models can be used to simulate the environmental and socioeconomic effects of various actions over time and space. Developing project specific models are, however, costly in terms of resources, time, and data. In general, it is advised that an agency calibrate an existing and recognized model using collected baseline data rather than develop a new model. Sophisticated models also necessitate numerous assumptions, which can taint the likelihood of public understanding and acceptance of model outputs (Executive Office of the President, 1997). For example, traditional transportation air quality assessment methods—both micro-scale and regional air quality assessment methods—have been found to have severe limitations in revealing disproportionate or adverse impacts on EJ populations at the project level (Bachman et al., 2000). The micro-scale methodologies, such as CALINE and CAL3QHC, provide an indication of how populations at “worst case sites”[7] (i.e., hot spot sites) are affected. However, the results cannot be extrapolated beyond the evaluated sites and, therefore, cannot be used to assess the variability in pollutant levels across exposed population groups. At the same time, regional air quality models, such as MOBILE6, assume a relatively uniform distribution of pollutants across the study area. Because the analysis does not allow for geographical disaggregation below the regional level, it is impossible to compare the magnitude of the emissions impacts by population group. Air quality analysis using pollution surfaces, such as CALRoads View, on the other hand, provides the regional variability in air quality (see Figure 3.9) that the above two cited methods fail to provide. Pollution surface analysis is, however, extremely data intensive and has not yet received the level of regulatory approval that the micro-scale analysis and regional air quality assessment methods have (Forkenbrock and Weisbrod, 2004).

[7] Typically around intersections in the study area.



Source: Forkenbrock and Weisbrod (2004)

Figure 3.9. PM_{10} Concentration Levels and Protected Population Areas within a Regional Study Area

Urban travel forecasting models have traditionally been used to estimate the impacts of transportation projects on trip distance and the spatial distribution of trips (FHWA, 1983). Newer activity-based approaches can, in addition, consider the interdependences in the trip decisions made by individuals (RDC, Inc., 1995). According to Forkenbrock and Weisbrod (2004), the Transportation Analysis and Simulation System (TRANSIMS) is a state-of-the–art, activity-based model that can (a) replicate a virtual metropolitan region with a completely disaggregated population and (b) simulate the movements of individual travelers across the transportation network using multiple modes. The model can thus forecast how infrastructure investments might impact individual trips by time of day and forecast the impacts on different sub-population groups (e.g., EJ communities) by considering their demographic characteristics. As stated earlier, simulation models are, however, costly in terms of resources, time, and data.

Overlay Mapping and Geographic Information Systems (GIS) allow the analyst to (1) overlay the socio-demographic characteristics of the impacted community and the anticipated impacts and (2) assess whether the measured impacts affect minority or low-income communities disproportionately compared to non-EJ communities. These map overlays can also be very useful in communicating adverse impacts and proposed mitigation options to the impacted communities.

Economic Impact Analysis determines the economic impacts and well-being of a community by considering the changes in business activity, employment, income, and population attributable to an activity, such as toll road building. Economic models (i.e., economic base models, input-output models, and econometric models) can be very complex and data intensive, but, in general, economic models are invaluable in the analysis of economic impacts (Executive Office of the President, 1997).

Social Impact Analysis entails the subjective perception of impacts. This type of analysis appraises the impacts of particular activities on certain key social variables. Key social variables include: population characteristics (e.g., the ethnic and racial diversity of the community), community and institutional structures (e.g., the activities of religious organizations), political and social resources (e.g., the leadership capacity within the community), individual and family changes (e.g., changes in family and community networks), and perceptions of risk, health, and safety. A number of methods can be used to determine social effects, including linear trend analysis, expert testimony, and simulation modeling (Executive Office of the President, 1997).

The research study provided guidance on the use of a number of tools (see Table 3.10) and analysis methodologies to quantify the additional impacts of toll roads in terms of accessibility, air and noise quality, residential and commercial property values, and pedestrian and bicycle safety as conceptualized in the Toll Road Impact Matrix. The study further evaluated the proposed tools in terms of data needs, robustness, assumptions, required expertise, and cost (see Appendix F).

Table 3.10. Recommended Tools to Measure the Additional Impacts

Effect	Impact	Recommended Tool
Mobility	Access to work Access to educational facilities Access to healthcare facilities Access to shopping centers	✓ TransCAD ✓ UrbanSim ✓ MEPLAN
Physical Environmental quality	Air quality	✓ CALRoads View (CALINE4 + CAL3QHC + CAL3QHCR) ✓ MOBILE 6.2 ✓ EPA's CAMx ✓ SURFER (contours of pollutant concentrations)
	Noise quality	✓ FHWA's Traffic Noise Model (TNM)
Economic Development	Residential property values Commercial property values	✓ Property comparison (Appraiser's Opinion) ✓ UrbanSim
Social	Pedestrian safety	✓ Pedestrian Danger Index
	Bicycle safety	✓ Bicycle Safety Index

Once the additional impacts are quantified, the results can be overlaid with the demographic profile of the impacted area to compare the impacts among zones with different concentration levels of EJ populations.

Are the EJ Communities Disproportionately Impacted by the Toll Road?

Although no clear federal guidance exists on what is a disproportionate or adverse impact, obviously if zones with high concentrations of EJ populations incur most of or significantly more of the burdens associated with a toll project compared to zones with no or low concentrations of EJ populations, there is cause for concern. The literature revealed that a number of studies have employed statistical techniques to determine the extent of burdens on minority and low-income populations relative to non-minority or higher-income reference groups. Step 5 of the EJEM thus attempts to determine whether the impacts imposed by a toll road on zones with medium and high concentrations of EJ populations are statistically significantly higher compared to zones with no or low concentrations of EJ populations. This requires two steps. First, the analyst needs to determine whether the measured impacts (Step 4) with the toll road (alternative 2) are statistically significantly higher than the measured impacts with the non-toll road (alternative 1) by EJ concentration level (i.e., vertical comparison). Second, if a statistically significant impact is imposed by the toll road, the analyst needs to determine whether the impact imposed on zones with high and medium concentrations of EJ populations are statistically significantly higher than the impact imposed on zones with no or low concentrations of EJ populations (i.e., horizontal comparison). Figure 3.10 provides a graphical representation of the vertical and horizontal comparisons that need to be undertaken.

<table>
<tr><th rowspan="2">Alternatives</th><th colspan="6">EJ Concentration Zones</th></tr>
<tr><th colspan="2">Low</th><th colspan="2">Medium</th><th colspan="2">High</th></tr>
<tr><td>1
(non-toll road condition)</td><td>MI_{01}</td><td rowspan="2">↕
↔</td><td>MI_{02}</td><td rowspan="2">↕
↔</td><td>MI_{03}</td><td rowspan="2">↕
↔</td></tr>
<tr><td>2
(toll road condition)</td><td>MI_{11}</td><td>MI_{12}</td><td>MI_{13}</td></tr>
</table>

Notes: ↕ = comparison between the toll and non-toll alternative
↔ = comparison between impacted EJ concentration zones given a statistically significant impact
MI = measured impact

Figure 3.10. Comparisons Required to Determine Significant Impacts

The statistical test to determine whether there is a statistically significant difference between the impacts imposed by alternatives 1 and 2 (i.e., vertical comparison) is the "paired *t* test", based on paired data analysis. In essence, the test determines whether the mean difference between the quantified impacts of alternatives 1 and 2 is statistically significant for zones with low, medium, and high concentrations of EJ populations. To test whether the mean difference is statistically significant, a one-sample *t* test (based on $n - 1$ degrees of freedom) on the differences is carried out. Box 3.3 illustrates how the "paired *t* test" may be applied to determine if a toll road imposes a statistically significant access burden compared to a non-toll road.

Box 3.3 Analysis of Paired Data Using a One-Sample *t* Test

A transportation agency is considering the conversion of a planned non-toll road into a toll road prior to the opening of the road to the public. To assess whether a disproportionate impact will be imposed, access to employment by EJ concentration zone has been estimated using TransCAD. The table below shows the number of employment opportunities that can be reached within 30 minutes by car in zones with high concentrations of minority and low-income populations, given the two alternatives. Does the data suggest that the number of employment opportunities accessible within 30 minutes in zones with high concentrations of EJ populations is significantly less, given the toll road compared with the non-toll road, at a 0.05 significance level?

	Number of jobs accessible within 30 minutes by car		
Zones with high concentrations of EJ populations	**Toll road condition (I_2)**	**Non-toll road condition (I_1)**	Difference (D)
1	19	15	4
2	21	20	1
3	18	22	-4
4	5	8	-3
5	34	25	9
6	12	17	-5

The hypothesis of interest is $H_0 : I_2 - I_1 = 0$ (versus $I_2 - I_1 < 0$). At level 0.05, H_o should be rejected if $t \leq -t_{0.05,5} = -2.015$. Since the value of the test statistic is 0.15, H_o cannot be rejected. Therefore, the data does not provide enough evidence to conclude that access to employment in zones with high concentrations of minority and low-income population is less, given the toll road, at a 0.05 significance level.

Given that a statistically significant impact is imposed by the toll road, the statistical test to determine whether the impact on zones with high and medium concentrations of EJ populations is significantly higher than on zones with no or low concentrations of EJ populations is a "large-sample test" based on differences between population proportions. Assuming a normal distribution, a statistically significant difference exists if the observed difference in the proportion of the impacted zones with high and medium concentrations of EJ populations and the proportion of the impacted zones with no or low concentrations of EJ populations cannot be explained by chance alone. Box 3.4 below provides a hypothetical example of how "inferences about population proportions" can be used to determine whether traffic noise is significantly higher in zones with medium and high concentrations of EJ populations.

Box 3.4 Inferences Concerning a Difference Between Population Proportions

A traffic noise analysis reveals that neighborhoods located near a toll plaza are exposed to noise levels that exceed the FHWA's noise abatement criteria (67 dbA). An analyst has identified the impacted EJ concentration zones by overlaying the racial characteristics of these zones with the results from the noise analysis (see accompanying table). Does the data suggest that the proportion of populations in zones with high/medium concentrations of EJ populations affected by excessive traffic noise is less than the proportion of populations in zones with no/low concentrations of EJ populations at a 0.025 significance level?

	EJ Concentration Zones		
	High/Medium	**No/Low**	**Total**
Total population in the impacted area	m = 569	n = 178	747
Population exposed to noise level > 67 dbA	x = 301	y =156	457
Sample proportion	$\hat{p}_1 = 0.529$	$\hat{p}_2 = 0.876$	$\hat{p} = 0.612$

Let p_1 and p_2 denote the two population proportions. The hypotheses of interest are H_o: $p_1 - p_2 = 0$ versus H_a: $p_1 - p_2 < 0$. At a 0.025 significance level, H_o should be rejected if $Z \leq -Z_{.025} = -1.96$. Since the value of the test statistic is -8.30, H_o must be rejected. The p-value is so minuscule that at any reasonable level α, H_o should be rejected. The data thus strongly suggests that zones with high/medium concentrations of EJ populations are not disproportionately affected by traffic noise compared to zones with no/low concentrations of EJ populations.

Although the statistically significant result from inferences concerning a difference between population proportions does not meet the assumption of random and independent assignment of individuals to locations, this statistical test serves as a useful starting point for a more detailed evaluation of potential adverse impacts (Forkenbrock and Weisbrod, 2004). For a detailed explanation of the statistical tests and specific applications, see Appendix F.

What are Potential Mitigation Options?

Step 6 of the EJEM aims to identify actions to mitigate or offset identified disproportionately high and adverse impacts imposed on zones with high and medium concentrations of EJ populations. Mitigation or enhancement measures comprise (1) avoiding or minimizing impacts by reducing the degree or magnitude of the implemented action, (2) mitigating or eliminating the impact by repairing, rehabilitating, or restoring the affected environment or community resource, (3) reducing or eliminating the impact over time by long-term preservation and maintenance operations, and (4) compensating for the impact incurred. Table 3.11 lists a number of documented mitigation strategies that have been found acceptable by EJ communities to reduce or eliminate the impacts of highways and tolled facilities on their communities.

Table 3.11. Actions to Mitigate or Offset the Burdens Imposed by Toll Projects on EJ Communities

Impact	Mitigation Options
Neighborhood Effects	
Displaced	Temporary or permanent relocation of housing units Construction of new housing units Fair relocation benefits
Remaining residential properties	Renovation of housing units
Neighborhood cohesion, social interaction	Relocation of the entire community Renovation of public areas used for community activities
Disruption of areas of unique significance (cemeteries)	Relocation of graves
Neighborhood safety	Crossing guards at local schools during project construction
Neighborhood traffic patterns	Ban heavy vehicles from neighborhood streets
Access to work	Relocation site accessible by primary neighborhood transportation mode Use of toll revenue to finance transportation improvements, such as new or expanded transit services that benefit low-income travelers Increase the quantity and quality of low-cost transportation alternatives Provide toll exemptions to low-income travelers
Access to community facilities and services	Conversion of former buildings to community centers Construction of parks and community centers
Noise effect	Noise barriers to reduce highway noise levels Soundproofing systems at sensitive sites (e.g., churches)
Local Business Effects	
Displaced	Permanent relocation of businesses
Effects on employment	Fair share of contracts generated by the project earmarked for local businesses
Effects on business access	Maintain or enhance access to local businesses
Economic Development Effects	
Job creation	Fair employment opportunities for local residents during construction phase
Effects on income	Return toll revenue to low-income households in the form of reduced regressive taxes and improved social services Reduce general taxes or other user fees Redistribute toll revenues according to income (i.e., lowest-income individuals receive the largest compensation)

Sources: Litman (1999), FHWA (2000), Lee (2003), DeCorla-Souza and Skaer (2003), and Litman (2004)

Ultimately, however, mitigation actions have to be determined in consultation with the impacted EJ communities.

3.2.2. Effective Public (EJ) Participation

One of the core principles of EJ analysis is the "meaningful" involvement of minority and low-income communities potentially impacted by a proposed toll road in the decision-making process surrounding the proposed toll project. Meaningful involvement is motivated by the fact that:

- EJ communities often face higher environmental risk and burdens associated with a transportation investment, due in part to their limited political influence and resources to participate in the decision-making process (National Environmental Policy Commission, 2003).
- EJ communities have the right to be informed and involved in the decision process regarding toll projects.
- EJ individuals should understand how the toll road impacts them and their communities, and that it is important for them to share their concerns.
- EJ individuals should understand the decision-making process and the critical decision points where their input can make a difference.
- The outcome (i.e., the proposed toll road and the mitigation options) should address the concerns expressed by EJ communities.

In general, transportation agencies recognize the need for and the clear benefits of EJ community participation in the decision-making process surrounding toll projects, but the tasks are often times more challenging than anticipated at first. This section of the report outlines some of the key considerations in informing and involving EJ communities in toll road decisions, as well as guidance on which stages of the EJEM require EJ participation. The approach focuses on the involvement of EJ communities, but in practice, an effort should be made to involve all people traditionally underserved by transportation investments.

EJ Participation: General Approach

Effective public participation techniques have been well researched, but the meaningful involvement of EJ communities requires a new perspective and emphasis, partly because conditions needs to be created that encourage the participation of people who likely do not have technical backgrounds, do not speak English, or do not have previous knowledge of toll road issues. A distinct approach is thus needed to ensure the meaningful participation of low-income and minority communities in the decision-making process regarding toll road projects. The general approach to ensure meaningful participation at each step of the EJEM can be outlined as follows:

- Understanding the EJ community, including the barriers faced by EJ communities and options on how to overcome these barriers,
- Defining the goals of the EJ outreach/participation effort,
- Identifying and selecting the most appropriate participation technique(s), and
- Managing and implementing the selected participation technique(s).

Effective and meaningful EJ participation should, in principle, result in a win-win situation for both the impacted EJ communities and the transportation agency. For example, the transportation agency will face less controversy during the planning, design, and construction of toll projects and the EJ communities will ensure projects that consider their wants and needs.

Understanding the EJ Community

The transportation agency should first and foremost gain a true understanding of the impacted EJ communities. Understanding the impacted EJ communities is imperative in reaching out to these communities effectively and in distinguishing the effort from public participation efforts in general. Without a true understanding of the impacted EJ communities and the barriers that prevent meaningful participation, the transportation agency risks selecting a participation technique or location to hold events that is inappropriate.[8] In addition to gathering basic demographic information describing the population, the transportation agency should be asking questions such as, "How do members of this community live?" and "What do they do from day to day?".

The U.S. Census captures information about a number of variables that can help the transportation agency understand the community and identify potential barriers that might prevent participation in the outreach activities (see Table 3.12).

Table 3.12. 2000 U.S. Census Data Relating to EJ Community Barriers

Attribute	U.S. Census Product	Lowest Geographic Level	Examples of Variables that Describe the Attribute
Household and family type	Summary File 1 (SF1)	Blocks	QT-P10−Households and families: 2000 (household type, household size, family type and presence of own children)
Mobility	Summary File 3 (SF3)	Block groups	P30−Means of transportation to workers 16+ Years
Disability	Summary File 3 (SF3)	Block groups	P42−Sex by age by disability status by employment status for the civilian non-institutionalized population 5 years and over
Work status (part-time, full-time)	Summary File 3 (SF3)	Block groups	P47−Sex by work status
Education (school enrollment and educational attainment)	Summary File 3 (SF3)	Block groups	P147−School enrollment by level of school by type of school for the population 3 years and over (by race) P148−Sex by educational attainment for the population 25 years and over (by race)
Vehicle availability	Summary File 3 (SF3)	Census tracts	QT-H11−Vehicle available and household income
Language	Summary File 3 (SF3)	Census tracts	DP-2−Profile of selected housing characteristics: 2000 (language spoken at home)

Other sources of information that may assist the transportation agency in understanding the EJ community are:

- public and private data captured by the FHWA (2006),

[8] The FHWA highlights a number of techniques that, when used with proper management, overcome many of the barriers to involving minority and low-income people. In almost all cases, the techniques require agency staff to gain an improved understanding of the EJ communities impacted by a transportation investment and the need to take the public participation effort to the communities, as opposed to requiring community members to attend meetings at specified times and locations away from the impacted communities.

- the county maps illustrating the 1999 per capita Food Stamp program participation produced by the U.S. Department of Agriculture's Food Stamp program (U.S. Department of Agriculture, 2006),
- participation data in Adult and Community Education and English as a Second Language (ESL)[9] programs captured by The Department of Education of each state, or county-level information about adult literacy and ESL collected by an equivalent agency,
- information on subsidized apartments by state, city, county and zip code captured by The U.S. Department of Housing and Urban Development (2005), and
- the tables and thematic maps produced by The Modern Language Association—a private organization—that provide information extrapolated from the 2000 Census on the top 30 languages spoken in every state, county, and zip code in the nation by the number of speakers (Modern Language Association, 2006).

Besides basic demographic information, the transportation agency should also gain an understanding of the lifestyles and daily activities of minority and low-income populations potentially impacted by toll road proposals to ensure that selected public participation techniques fit into their lives and, with proper management, get the most useful results. It is thus essential to gain a better understanding of the EJ people and their economic, linguistic, and cultural barriers to meaningful participation and involvement (FHWA, 1996; National Environmental Policy Commission, 2003). Although each community impacted by a toll road project would exhibit unique barriers to participation, there are some common barriers that might be expected (see Table 3.13). These barriers should, however, only be viewed as a starting point.

[9] Although the information captured by the Food Stamp and ESL Programs may be too aggregate to inform EJ assessments at the project level, it may serve as a starting point to develop a profile of a community impacted by a toll road project.

Table 3.13. Typical Barriers Faced by EJ Communities

Barrier	Resulting Challenges
Individuals holding multiple jobs / unusual job hours	Time constraints prevent participation in community outreach activities
Low levels of education/ literacy issues	Less understanding of potential impacts of toll roads Less understanding of rights Unable to provide written responses/comments
Unique family structures (e.g., single parents, multi-generational families)	Time constraints prevent participation due to family obligations, such as caring for children and elderly
Less likely to have modes of personal transportation (i.e., private car)	Greater difficulty getting to community outreach activities Less concerned about toll road projects if they do not intend to use it
Less access to internet / technology / computer literacy issues	Use of Web sites and e-mails to inform and involve EJ communities would be ineffective
Language barriers	Less ability to participate in public involvement efforts Less aware of opportunities to influence toll road project outcomes
Distrust of government agencies	Less likely to participate in community outreach activities
Limited understanding of how a project will affect their lives and how participation in the process would benefit them	Less likely to participate in community outreach activities Need to convince people of their power to influence decisions
Cultural differences	Techniques need to be adapted to consider how cultural groups interact with one another and make decisions

Table 3.14 lists a number of measures that can be implemented to overcome the barriers listed in Table 3.13.

Table 3.14. Overcoming EJ Barriers

Barrier	Examples of Overcoming the Barrier
Individuals holding multiple jobs / unusual job hours	• Take outreach activities to them (e.g., schedule community outreach activities at days and times convenient to EJ people or at an already scheduled community event)
Low level of education / literacy issues	• Hire consultants with special expertise in communicating with people who have low or no education
Unique family structures	• Provide care for children and the elderly during community outreach activities
No modes of personal transportation (i.e., private car)	• Hold meetings at locations accessible by public transit • Schedule community outreach activities at places within the community, such as schools, parks, and community centers • Provide transportation to community outreach activities • Ensure access for the elderly and people with disabilities
Less access to internet / technology / computer literacy issues	• Distribute printed materials at laundry facilities, homeless shelters, employment offices, food banks, post offices, bus stops/transit stations, churches, parks, health clinics, grocery stores, community centers, etc. • Distribute information via local radio stations (National Academy of Public Administration, 2001) • Use flyer inserts in newspapers (e.g., Latino papers) or distribute information via school district newsletters/cultural programs
Language barriers	• Translate public documents, notices, and hearings for limited English speaking populations • Provide translations and use bilingual speakers during community outreach activities • Prepare communication materials for limited English speaking populations (e.g., bilingual flyers, bilingual radio announcements)
Distrust of government agencies	• Work with EJ community leaders to increase the credibility of the participatory planning process (FHWA, 1996) • Hire consultants with special expertise working with minority and low-income populations • Hold public meetings or events in non-governmental (or less traditional) buildings such as schools, churches, and community centers (National Academy of Public Administration, 2001) • Provide opportunities for EJ communities to comment prior to making each decision • Keep the EJ community informed • Reply to EJ public input promptly and respectfully

Barrier	Examples of Overcoming the Barrier
Limited understanding of how a project will affect their lives and how participation in the process would benefit them	• Hold informal meetings early in the process to increase public understanding of how the project may impact the community and why their input is important • Seek public input early in the process and make information available • Involve the EJ communities in decisions that might impact them and in approvals and implementation/Provide opportunities for EJ communities to comment prior to making each decision • Keep the EJ community informed • Reply to EJ public input promptly and respectfully • Hire consultants with special expertise working with minority and low-income populations
Cultural differences	• Identify preferred community outreach techniques (e.g., in Orange County, California, the open-house format and one-to-one interaction made Mexican-Americans uncomfortable, while informal, small-group meetings increased the participation of Latino neighborhoods) (FHWA, 1996) • Work with local church leaders, school principals, community center staff, health clinic staff, etc. to learn more about cultural factors (National Academy of Public Administration, 2001) and to identify venues for outreach activities (e.g., meetings at churches, schools, libraries, or community service centers, or talking face-to-face at individual homes).

Finally, it is important for the transportation agency to determine "How does the EJ community currently receive information? Are there strong religious followings in the community?" By having more knowledge of the typical lives led by people in these communities, the community outreach efforts through which they can best be reached become clearer.

Defining the Goals of the EJ Outreach/Participation Effort

The next step is to define the goals for the public participation efforts. The goals and what can be gained will vary depending on the community and the particular stage in the EJEM. This step is imperative, because the transportation agency should be clear about the information provided to the community and the decisions they can impact to ensure a trusting relationship.

The transportation agency must also be cognizant of the difference between public consultation and public participation (Tyler, 2003). Public consultation implies that the community is, for example, presented a plan with alternatives and then asked for their views and comments. The agency takes these results and then decides which plan to put forward, bearing all of the responsibility for the decision. This is a much more passive way of involving the public and does not necessarily indicate that they have participated in the decision making. They have been considered but they essentially have no ownership or responsibility concerning the project decisions.

Furthermore, public participation efforts can be divided into "inform and involve" techniques (Creighton, 2005). This is helpful to evaluate participation techniques in terms of a specific task and to refocus the transportation agency from the typical engineering mindset of "decide and defend." In the case of EJ communities, it is foreseeable that more time will be required "informing" EJ communities as the interest in toll projects and the willingness to participate may not come as quickly as in other communities. For example, an agency might decide to spend two-thirds of its efforts on "inform" techniques, because the community has shown no previous interest or concern about toll road projects, and spend the rest of the time and resources on "involve" techniques to ensure better results and a more efficient outcome.

Public Involvement Techniques

Methods for enhancing public participation have advanced to a point where a substantial body of knowledge is found in the literature (FHWA, 1996; Lawrence, 2003; Creighton, 2005). These authors have carefully reviewed various techniques to determine their relevance for involving EJ communities to ensure the meaningful participation of these communities in the decision making process regarding toll road projects. In essence, the agency has to consider everything learned about the community and seek techniques that will overcome most of the barriers identified. These might be:

- proven techniques used in other projects,
- completely new techniques, or
- previously used techniques adapted to overcome the barriers to participation of the specific EJ community.

Table 3.15 lists a number of techniques and their strengths and weaknesses as EJ participation techniques.

Table 3.15. Public Participation Techniques

Participation Technique	Details	Strengths	Weaknesses
Personalized Involvement			
Walkabouts	• Door-to-door canvassing of neighborhoods • Inform and involve • Opportunities for surveys/interviews • Opportunities to distribute flyers	• Immediate communication with EJ community members • Takes the project and participation opportunities to the EJ communities • More likely to fit into lives of EJ people	• Large time commitment by agency • Relatively small number of people involved
Personalized Letters	• Send letters addressed to specific individuals • Send personal invitations to events • Send personal informative letters	• Makes an impact on community members if they think their opinions are important to the agency • More likely to capture public interest in the project	• Costly • Might not significantly increase attendance at events
Outreach Booths	• Similar to "info booths" • Set up stands at popular locations within the community • Provide information and involve community members	• Brings participation opportunities to the community • Flexible in terms of time and location • May overcome language barriers	• Many people may not take the time to learn about project and get involved
Local Teams			
Create a Local Team	• Teams formed by local community members concerned about the project • Teams help to inform and involve	• Increase attendance at community outreach activities • More personal • Community members relate to other community members better than to agency staff	• Requires substantial resources in terms of time, manpower, and funding • If the community is transitional or too divided, it may be hard to find leaders who are able to bring a strong effort to the community
Meeting Variations			
EJ Public Meetings	• Integrate into the activities people already partake in, such as church activities and community or school events • Increase attendance by having interpreters, refreshments, and staff available to care for children • Multiple meetings at varying times	• Facilitate a large number of community members to get together • Good attendance may produce many results	• Risks low attendance • May not represent full spectrum of EJ community members

Participation Technique	Details	Strengths	Weaknesses
Open House	• Similar to public meeting but no speeches/lectures • Lots of visual aids • Agency staff speaks to attendees on a one-to-one basis • Opportunities to do surveys/interviews	• Lots of opportunities for feedback • Overcomes language barriers • Flexible in terms of time • Not as strict as public meeting	• Risks low attendance • May not represent full spectrum of EJ community members
Deliberative Polling®	• Representative sample of community participates in deliberations about proposed project • Exposed to continuing dialogue with experts and stakeholders • Participants are surveyed before and after deliberations	• Lots of opportunities for feedback • Informed judgments about toll projects	• Requires substantial resources in terms of time, manpower, and funding • Participants are required to meet at a specified location for a significant period of time (e.g., weekend) • Risks low participation if participants are not compensated • Significant number of barriers to participation (e.g., transportation to location, available time, etc.)
School Programs			
Create School Programs	• Programs to educate the children about the project and then parents receive information from children • Parents attend a school event where children present information and parents participate	• Flexible • Far-reaching • Overcomes language barriers • It can be designed to fit the specific community	• Not all community members connected to school
Media			
Using the Media	• Advertise events/information regarding project using the most popular media resources in area: newspaper, radio, TV, flyers, community news boards, etc.	• Flexible • It can reach a lot of people	• It does not guarantee increased involvement • It can be expensive

For a detailed discussion of various special techniques to enhance public participation, consult the FHWA document entitled “Public Involvement Techniques for Transportation Decision-Making” (FHWA, 1996).

Personalized Involvement

These types of techniques are particularly relevant for involving EJ communities, as they overcome the barriers of time and access that traditional techniques, such as public meetings, do not. In essence, these techniques require the transportation agency to enter the community and take the public participation effort to the community rather than expecting the community to come to the agency. This technique also demonstrates the agency's concern for the community and will help garner trust and interest in the toll project more than other methods. Some of these techniques include "walkabouts," personalized letters, and outreach booths.

"Walkabouts" is essentially a canvassing of the neighborhoods in the impacted area. Agency staff can go to the streets, and as a result, make the toll road project more tangible to the EJ communities. They can pass out information or advertisements for public participation opportunities. At the same time, these "walkabouts" can also incorporate in-home and on-street interviews with members of the EJ communities, thus combining the "inform" and "involve" tasks. This technique was successfully used in the South Park Avenue improvement project in Tucson, Arizona to involve disadvantaged populations (FHWA, 2000).

Personalized letters can be an effective means of communicating with people when many of the EJ community members in the impacted area have permanent addresses. Contacting EJ community members by means of the internet or even telephone may not necessarily be an option as many EJ people might not have access to these resources. It is best to address a letter to a specific person to demonstrate the transportation agency's commitment to the individuals in the community and the agency's desire to get them involved. In the case of the widening of South Carolina Route 72, first-class letters were sent by the mayor, and any that were returned undeliverable were delivered in person by the mayor in an effort to involve minority and low-income communities who were not attending other outreach events (FHWA, 2000). This made a distinct impression on community members. Handwritten letters show an even more personal touch. Variations on this technique are the sending of an information packet or perhaps a survey. Although the response rate to a mailed survey is typically low, the response rate might be increased if the survey is addressed to a specific person. This technique offers room for creativity and innovation and should be considered to increase public participation in the decision making process of toll road projects.

Outreach booths can be considered for EJ communities where time is an important barrier to participation. Outreach booths differ from traditional "info booths" in that besides informing the community about a project, public input can also be received, thereby using the time at these booths with EJ people more effectively. By setting up outreach booths at convenient locations, such as shopping malls or grocery stores, at reasonable times, the transportation agency can integrate the outreach effort into the daily lives of EJ community members without overly inconveniencing them. The outreach booths can be used to achieve multiple participation objectives, such as informing and involving the EJ community about the toll road project. For example, interviews or simple polls can be taken at the booths to get an idea of how people feel about the toll road project. These outreach booths could take multiple forms and are more likely to be successful if placed at a location and at a time when people have a few minutes to spare, such as a weekend. Another excellent location would be a large special event in the EJ community. Finally, participation can be increased by making it fun to stop at the booth or perhaps even adding possible incentives, such as food.

Create a Local Team

A common method that proves successful in increasing public concern and consequently participation is the creation of **a local team**. With trust being a common barrier to participation, the EJ community may not be inspired by the efforts of the transportation agency, or they simply might not listen to authoritative groups. They may, however, listen to their friends and neighbors, their minister at church or their child's teacher at school. The challenge is then how to get these leaders together and take it upon themselves to involve the EJ community in toll road project decisions.

The success of this method varies and it could require substantial resources in terms of time, manpower, and funding. Although the results, if successful, could be tremendous, the risks of failure are unfortunately rather high. Depending on the community, a local team might be very compelling and inspire confidence and concern. However, the community might be too transitional or divided to find leaders who could bring a strong effort to the community. Ideally, the local team should spread the word about the toll road project and the need for community members to participate in the decision process or even spearhead their own participation efforts on behalf of the transportation agency.

Variations on the Traditional Public Meeting

Almost all of the available public participation literature mentions public meetings as one of the most commonly used techniques. Not only are public meetings used often and therefore well understood, they are also often required by law. It is, however, not the idea to schedule a few public meetings and claim that the public participated in the project. This would be unwise, especially in EJ communities, as public meetings potentially overcome few of the barriers to participation faced by these communities. For example, public meetings require community members to attend these meetings at a specified time and location. Also, language and even literacy barriers might not be addressed if there are no alternatives to the main presenter.

Having said this, public meetings can still be effective if they are viewed with a different perspective and adapted to overcome the barriers faced by EJ communities (i.e., **EJ Public Meetings**). Ideally, public meetings provide a forum for a larger number of community members to get together and participate than do the personalized involvement techniques. Given the day-to-day challenges of EJ community members, it is recommended that the public meeting is somehow integrated into the activities EJ people already partake in, such as church activities and community or school events. Also, attendance can potentially be increased by having interpreters, refreshments, and staff available to care for children. At the same time, EJ public meetings can be structured differently. Traditionally, these meetings have been "closed," meaning they took place over a couple of hours and participants had to stay the entire time to hear the information and participate in the meeting. A different, more EJ-friendly version is to have an "open" meeting over a period of time, where people are free to come and go. This version is more like the format of an open house.

The **Open House** is a more social version of the traditional public meeting by allowing community members to interact with agency representatives on an individual basis. The latter is a means to overcome language and literacy barriers if agency staff is fluent in the languages spoken by the EJ community members. Also, having agency staff available to talk to the EJ community on an individual basis removes the need for someone to have to read a poster or pamphlet, for example. The format of an open house can therefore be adapted to fit the needs of the specific EJ community and help make participants feel more involved than a traditional public meeting, which tends to take the format of present and respond. The challenge again is timing and location. Multiple open houses might be effective and, although more time consuming, might result in increased participation. The key is to consider the schedules of EJ community members and integrate the open house into their schedules, resulting in more participation.

Deliberative Polling® (2006a), a technique developed by Professor James Fishkin at The University of Texas at Austin, has shown to be especially suitable for obtaining input regarding issues the public may have little knowledge of. To achieve both representation and deliberation, Deliberating Polling® combines sample surveys and focus groups into a powerful technique for gauging informed public opinion. Representatives of a population are surveyed, and opportunities are provided for residents both to become informed on the issues on which they will be consulted and to voice their concerns (Fishkin, 2006). Polling not only educates participants, but helps them become well-informed citizens who can think about complex issues (Center for Deliberative Polling, 2006b).

<u>School Programs</u>

School programs are a commonly used technique and have proven to be quite effective in encouraging low-income and minority populations to participate. By using schools and the community children as resources, it is possible to overcome multiple barriers faced by EJ communities, including language and literacy. It also fits into the everyday lives of the families.

There are numerous ways the transportation agency could work with community schools to effectively encourage the participation of EJ communities. Schools can be used as an avenue to educate the children about the toll road project and then in return inform their parents about the project by having them take home information about the toll road. Parents can be asked to attend children's presentations about the toll project and provide their feedback about the toll road. A good example where schools formed an important component of the public participation efforts of a transportation project was the Verona Road and West Beltline Needs Assessment Study in Wisconsin. The project team worked with students from the Akira Toki Middle School to inform and involve low-income and minority community members (FHWA, 2000).

Using school programs as a part of the EJ participation plan is not only effective and far reaching in terms of EJ community members exposed to the toll project, it is also very flexible. A school program can be designed to fit the specific school and community and blend into the lives of the students and families without requiring a major effort or time commitment from participants. Additional contact can be made with EJ community members at Parent Teacher Association (PTA) meetings, when family members are already attending the school or following parent-teacher meetings. In the worse case, children can be educated about a transportation investment, such as toll roads, that they probably would not have learned about otherwise and at least bring the topic to the parents' attention by telling them about it. This technique, however, does bias the public participation effort to EJ community members with children or grandchildren in local schools. Although it might be less of a concern in EJ communities as large, multi-generational families are often more common, it should not be assumed that all EJ community members would have a link to the local schools.

<u>Using the Media</u>

The many forms of the media are a common way for individuals, including those in EJ communities, to hear about what is happening in their communities. The media can be used in many ways, from formal advertising to encouraging the local paper to run articles about the proposed toll project. The transportation agency should, however, determine the frequency with which people read newspapers, as some EJ communities might not have high newspaper subscription rates and therefore a small number of people that read the paper. Radio and television advertisements are also options, but they tend to be substantially more costly than simpler methods, such as flyers in grocery bags or bulletins on community news boards at churches. The transportation agency should make an earnest effort to identify the most appropriate media resources to inform the EJ community about the toll project and any planned outreach efforts.

When using media advertisements, it is important that the transportation agency provide an appropriate contact number. The agency must make it clear to the EJ community that their input regarding the toll road project is highly desired and even if they cannot attend the participation events they can contact the agency. Phone numbers, e-mail, and mailing addresses, as well as comment boxes in different locations around the EJ community where people can drop letters or notes, must be made available. By providing as many opportunities as possible for EJ community members to contact the transportation agency, confidence and trust will be instilled with the EJ community that the transportation agency cares about the community's contributions and have their interest at heart.

Manage and Implement the Selected Participation Technique(s)

While the transportation agency might experience some level of success by simply getting the EJ community together and informing them about the toll project and getting basic feedback, the process will be much more meaningful when dedicated and well performed management strategies are in place. This does not necessarily require the involvement of management experts but rather careful planning, organization and preparation.

Each of the public participation techniques listed previously will have specific management requirements, but there are several general concepts to keep in mind. First, everything about the technique and the subsequent participation event needs to be well thought through and planned ahead of time. Any disorganization, down to the setup of seating or the position of posters, can lead to wasted time and effort on the day of the event. Second, the location must be well prepared. Handout materials must be ready and translated into the languages spoken in the EJ community if English is not the only language spoken. Third, staff must be well trained and prepared in terms of what they have to say and questions to ask to give the best impression to the EJ community and extract the most useful contributions from those attending. Fourth, time management is essential, and allotting time for different components of the event will be helpful in making the best use of the little interaction time the agency staff typically will have with those participating. Finally, the transportation agency could demonstrate to the EJ communities that their inputs are important by showing EJ participants what was gained from past public participation efforts and how it affected the project outcome. This is especially important when reaching out to EJ communities, as one of the key issues is to build trust between the agency and the community.

Effective EJ Participation Component

The overall objective of the transportation agency should be to ensure meaningful representation and participation by minority and low-income individuals living within the impacted area of the toll road in the decision process. EJ outreach efforts are foreseen in various stages of the EJEM to ensure that (1) all EJ communities are identified and given the opportunity to participate in a meaningful way, (2) all the adverse impacts are identified and prioritized, (3) the measured impacts are shared with the impacted EJ communities, and (4) effective mitigation options are designed in consultation with the impacted EJ communities to lessen or offset identified disproportionately high or adverse impacts.

Who Would be Impacted?/Is there a Potential EJ Concern?

EJ communities should be invited to participate in the decision-making process of toll road projects as early as possible. The goals of the EJ outreach effort during this step of the EJEM are to:

- Validate the U.S. Census data used to identify EJ communities within the impacted area.
- Identify potential "avenues" that can be used to distribute information about the proposed toll project to minority and low-income people living in the impacted area.
- Obtain input from those who can speak on behalf of the entire EJ community. In other words, identify and engage individuals who can represent the views of the impacted EJ communities, such as presidents of neighborhood associations, religious/community leaders, school district officials, environmental group leaders, leaders of charity organizations, elected local government representatives, and local health officials.
- Identify the most appropriate participation technique(s) for informing and involving the impacted EJ communities.
- Identify strategic locations for liaising with EJ communities to ensure participation efforts span all of the potentially impacted EJ communities.

Depending on the impacted community, a telephone survey and/or personalized letter and mail survey might be appropriate participation technique(s) to contact and engage individuals from community-based organizations who can represent the views of the impacted EJ community. During the survey, the transportation agency should include questions that can help the agency gain a better understanding of the impacted EJ communities and questions that can help inform the development of future outreach activities, such as questions that provide information about the following:

- Number of minority and low-income people served or represented by the organization,
- Awareness of proposed toll roads and foreseen potential impacts to help establish the existing level of awareness of the toll project,
- Preferred language(s) of communication,
- Willingness to participate by informing the community about the proposed toll project and or facilitating future EJ outreach activities,
- Preferred community outreach activities (e.g., formal meetings, informal meetings, focus groups, telephone surveys, personal interviews, and mail questionnaires),
- Strategic locations (e.g., markets, schools, libraries, and parks), days, and times most appropriate for obtaining input from EJ communities, and

- Special arrangements required to ensure community participation (e.g., childcare and transportation for those who do not have means to get to the meeting places).

By contacting these community-based organizations early on, the transportation agency will gain a better understanding of the potentially impacted EJ communities and how to inform and involve them in the subsequent steps of the EJEM. Specifically, the survey responses will (a) provide insights into the minority and low-income communities that need to be targeted, (b) identify preferred community outreach efforts, and (b) engage community leaders who are willing to participate and facilitate subsequent outreach activities. The research team conducted a telephone survey with a sample of neighborhood associations, school officials, and religious organizations representative of EJ communities in the impacted area of the toll road system planned for Central Texas. The results of this survey are summarized in Appendix G.

What are the Additional Impacts of Concern Imposed by the Toll Road versus the Non-Toll Road?

The goals of the outreach effort during this step of the EJEM are to inform the EJ community about the proposed toll road project (educate the community) and involve the community by obtaining their views and concerns about how the proposed toll project will impact their trips and community.

It is imperative that the EJ community and representatives of the community be educated about the proposed toll project and gain an understanding of the potential impacts to ensure an informed and meaningful discussion and prioritization of the impacts of concern surrounding toll roads relative to non-toll roads. The EJ assessment of toll road projects is especially complex, because toll roads may impose substantial burdens as well as benefits on EJ communities compared to non-toll roads. For example, the conversion of an existing non-toll road into a toll road may have a disproportionate impact on low-income drivers if they have to shift to congested roads to get to their workplaces to avoid the toll. On the other hand, local minority communities may benefit from the conversion and operation of a non-toll road into a toll road if it generates employment opportunities for them. Furthermore, EJ people might be unsure of how a toll road may impact them, especially if they do not have their own cars and tend to use public transportation. Obviously, benefits and burdens imposed by a toll road project on EJ communities cannot be generalized and should be examined at the project level.

Once the communities understand the technical issues and can articulate their views and concerns, meaningful and informed participation can be accomplished. At this stage, EJ people should thus be in a position to articulate how they think the proposed toll road would impact their activity space (i.e., the places where they live, work, shop, and partake in other activities).

A number of avenues exist to share information about the proposed toll project, such as personalized letters, outreach booths, church bulletins, neighborhood organization newsletters, public meetings, open houses, and the media. On the other hand, focus groups, mail questionnaires, personal interviews, and walkabouts can be used to obtain the input of potentially impacted EJ communities. At least two techniques—school programs and Deliberative Polling®— can be used to both inform and involve the community.

The EJ input received during this step of the EJEM can be used by the transportation agency to finalize and prioritize the additional impacts associated with the toll road compared to the non-toll road. Appendix H contains the results of the personal interviews that were conducted in a number of EJ communities that could potentially be impacted by the SH 130 toll road and the toll road system planned for Central Texas.

Are the EJ Communities Disproportionately Impacted by the Toll Road?/What are Potential Mitigation Options?

The goals of the EJ outreach effort during this step of the EJEM are to inform the EJ community about the magnitude of the additional impacts (benefits and burdens) associated with the proposed toll road project compared to the non-toll road (educate the community) and to involve the EJ community in the conceptualization and design of acceptable options to avoid, minimize, or mitigate any disproportionate impact on the community.

The transportation agency should thus present up front the measured benefits and burdens imposed by the toll road project on the EJ communities calculated in steps 4 and 5 of the analytical component of the EJEM. Table 3.16 presents a number of performance measures that can be calculated and shared with the impacted EJ communities. The table also highlights the simplicity and clarity of these measures in terms of communicating and sharing them with EJ communities. Once the EJ communities have gained an understanding of how they will potentially be impacted by the toll road, appropriate mitigation options can be designed. EJ communities should be active in the decision-making process, including problem solving to mitigate or remediate the disproportionate adverse impacts the toll road may have on their communities. Ultimately, these mitigation options should help ensure that the toll road project is designed, built, and operated without disproportionate disruption to the EJ community.

Table 3.16. Environmental Justice Performance Measures

Impact	Performance Measures	Simplicity and Clarity
Physical Environmental Quality		
Air Quality	Carbon Monoxide (CO) Particulate (PM_{10}, $PM_{2.5}$) Ozone (O_3)	Geared for technical audience
Traffic Noise	Noise levels (dB)	Easy for public to relate to
Mobility		
Accessibility	Number of jobs accessible by auto/transit within a specific travel time threshold	Varies, usually geared for technical audience
	Number of educational facilities accessible by auto/transit within a specific travel time threshold	Varies, usually geared for technical audience
	Number of healthcare facilities such as hospitals and nursing homes accessible by auto/transit/foot within a specific time span	Varies, usually geared for technical audience
	Number of shopping centers accessible by auto/transit within a specific travel time threshold	Varies, usually geared for technical audience
	Number of recreation centers accessible by auto/transit within a specific travel time threshold	Varies, usually geared for technical audience
	Number of recreational facilities such as parks, playgrounds, and pools, accessible by auto/transit within a specific travel time threshold	Varies, usually geared for technical audience
	Walk to transit (number of bus stops within a ¾ mile radius)	Varies, usually geared for technical audience
	Walk to community facilities (number of schools, libraries, hospitals, and senior centers within a ¾ mile radius)	Varies, usually geared for technical audience
Safety		
Bicycle use	Changes in the number of injuries	Easy for public to relate to
Pedestrian use	Changes in the number of injuries	Easy for public to relate to
Social and Economic Impacts on Neighborhood		
Displacement of residential properties	Number of displaced residents	Easy for public to relate to
	Number of displaced homes	Easy for public to relate to
	Value of displaced homes	Easy for public to relate to
Neighborhood cohesion, social interaction	Changes in the number of households within neighborhoods	Public can relate to
	Average distance moved of displaced residents in their neighborhood	Public can relate to
	Number of displaced residents with at least one relative in their neighborhood	Public can relate to
	Number of residents working within a specific distance of their neighborhoods	Public can relate to
	Changes in community support activities (e.g., residents provide child care and transportation to one another)	Public can relate to
Neighborhood traffic patterns	Changes in vehicle volumes on local streets	Varies, public can relate to
	Changes in truck volumes on local streets	Varies, public can relate to

Impact	Performance Measures	Simplicity and Clarity
	Changes in traffic delays on local streets	Varies, usually geared for technical audience
Land and residential property values	Changes in residential property values	Public can relate to
Visual quality/aesthetics	Changes in visual aesthetics	Easy for public to relate to
Social and Economic Impacts on Local Businesses		
Displacement of local businesses	Number of displaced businesses	Public can relate to
	Value of displaced businesses	Public can relate to
Local employment	Number of displaced jobs	Public can relate to
Business access and deliveries	Number of local businesses accessible by auto/transit within a specific travel time threshold	Varies, usually geared for technical audience
Land and commercial property values	Changes in commercial property values	Public can relate to
Economic Development		
Job creation	Changes in employment opportunities for local residents	Public can relate to
Changes in available job types	Changes in type of jobs available for local residents	Varies
Tax revenues	Changes in tax revenues	Varies
Cultural and Aesthetic Resources		
Cultural resources	Landmarks and gathering places	Suitable for specific audiences

Source: Adapted from Turner et al. (1996)

A number of avenues exist to share information about the impacts of the proposed toll project, such as personalized letters, outreach booths, public meetings, and open houses. On the other hand, focus groups and deliberative polling may be appropriate tools to obtain the input of community members regarding potential mitigation options.

3.3 Concluding Remarks

The recommended EJEM for toll-road projects has two equally important components: an analysis/quantitative and an effective EJ participation component. The analysis component allows the analyst to (a) compile the demographic profile and the spatial distribution of population groups in the impacted area, (b) identify the spatial concentrations of EJ communities in the impacted area, (c) determine the additional impacts of concern associated with the toll road compared to the non-toll road, (d) calculate the magnitude of the additional impacts, (e) determine if zones with high and medium concentrations of EJ communities are disproportionately impacted by the toll road, and finally (f) formulate acceptable mitigation options if it is found that the impacts suffered by zones with high and medium concentrations of EJ communities are significantly more severe than the impacts suffered by zones with no or low concentrations of EJ communities. The second component, the EJ participation component, aims to ensure that EJ communities are given the opportunity to participate in a meaningful way. EJ community outreach efforts are thus foreseen in various stages of the analysis to ensure that all adverse impacts are fully presented and that effective mitigation options are designed to lessen or offset identified disproportionately high or adverse impacts.

Chapter 4. Conclusions and Recommendations

From the literature it is clear that toll roads can have EJ impacts on the physical, mobility and safety, social and economic, and cultural environments that differ from the EJ impacts of non-toll roads. Appropriate guidance to assess the EJ impacts of tolled facilities is, however, largely unavailable. The objective of this research study was to develop a robust approach for the effective identification, measurement, and mitigation of disproportionately high additional impacts imposed by toll roads relative to non-toll roads given four specific scenarios. The scenarios were conceptualized considering the tolling policy adopted on December 16, 2003 by the Texas Transportation Commission.

4.1. Recommended EJ Evaluation Methodology

The recommended EJ evaluation methodology (EJEM) for toll road projects has two equally important components: an analysis/quantitative and an effective EJ participation component. The analysis component requires the analyst to:

1. identify the demographic profile and the spatial distribution of population groups within the impacted area,
2. identify the spatial concentrations of EJ communities in the impacted area,
3. determine the additional impacts of concern imposed by the toll road relative to the non-toll road,
4. calculate the magnitude of the additional impacts,
5. determine whether zones with higher concentrations of EJ populations are disproportionately impacted by the toll road, and finally,
6. identify and formulate effective mitigation options if it is found that the impacts suffered by zones with higher concentrations of EJ populations are disproportionately higher than the impacts suffered by zones with lower concentrations of EJ populations.

The second component, EJ participation, aims to ensure that (1) all EJ communities are identified and given the opportunity to participate in a meaningful way, (2) all the adverse impacts are identified and prioritized, (3) the measured impacts are shared with the impacted EJ communities, and (4) effective mitigation options are designed in consultation with the impacted EJ communities to lessen or offset the identified disproportionately high or adverse impacts imposed by the toll road. EJ community outreach efforts are foreseen during at least the following steps of the EJEM: (a) step 1 and step 2 (who would be impacted and is there a potential EJ concern?), (b) step 3 (what are the additional impacts of concern imposed by the toll road versus the non-toll road?), and (c) step 5 and step 6 (are the EJ communities disproportionately impacted by the toll road, and what are the potential mitigation options?).

4.2. Major Contributions and Findings

4.2.1. Analysis/Quantitative Component

The first step in the analysis component of the EJEM is the identification of the population impacted by the proposed toll road. This research study discusses the use of U.S. Census data and GIS-based techniques to develop demographic profiles of the population groups at the project level. Specifically, the study highlighted the content and geographic scales of census data products relevant for EJ analysis and listed the variables that can be used for identifying the spatial distribution of the impacted population groups. The study showed that the scale of geographic analysis (i.e., census tract, block, block group, and TAZs) adopted for identifying EJ communities could potentially affect the demographic profiles of the impacted area. A sensitivity analysis of different geographic scales (i.e., census tract, block, block group, and TAZs) revealed that the conventional approach, which classifies communities into target and non-target populations using threshold values, is sensitive to the geographic scale of analysis used. In other words, the spatial distribution of target and non-target minority and low-income populations in the impacted area changed when the scale of geographic analysis changed. In this regard, the analysis showed that the course scale of TAZs used in travel demand modeling might overlook smaller minority and low-income population groups and prevent local analysis (e.g., calculating access to sensitive sites). A more complete spatial distribution of the EJ communities was obtained at the block level. Block-level analysis is thus recommended for toll road projects if (a) the impacts are not uniformly distributed over the impacted area, (b) there is a possibility that smaller low-income and minority communities might be overlooked at more aggregate levels of geographic analysis, and (c) the proposed toll project is perceived to be highly controversial. Since income data are not available at the census block level, a *block-low-income mode* was estimated to allow EJ analyses of toll-road projects that require a high degree of demographic resolution.

The second step of the EJEM is the identification of EJ communities in the area impacted by the toll road. The research study showed that the use of thresholds for identifying EJ communities is a function of the geographic scale of analysis chosen, the socio-demographic characteristics of the community of comparison (COC), and ultimately the geographic scale of analysis chosen (e.g., state, county, etc.) for the COC. Using an aggregate scale for the COC could thus result in a number of EJ communities impacted by a toll project being overlooked. The research team developed an innovative approach for identifying EJ communities that overcomes some of the limitations of the threshold approach. This approach uses U.S. Census data, spatial autocorrelation measures, and GIS modeling in vector and raster data structures to categorize minority and low-income communities and to define zones with no, low, medium, and high levels (concentrations) of EJ populations within the impacted area. If the threshold approach is used, it is recommended that the COC specified is only one level more aggregate than the geopolitical unit chosen for developing the demographic profiles of the impacted area.

The objective of step 3 of the EJEM is to determine what the additional impacts of concern imposed by a toll road compared to a non-toll road would be, given the four conceptualized scenarios. The research team conducted an in-depth literature review of (1) the potential ecological, social, and economic impacts of highway investments, including priced facilities, and (2) the socio-demographic characteristics of the users of priced facilities to identify the potential additional impacts of toll roads relative to non-toll roads on EJ communities. The outcome was a detailed *Toll Road Impact Matrix* that may be used by the transportation agency as a reference when identifying the additional benefits and burdens associated with toll roads compared to non-toll roads.

Step 4 of the EJEM requires the measurement of the additional impacts—both positive and negative—that minority and low-income populations are most likely to experience as a result of the proposed toll road. The research study provided guidance on the use of a number of tools and analysis methodologies to quantify the additional impacts of toll roads in terms of accessibility, air and noise quality, residential and commercial property values, neighborhood cohesion, and pedestrian and bicycle safety. The study further evaluated the proposed tools in terms of data needs, robustness, assumptions, required expertise, and cost.

Step 5 of the EJEM attempts to determine whether the measured impacts imposed by a toll road on zones with medium and high concentrations of EJ populations are statistically significantly higher compared to zones with no or low concentrations of EJ populations. This requires two sub-steps. First, the analyst needs to determine whether the measured impacts (step 4) with the toll road are statistically significantly higher than the measured impacts with the non-toll road. Second, if a statistically significant impact is imposed by the toll road, the analyst needs to determine whether the impact imposed on zones with high and medium concentrations of EJ populations are statistically significantly higher than the impact imposed on zones with no or low concentrations of EJ populations. The research study illustrated the use of two statistical tests: the "paired *t* test", based on paired data analysis to determine whether there is a statistically significant difference between the impacts imposed by the toll road compared to the non-toll road, and a "large-sample test", based on differences between population proportions to determine whether the impact on zones with high and medium concentrations of EJ populations is significantly higher than zones with no or low concentrations of EJ populations.

Finally, step 6 of the EJEM aims to identify and design measures to mitigate or offset the disproportionately high and adverse impacts imposed on zones with high and medium concentrations of EJ populations. Mitigation measures comprise (1) avoiding or minimizing impacts by reducing the degree or magnitude of the implemented action, (2) mitigating or eliminating the impact by repairing, rehabilitating, or restoring the affected environment or community resource, (3) reducing or eliminating the impact over time by long-term preservation and maintenance operations, and (4) compensating for the impact incurred. The study lists a number of mitigation measures to reduce or eliminate the additional impacts of tolled facilities on EJ communities. Ultimately, however, mitigation actions have to be determined in consultation with the impacted EJ communities.

4.2.2. EJ Participation Component

One of the core principles of EJ analysis is the *meaningful* involvement of minority and low-income communities potentially impacted by a proposed toll road in the decision-making process surrounding the toll project. In general, transportation agencies recognize the need for and the clear benefits of EJ community participation, but the tasks are often more challenging than first anticipated. This research study (a) outlines general principles to ensure the meaningful participation of low-income and minority communities in the decision-making process regarding toll projects, and (b) provides more specific guidance on the implementation of these general principles during various stages of the EJEM.

EJ Participation

In general, the transportation agency should (a) gain a true understanding of the impacted EJ communities, including the barriers faced by these communities and the measures to overcome those barriers, (b) define the goals of the EJ outreach and participation effort, (c) identify and select the most appropriate participation technique(s), and (d) manage and implement the selected participation technique(s).

Understanding the impacted EJ communities is essential to effectively reaching out to these communities and for distinguishing the effort from public participation efforts in general. Without a true understanding of the impacted EJ communities and the barriers preventing meaningful participation, the transportation agency risks selecting inappropriate participation techniques or locations. The research study highlighted the data variables captured by the U.S. Census and other data sources that can help the agency understand the demographics of the impacted communities and also understand potential barriers to participation. In addition to gathering basic demographic information, the transportation agency should also be asking questions, such as, "How do members of this community live?", and "What do they do from day-to-day?" to help ensure that the selected public participation techniques fit into the lives of these communities and, with proper management, get the most useful results. Although each EJ community impacted by a toll road project could encounter unique barriers to participation, the research study lists some common barriers that can be viewed as a starting point. Finally, the research study highlights a number of measures that can be implemented to overcome the listed barriers.

The next step is to *define the goals for the foreseen EJ participation efforts*. The goals and potential results will vary depending on the community and the particular stage in the EJEM. The transportation agency should be clear about the information provided to the EJ community and the decisions they make that can impact insurance of a trusting relationship. The agency should also be cognizant of the difference between public consultation and public participation, and between *inform and involve* public participation techniques. Public consultation (e.g., when an EJ community is asked to comment on a plan), is a much more passive way of involving the EJ community and does not necessarily indicate their participation in the decision making. They have been considered but essentially have no ownership or responsibility concerning the project decisions. Also, it is foreseeable that more time will be required *informing* EJ communities as the interest in toll projects and the willingness to be involved may not come as quickly as in other communities.

Given a true understanding of the community and a clear understanding of the goals of the foreseen EJ outreach effort, the next step is to *identify and select the most appropriate participation technique(s).* Methods for enhancing public participation have advanced to a point where a substantial body of knowledge is found in the literature. The authors have carefully reviewed the literature to determine the relevance of the various techniques of ensuring meaningful participation of EJ communities in the decision process regarding toll road projects. The report lists a number of techniques and discusses their strengths and weaknesses as EJ participation tools.

Finally, while the transportation agency might experience some level of success by simply getting the EJ community together, informing them about the toll project, and getting basic feedback, the EJ participation effort will be much more meaningful when well managed and implemented. This requires careful planning, organization, and preparation. Although each of the public participation techniques listed will have specific management requirements, the research study lists several considerations when implementing each of these techniques, including the need for detailed and careful planning ahead of time, preparing the location, training and preparing staff, and effective time management.

Effective EJ Participation Component

The goals of the EJ outreach effort during steps 1 and 2 (who would be impacted and is there a potential EJ concern?) of the EJEM could be to (a) validate the U.S. Census data used to identify EJ communities within the impacted area, (b) identify potential *avenues* that can be used to distribute information about the proposed toll project to EJ communities living in the impacted area, (c) obtain input from those that can speak on behalf of the entire EJ community, (d) identify the most appropriate participation technique(s) for *informing* and *involving* the impacted EJ communities, and (e) identify locations and avenues for interacting with EJ communities to ensure that participation efforts span all of the potentially impacted EJ communities. Depending on the impacted community, a telephone survey and or personalized letter and mail survey might be appropriate participation technique(s) to contact and engage individuals from community-based organizations who can represent the views of the impacted EJ community. During the survey, the transportation agency should include questions that can help the agency gain a better understanding of the impacted EJ communities and questions that can help inform the development of future outreach activities.

The goals of the outreach effort during step 4 (what are the additional impacts of concern imposed by the toll road versus the non-toll road?) of the EJEM could be to (a) inform the EJ community about the proposed toll road project (educate the community), and (b) to involve the community by obtaining their views and concerns about how the proposed toll project will impact their trips and communities. Not until the EJ communities and those that speak on behalf of the communities understand the technical issues and can articulate their views and concerns about how the toll road would impact their activity spaces (i.e., the places where they live, work, shop, and partake in other activities), can meaningful and informed participation be accomplished. A number of avenues exist to share information about the proposed toll project and to obtain the input of potentially impacted EJ communities. At least two techniques, school programs and Deliberative Polling®, can be used to both inform and involve the impacted communities.

The goals of the EJ outreach effort during steps 5 and 6 (are the EJ communities disproportionately impacted by the toll road, and what are the potential mitigation options?) of the EJEM could be to inform (educate) the EJ community about the magnitude of the additional impacts (benefits and burdens) associated with the proposed toll road project compared to the non-toll road and to involve the EJ community in the conceptualization and design of acceptable options to avoid, minimize, or mitigate any disproportionate impact on the EJ community. The transportation agency should thus present upfront the measured benefits and burdens imposed by the toll road project on the EJ communities calculated in step 4 and 5 of the analytical component of the EJEM. The research report presents a number of performance measures that can be calculated to illustrate the magnitude of the impacts and the simplicity and clarity of these measures in terms of communicating and sharing them with EJ communities. Once the EJ communities understand how they could be impacted by the toll road, appropriate mitigation options can be designed. EJ communities should be active in the identification and design of mitigation or remediation measures to address the disproportionately adverse impacts on their communities. The research study highlights a number of avenues to share information about the impacts of the proposed toll project and appropriate tools to obtain input from community members regarding potential mitigation options.

4.3. Recommendation

The reports and products developed in this research study provide TxDOT transportation planners and environmental coordinators with a robust and defendable methodology to address EJ concerns associated with toll road projects in Texas. It is thus recommended that TxDOT pilot this proposed methodology in one or two districts considering toll road projects in order to test and validate the proposed approach.

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Appendix A: Sensitivity Analysis of the Geographic Scales

This appendix presents the results from a sensitivity analysis that was conducted to determine how different geographic scales (i.e., census tracts, block groups, blocks, and Traffic Analysis Zones [TAZs]) influence the spatial identification of Environmental Justice (EJ) communities at the project level. The sensitivity analysis was conducted for a section of the SH130 toll road in Travis County, Texas. This exercise revealed a more comprehensive spatial distribution of EJ communities at the block level.

A.1 Methodology

The methodological steps can be summarized as follows: (a) the U.S. Census Data, GIS-based techniques, and a threshold approach were used for developing and displaying the demographic profiles and the spatial distributions of the population groups in the study area for the four geographic scales (i.e., census tracts, block groups, blocks, and Traffic Analysis Zones), (b) statistical analyses were conducted, and (c) relevant findings and conclusions were presented.

First, the various EJ populations (identified from U.S. Census Data) were mapped at the different geographic scales using vector models. The vector models display the spatial distribution of the EJ and non-EJ population groups by dividing the impacted area into polygons (i.e., tracts, block groups, blocks, and TAZs). Tracts, block groups, blocks, and TAZs with minority/low-income populations greater than an established threshold are considered to have a target population group. On the other hand, tracts, block groups, blocks, and TAZs with minority/low-income populations lower than the established threshold are considered not to have a target population group.

Second, statistical analyses were conducted to compare the proportions of EJ and non-EJ populations at the various study scales. Homogeneity tests were conducted to test whether the true proportions of the EJ and non-EJ populations were identical for the four study scales. In this case, there are I geographic scales (I = 4) and the population is divided into the same J population groups (J=2). The null hypothesis states that the proportion of individuals in population group j is the same for each geographic scale, and that this is true for all population groups. Therefore, for every j, $p_{i1} = p_{i2}$ for $i = 1 \ldots 4$. The test statistic is as follows:

$$\text{If} \quad \chi^2 \geq \chi^2_{\alpha,(I-1)(J-1)}, \text{ reject } H_0 \text{ at level } \alpha \text{ test}$$

Inferences about population proportions were conducted to assess the statistical significance of the difference between population proportions. In this case, p_1 and p_2 denote the proportions of individuals in population groups 1 and 2, respectively, which exhibit a particular characteristic (i.e., low-income or minority). The null hypothesis is: H_o: $p_1 - p_2 = 0$. When H_o is true the standardized variable Z has an approximate standard normal distribution. The test statistic is as follows:

$$\text{If either } Z \geq Z_{\alpha/2} \text{ or } Z \leq -Z_{\alpha/2}, \text{ reject } H_0 \text{ at level } \alpha \text{ test}$$

A.2 Empirical Results

The sensitivity analysis was conducted for the proposed SH 130 toll road segment that traverses Travis County, Texas. Because SH 130 is expected to impact a sizable area adjacent to the corridor, the impacted area was defined by a 6-mile wide buffer along the proposed alignment (see Figure A.1). According to the Final Environmental Impact Statement for SH 130 (U.S. Department of Transportation & Texas Department of Transportation, 2001), this area covers the footprints of all potential ecological, mobility, safety, social, economic, and cultural impacts (i.e., the potential EJ concerns) associated with the proposed road.

A.2.1 Data Sources

Digital and socio-demographic data for the study area were obtained from the U.S. Census Bureau. Digital files (i.e., "TIGER/LINES") were obtained for the tract, block group, block, and TAZ levels from the ESRI Web site. Custom tables containing the minority and low-income populations for the different geographic scales were obtained from the U.S. Census Bureau's American Factfinder Web site. GIS was used to compile minority populations at the TAZ level. The CTPP 2000 CDs containing Texas data were acquired from the Bureau of Transportation Statistics. To estimate low-income population at the block level, a block-low-income model was estimated (see Appendix C). Table A.1 summarizes the data sources used in this analysis.

Table A.1. Data Sources Used for Sensitivity Analysis

Scale of Geographic Analysis	Data Sources	
	Race	Income
Census Tracts	**SF 1**	**SF 3**
Census Block Group	**SF 1**	**SF 3**
Census Block	**SF 1**	**Block-Income Model**
TAZ	**SF 1***	**CTPP 2000**

*Based on data at block level
Source: 2000 U.S. Census Data

A.2.2 Identify the Community of Comparison

The threshold approach requires the identification of an appropriate community of comparison (COC) to determine whether the additional impacts from toll roads will affect minority and low-income communities disproportionately. For this analysis, the chosen COC consisted of Williamson, Travis, Bastrop, Hays, Caldwell, and Guadalupe counties (see Figure A.1). GIS was used to compute descriptive statistics for the COC (see Table A.2).

Table A.2. Demographic Characteristics of the Community of Comparison

2000 Census Data	Community of Comparison (COC)	Mean	Standard Deviation
Total population	1,338,789	4,868	2,310
Minority population	489,789	1,781	1,351
Population at or above poverty level	1,129,325	4,107	2,181
Population below poverty level (low-income population)	138,151	502	543

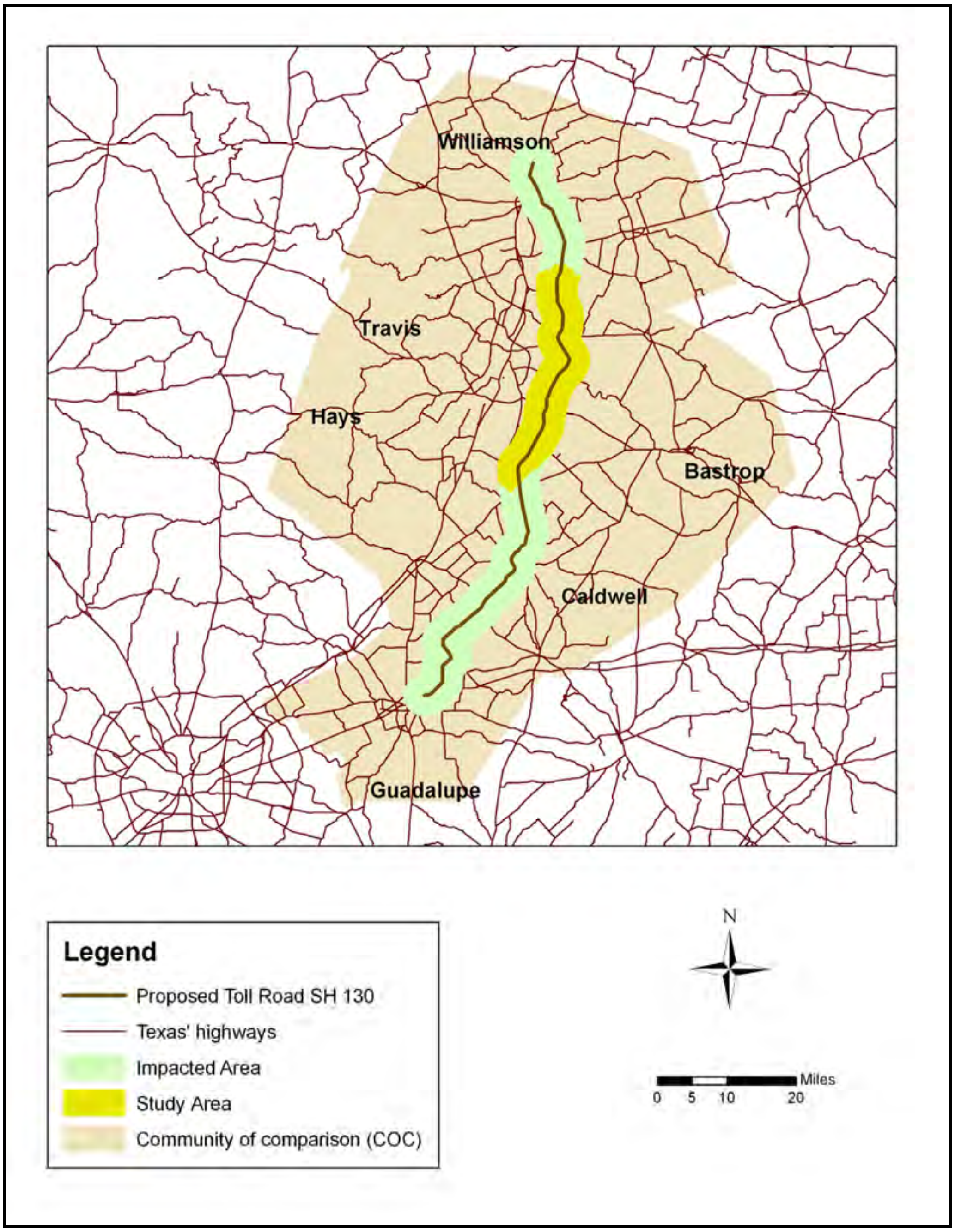

Figure A.1 Study Area and Community of Comparison

A.2.3 Determine Threshold Values

Thresholds are used as comparative values to identify EJ populations in a study area. Threshold values (percentages) are calculated by dividing the minority and low-income populations in the COC by the total population in the COC (see Table A.3).

Table A.3 Threshold Values for the Identification of EJ Communities

Population Groups	Threshold values
Minority Population	36.7 %
Low-Income Population	10.9 %

A.2.4 Spatial Distribution of the Target and Non-target Population Groups

Figures A.2 and A.3 were prepared to illustrate the spatial distribution of the target population groups (i.e., minority/low-income populations) at each geographic scale. When comparing these maps, the following observations can be made:

- The spatial distribution of target minority/low-income populations is sensitive to the scale of geographic analysis used. In other words, the identified areas with target population groups differ from one scale to another. When comparing these maps it is evident that some areas exhibit target population groups at a certain scale (e.g., block group), but not at a more detailed scale (e.g., block). On the other hand, some areas are identified as non-target population areas at a certain scale (e.g., block group) and as target population areas at a more course scale (e.g., tracts). Furthermore, the changes observed in the spatial distribution among different scales (i.e., a course scale vs. a detailed scale and vice versa) do not reveal a specific pattern.
- The chosen scale of geographic analysis affects the spatial concentration of EJ populations. Target populations seem to be more clustered at the more aggregated scales (i.e., tracts, block groups, and TAZs) and more dispersed at the more disaggregate scale (i.e., blocks).
- When comparing the results for the four geographic scales, it appears that the more detailed scale (i.e., block) provides a more complete spatial distribution of the target population groups within the study area. In contrast, the outcome of the course scales (i.e., tracts, block groups, and TAZs) may overlook some EJ population groups that do not align with these levels of aggregation.

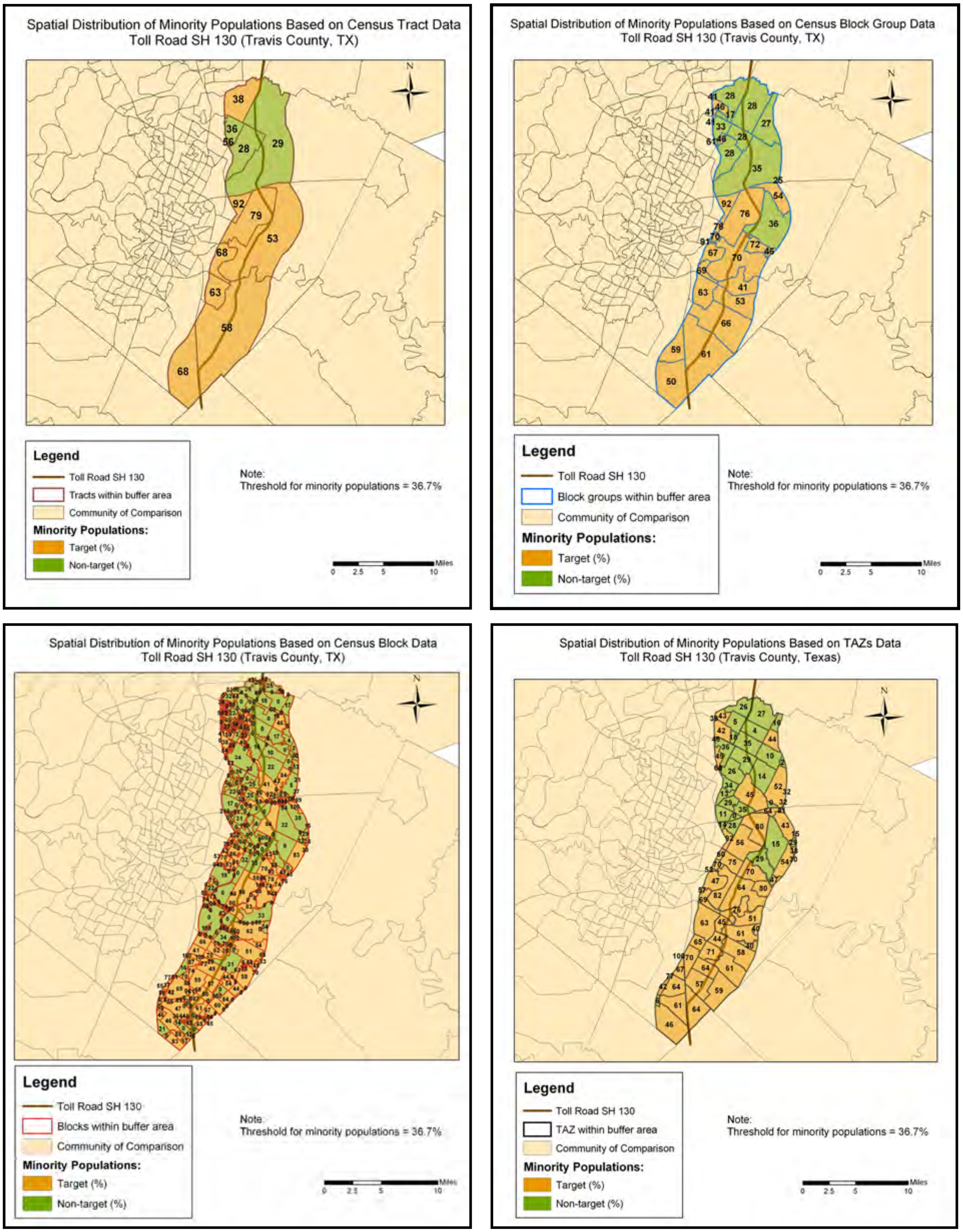

Figure A.2 Spatial Distribution of Minority Populations Given Different Geographic Scales

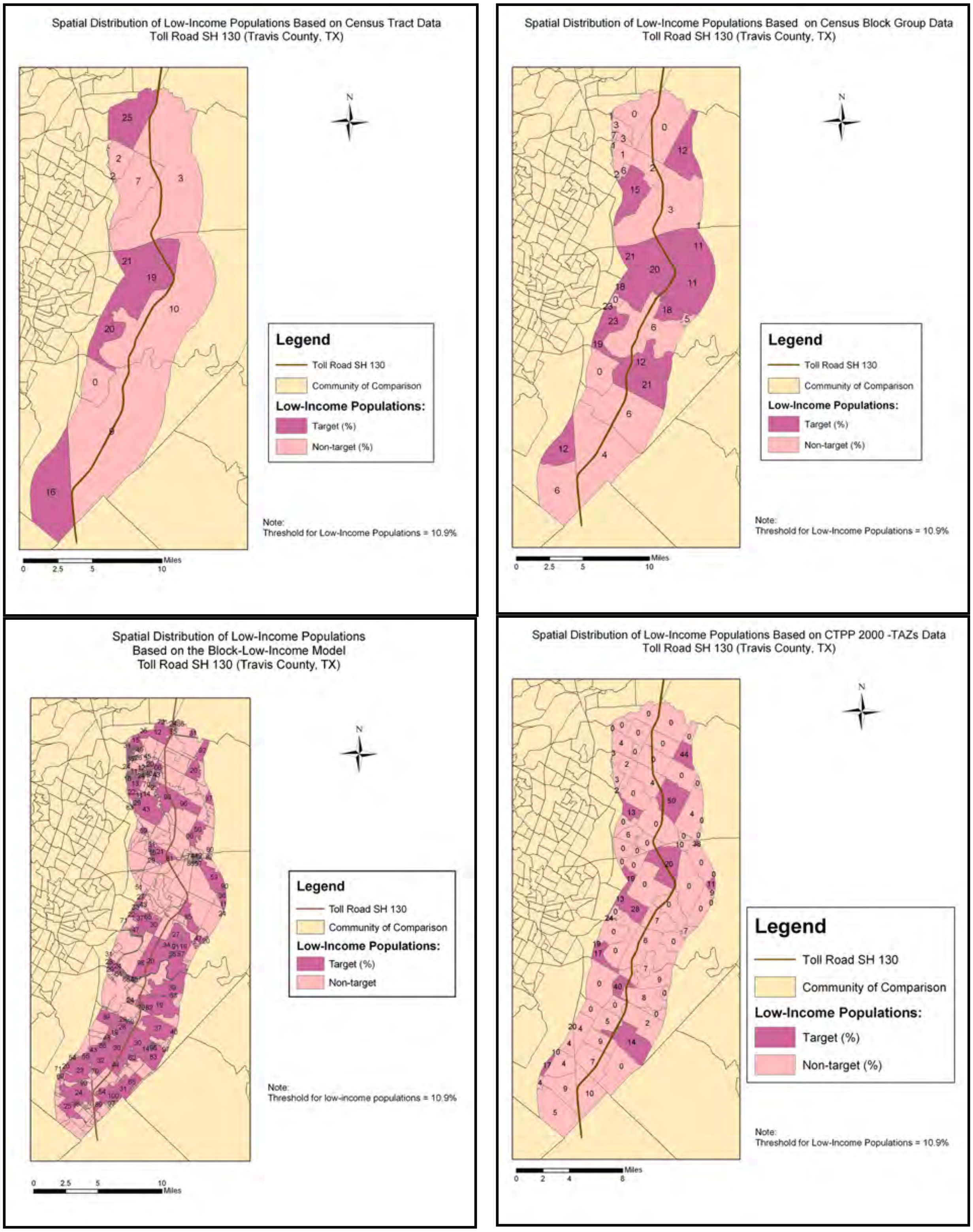

Figure A.3 Spatial Distribution of Low-Income Populations Given Different Geographic Scales

A.2.5 Statistical Analyses of the EJ Population Groups within the Study Area

Using GIS, descriptive statistics for minority and low-income populations in the study area were calculated (see Tables A.4 and A.5, respectively).

Table A.4 Descriptive Statistics for Total Population and Minority Populations in the Study Area

Scale of Geographic Analysis	Study Area			
	Units	Total Population (Inhabitants)	Mean	Standard Deviation
Tracts	13	89,702	6,900	3,654
Block groups	35	83,586	2,388	1,463
Blocks	1,084	58,961	54	124
TAZs	80	58,991	737	1,296
Scale of Geographic Analysis	**Units**	**Total Minority (Inhabitants)**	**Mean**	**Standard Deviation**
Tracts	13	47,486 (53%)	3,653	1,736
Block groups	35	42,994 (51%)	1,228	925
Blocks	1,084	28,990 (49%)	27	73
TAZs	80	29,014 (49%)	363	587

Table A.5 Descriptive Statistics for Total Population and Low-Income Populations in the Study Area

Scale of Geographic Analysis	Study Area			
	Units	Total Population (Inhabitants)	Mean	Standard Deviation
Tracts	13	68,392	5,261	2,604
Block groups	35	77,257	2,207	1,498
Blocks	1,084	55,709	51	104
TAZs	80	24,199	302	526
Scale of Geographic Analysis	**Units**	**Total Low-Income (Inhabitants)**	**Mean**	**Standard Deviation**
Tracts	13	6,979 (10%)	537	427
Block groups	35	6,049 (8%)	173	208
Blocks	1084	16,876 (30%)	15	28
TAZs	80	1,632 (7%)	20	41

The results from the statistical analysis suggest the following:

- The spatial identification of EJ communities is sensitive to the scale of geographic analysis. The variability in the descriptive statistics for minority populations given the four geographic scales of analysis may be due to the scale effect (Wrigley, 1995). The scale effect is the tendency to obtain different statistical results from the same data set when the information is grouped at different levels of spatial resolution (i.e., tracts, block groups, blocks, and TAZs). The same is true for the descriptive statistics for low-income populations at the tract and block group levels.
- The homogeneity test revealed that the proportions of minority and non-minority population groups in the study area <u>are not the same</u> for the four scales of geographic analysis. The same is true for the two courser scales (i.e., tracts and block groups). In

both cases, the p-values are so minuscule that the null hypothesis can be rejected at any level of significance (α). On the other hand, the proportions of minority and non-minority population groups are the same for the two detailed scales (i.e., blocks and TAZs) at any α. This is expected because minority populations at the TAZ level were computed from block data using GIS. As a result, the scale effect had no influence in the statistic.

- The homogeneity test also suggests that the proportions of low-income and non-low-income population groups are not the same for the four scales of geographic analysis. This is also true in the case of the two courser scales (i.e., tracts and blocks groups) and for the blocks groups and TAZs. In all three tests, the p-values were so small that the null hypothesis can be rejected at any α.

A.2.6 Statistical Analyses of the Target EJ Population Groups within the Study Area

Using GIS, descriptive statistics for the target population groups at the four scales of geographic analysis were computed (see Table A.6).

Table A.6 Descriptive Statistics for Target Population Groups in the Study Area

Scale of Geographic Analysis	Target Minority (% Minority)	Mean	Standard Deviation
Tracts	41,236 (87%)	4,124	1,677
Block groups	35,124 (82%)	1,405	987
Blocks	24,527 (85%)	57	106
TAZs	23,092 (80%)	453	609
Scale of Geographic Analysis	**Target Low-Income (% Low-Income)**	**Mean**	**Standard Deviation**
Tracts	4,578 (66%)	4,124	1,677
Block groups	4,658 (77%)	1,405	987
Blocks	16,475 (98%)	57	106
TAZs	1,045 (64%)	453	609

Finally, statistical comparisons of population proportions were conducted using census blocks as the basis for comparison. The results suggest the following:

- The proportion of target minorities at the block level differs from the proportion of target minorities at the other levels of aggregation. The data clearly shows that the proportion of target minorities at the block level is higher than that at the block group and TAZ levels. The p-value is so minuscule that for any reasonable α, the null hypothesis—no difference between population proportions—should be rejected. On the other hand, the data strongly suggest that the proportion of target minorities at the block level is lower than that at the tract level. Again, the p-value is so small that for any reasonable α, the null hypothesis should be rejected.

- The proportion of target low-income individuals at the block level differs from the proportion of target low-income individuals at the other levels of aggregation. The data strongly suggest that the proportion of target low-income individuals at the block level is higher than that at the tract, block group, and TAZ levels. The p-value is so minuscule that for any reasonable α, the null hypothesis should be rejected.

A.3 Conclusions

This appendix showed that the conventional approach, which classifies communities into target and non-target populations using threshold values, is sensitive to the geographic scale of analysis used. The spatial distribution of target and non-target minority/low-income populations in the study area changed when the scale of geographic analysis (i.e., tracts, block groups, blocks, and TAZs) changed. In this regard, the analysis showed that the coarse scale of TAZs used in travel demand modeling might overlook smaller minority/low-income population groups. A more complete spatial distribution of the EJ communities was obtained at the block level and it is therefore considered more appropriate to assess EJ concerns.

Appendix B: Relevant Census Data for Environmental Justice Analysis

Table B.1 summarizes the contents and geographic scale of U.S. Census data products relevant for Environmental Justice (EJ) analysis. The Redistricting File (PL-94-171) and Summary File 1 (SF 1) contain data (100 percent) obtained from the short census form. The Summary File 3 (SF 3) contains a weighted sample—weighted to represent the total population—of data collected from the long census form. The Census Transportation Planning Package (CTPP) 2000—the data is also from the long census form—is a set of special tabulations not found in any other decennial census product. These four products are available free of charge from numerous sources, including online from the U.S. Census Bureau and federal repository libraries.

Table B.1. Census Data Products Relevant for Environmental Justice Analysis

Census Data Product	Contains	Geographic Scale
Census 2000 Redistricting Data File (PL-94-171)	• Location of the population by race and ethnic origin, and location of population over the age of 18 by race and ethnic origin. • Six single race tabulations (African American, American Indian/Alaska Native, Native Hawaiian and other Pacific Islander, Asian, White, and some other race). Fifty-seven combinations for those that marked more than one of the six race categories.	• Census Block • A TAZ field included in the redistricting file allows users to aggregate blocks into TAZs.
Summary File 1 (SF 1)	• Population variables include age, sex, race, ethnic origin, household type, household relationship and group quarters. • Household data include occupancy status, vacancy status, and tenure status (owner occupied or renter occupied).	• Census Block (171 population tables and 56 housing tables) • Census Tract (56 population tables with detailed race and ethnic origin data)
Sample Summary File 3 (SF 3)	• Population data include age, mobility limitation status, ancestry, occupation, citizenship, place of birth, class of worker, place of work, educational attainment, poverty status, ethnic origin, sex, household type and relations, travel time to work, income, urban and rural population, veteran/military status, language spoken at home, work disability status, marital status, work status, means of transportation to work, and workers in family. • Housing data include age of householder, race of householder, ethnic origin of householder, telephone availability, vehicle availability, selected monthly owner costs, condominium status, tenure, units in structure, housing units, value of housing unit, mortgage status, occupancy status, and rent.	• Census Block Group • Census Tract
Census Transportation Planning Packages	• Tabulations by place of residence (Part 1), place of work (Part 2), and worker travel patterns between residence and workplace (Part 3). • 120 tables by place of residence; 66 tables by place of work; and 14 tables related to the flow between home and work (i.e., summaries of the home and work locations of workers). • Housing data include housing size, housing income, and vehicles per household. • Worker data include age and gender of workers, occupation of workers, and worker earnings. • Transportation mode data include usual mode to work, commuting time, and work trip departure time. • Work data include work location and time of arrival at work.	• TAZ for those counties that have a TAZ layer defined in Tiger/Line. For other metropolitan areas, the lowest level of detail is the tract or block group, depending on the choice of the local MPO.

Table B.2 summarizes the variables captured by the census data products, which can be useful in identifying EJ populations.

Table B.2. Relevant Census Data Variables for Identifying Minority Populations

	Variable	Census Data Products		
		PL 94-171	**SF 1**	**SF 3**
	Total population: Total	PL002001	P004001	P007001
Minority Population	Total population: Hispanic or Latino	PL002002	P004002	P007010
	Total population: Not Hispanic or Latino; Black or African American alone	PL002006	P004006	P007004
	Total population: Not Hispanic or Latino; American Indian and Alaska Native alone	PL002007	P004007	P007005
	Total population: Not Hispanic or Latino; Asian alone	PL002008	P004008	P007006
	Total population: Not Hispanic or Latino; Some other race alone	PL002010	P004010	P007008
	Variable	**SF 3**		
		Total	**Income in 1999 below poverty level**	**Income in 1999 at or above poverty level**
Low-Income Population	White alone for whom poverty status is determined	P159A001	P159A002	P159A010
	Black or African American alone for whom poverty status is determined	P159B001	P159B002	P159B010
	American Indian and Alaska Native alone for whom poverty status is determined	P159C001	P159C002	P159C010
	Asian alone for whom poverty status is determined	P159D001	P159D002	P159D010
	Some other race alone for whom poverty status is determined	P159F001	P159F002	P159F010

Appendix C: Block-Low-Income Model

It is foreseen that some toll road projects—either because of the scope of work or because impacts are not uniformly distributed among those affected—would require a higher degree of demographic resolution when conducting EJ analysis. Appendix D shows that a more comprehensive spatial distribution of EJ communities is obtained at the census block level. Because the U.S. census does not capture income data at the census block level, this appendix estimates a model at the block group level, using available U.S. census data, to estimate low-income populations at the block level. This is possible because there is a perfect correlation between block groups and blocks (i.e., block groups are made up of blocks).

The econometric approach to develop the *block-low-income model* is as follows: (a) the "best" ordinary least-square (OLS) model is estimated, similar to the model estimated by Forkenbrock and Schweitzer (1997) (b) relevant analysis is undertaken to determine spatial dependence, and (c) if the latter exists, better estimates are constructed by incorporating spatial effects into the regression analysis. To test the validity of the methodology, the econometric approach is applied to a section of SH 130 in Travis County, Texas. The methodology, empirical results, and relevant findings from the SH 130 case study are presented in this appendix.

C.1 Methodology

Several econometric models were applied to assess the effects and statistical significance of potential explanatory variables on predicting low-income populations at the census block level. The classic ordinary least-square (OLS) approach was used for the initial specification of the *block-low-income model*. Two spatial econometric models were estimated (i.e., the spatial lag model and the spatial error model) because the OLS estimates are sensitive to (a) the spatial context of each observation and (b) the presence of estimation errors that are spatially correlated. The spatial econometric approach results in better estimates if spatial dependence is present in the data by accounting for spatial autocorrelation.

C.1.1 Ordinary Least-Square Regression Analysis

The OLS regression model aims to predict the low-income population at the census block level through a best-fit of specified explanatory variables. Using blocks as the unit of geographic analysis, a benchmark model can be defined as follows:

$$\mathrm{I}_i = K_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \dots + \varepsilon_i \quad \text{single observation}$$

$$\mathrm{I} = K + \beta X + \varepsilon \qquad \text{set of observations} \qquad (1)$$

where:

I_i = number of individuals below the specified poverty level in block i (i=1,…,n)

K_o = constant

X_{ki} = value of the k_{th} explanatory variable observed for block i

β_k = coefficients representing the numerical effect on I_i resulting from a unit increase in the explanatory variable (X_{ki})

ε_i = residual representing the difference between the actual values and the values predicted by the estimated values of the explanatory variables and their coefficients

To estimate the model, available demographic data from the U.S. census at the block group and block levels were identified. As stated, the model was developed at the block group level because (a) low-income population data (i.e., the number of individuals below the poverty level) is available at the block group level, and (b) there is a perfect match between block groups and blocks. Several models were tested to ensure that the final model is theoretically sound and performs well statistically. Estimation commences with a broad specification of all potential explanatory variables. Given this broad specification, incremental changes are tested to improve the model's realism and empirical fit to the data. The incremental changes involve alternative variable specifications (e.g., summing variables) and deleting variables that are not statistically significant. The following statistic is used to compare two models, where one is a restricted version of the other:

$$If \quad F_{STATISTIC} = \frac{(SSE_R - SSE_{UR})/\#\ of\ restrictions}{SSE_{UR}/(n-m)} > F_{(\alpha, v_1, v_2)},\ reject\ H_0$$

where

SSE_R = sum of the squared errors of the restricted model
SSE_{UR} = sum of the squared errors of the unrestricted model
n = number of observations (i.e., number of blocks within the study area)
m = number of parameters of the unrestricted model

The number of restrictions varies depending on the number of constraints imposed on the unrestricted model to get the restricted model. The F test-statistic is calculated to determine whether to accept or reject the null hypothesis. The critical value for determining whether to reject the null hypothesis depends on:

- the alpha-level (α)
- the number of numerator degrees of freedom (v_1 = number of restrictions)
- the number of denominator degrees of freedom ($v_2 = n$).

Once the "best" OLS model was estimated, tests for spatial dependence was undertaken because the OLS estimates are sensitive to the specification of the model and the existence of spatially correlated

Spatial Effects and Regression Analysis

Two kinds of spatial effects are discussed in the literature:

- Spatial dependency occurs when observations that are spatially closer are more related than observations that are spatially distant. If spatial dependency (i.e., spatial autocorrelation) is present in the data, the OLS parameters are not efficient and significance tests are unreliable (Anselin & Griffith, 1988; Miron, 1984).
- Spatial heterogeneity occurs because of a lack of homogeneity across space, a lack of association among the variables under study, or both. In the presence of spatial heterogeneity, the estimated parameters of the spatial model are inadequate descriptors of the situation at any given location (Anselin & Getis, 1992).

estimation errors. OLS assumes that all observations are independent. However, if there is correlation among the observations (i.e., the observations are not independent), the estimated number of degrees of freedom may be too high, while the estimated standard errors may be too low (Anselin, 1988). This may result in some coefficients being considered significant when they are not. If spatial autocorrelation exists in the residuals, the model will overestimate the observed values in some blocks and underestimate the observed values in other blocks. Therefore, given the presence of spatial dependence, estimates can be improved by developing a model that accounts for spatial autocorrelation (Odlund, 1988)

Examining the OLS Residuals

Local Indicators of Spatial Association (LISA) were used to reveal the spatial patterns of heterogeneity in the OLS residuals across the study area (Anselin, 1995). The following indicators were calculated (Anselin, 2003a):

- The Moran scatter plot, illustrating the Moran's I statistic and the different types of spatial autocorrelation
- The LISA cluster map, showing the clustering spatial patterns
- The LISA significance map, showing the p-values of the clustering spatial patterns.

The *Moran scatter plot* consists of four quadrants illustrating the residuals within the study area by type of spatial autocorrelation. The upper right and lower left quadrants contains the residuals with positive spatial autocorrelation (i.e., can be high-high or low-low). The lower right and upper left quadrants contain the residuals with negative spatial autocorrelation (i.e., can be high-low or low-high). Moran's Index (I) for spatial autocorrelation can be applied to regression residuals as follows:

$$I = \left(\frac{n}{S}\right)\left(\frac{\varepsilon' W \varepsilon}{\varepsilon' \varepsilon}\right)$$

where:

n = number of observations (i.e., number of blocks within the study area)
ε = vector of the OLS residuals
W = the n x n spatial weight matrix
S = standardized factor equal to the sum of all elements in the weight matrix

The value of I ranges from –1 for negative spatial autocorrelation to 1 for positive spatial autocorrelation, and with 0 meaning no spatial autocorrelation. The statistical test to accept or reject the null hypothesis of no spatial dependence is based on the standard normal distribution as follows (Anselin, 1988):

$$Z_I = \frac{I - E(I)}{\left[V(I)\right]^{1/2}}$$

where:

E(I) = the mean of the Moran statistic
V(I) = the variance of the Moran statistic

The analysis of spatial dependence in regression residuals is complex because the residuals are imperfect estimates of the unobserved error terms (Anselin, 1988). A permutation procedure based on a Monte Carlo type test was used to assess the significance of Moran's I statistic relative to the stated null hypothesis. Because the Monte Carlo procedure can result in slightly different results between replications (Anselin, 2003a; Anselin, 1986), several replications were required to obtained stable results.

The *LISA cluster map* shows where the residuals are clustered. The *LISA significance map* shows the significant locations by type of spatial autocorrelation. If the model produces residuals with a definite spatial pattern, the model is under- or overestimating the true values. High values (i.e., large positive residuals) indicate model under-prediction. In other words, the "actual" block-low-income is higher than would be estimated by the explanatory variables. Low values (i.e., large negative residuals) indicate model over-prediction. In other words, the "actual" block-low-income is lower than would be predicted by the explanatory variables.

C.1.2 Spatial Models

The spatial lag and spatial error models present two basic approaches to incorporate spatial effects into a regression model. Although the two model specifications are closely related mathematically, they have very different interpretations (Kim et al, 2001). In this analysis, the *spatial lag model* assumes that the number of low-income individuals in a specific block is affected by the spatially weighted average number of low-income individuals in neighboring blocks in addition to the explanatory variables that capture the housing characteristics. The *spatial error model* assumes that certain explanatory variables are omitted and that the omitted variables vary spatially. The spatial pattern in the omitted variables results in the error term of the OLS model being spatially autocorrelated.

Spatial Lag Model

The spatial lag *block-low-income model* can be written as follows:

$$\mathrm{I} = \rho W \mathrm{I} + K + \beta X + \varepsilon \qquad (2)$$

where:

I = vector of the number of low-income individuals at the block level
ρ = spatial autocorrelation parameter
W = n x n spatial weight matrix (n = number of blocks within the study area)
K= constant;
X = matrix with observations on block characteristics
ε = vector of independently and identically distributed error terms

Essential to this analysis is the spatial weight matrix, which enables the calculation of the spatial lag, a weighted average of the dependent variable at neighboring blocks. Because of the endogenous nature of the spatial lag term (WI), the OLS parameter estimators are biased and inconsistent for the spatial lag model. Instead, the Maximum Likelihood Method (MLM) was used for parameter estimation to account for spatial autocorrelation in the independent variables (Ord, 1975; Anselin, 1988).

Spatial Error Model

When spatial dependence is present in the error term, a spatial error model can be estimated using a spatial autoregressive specification. The block-low-income spatial error model can be written as follows:

$$\mathrm{I} = K + \beta X + \varepsilon \qquad (3)$$
$$\varepsilon = \lambda W \varepsilon + \nu$$

where:

λ = the spatial autoregressive coefficient
W = n x n spatial weight matrix
ν = a vector of independently and identically distributed error terms with constant variance

The spatial error model suggests that the number of individuals below the poverty level (in any block) is a function of the specific block's characteristics and the omitted variables at the neighboring block level. The MLM is used for parameter estimation to account for spatial autocorrelation in the error terms (Anselin, 1988). The OLS estimates of the regression coefficients remain unbiased in the spatial error model, but would have no longer been efficient (Anselin, 1988).

Spatial Weight Matrix

A binary connectivity matrix (i.e., the spatial weight matrix) is constructed to define the spatial relationship among blocks based on the rook's case and the higher order of contiguity. Rook's case refers to the boundary share. In other words, neighboring geographical units have to share a boundary with a length greater than zero[x]. The higher order contiguity weights remove redundancies and circularities in the weight calculations that are undesirable when specifying and estimating econometric models (Anselin and Smirnov, 1996). The components of the spatial weight matrix can be represented as follows:

$$c_{jk} = \begin{cases} 1 & \textit{if blocks } j \textit{ and } k \textit{ are contiguos}, \ j \neq k \\ 0 & \textit{otherwise} \end{cases}$$

The weight matrix that is used for detecting spatial dependence is standardized such that the row elements sum to one. The elements of this row standardized weight matrix take non-zero values only for those pairs of blocks that are contiguous to each other. This facilitates the interpretation of the model coefficients, but it adds complexity to the estimation and testing procedures (Anselin, 1988). The standardized weight matrix can be represented as follows:

[x] The rook's case (i.e., the length of the boundary share among neighboring geographical units must be greater than zero) might, however, not necessarily be the best approach to define the spatial interaction among blocks. For example, the interaction could also be defined as a function of the shared boundary length between neighboring blocks. Such alternative specifications should be tested by means of sensitivity analyses.

$$w_{jk} = \frac{c_{jk}}{c_j}$$

$$c_j = \sum_k c_{jk}; \quad \sum_j w_{jk} = 1$$

where:

w_{jk} = spatial weight between neighboring blocks *j* and *k*

c_j = the row sum of the binary connectivity matrix

The standardized weight matrix represents how much each neighboring block contributes to the low-income population in the block of concern by assuming that each neighboring block exerts the same influence on the block of concern. For example, for a block surrounded by four neighboring blocks, the spatial lag will be the weighted average for the four neighboring blocks, where each has an equal weight of 0.25. For EJ analysis, assigning the same weight to each neighboring block implies that each of the surrounding blocks exerts the same influence on the low-income population in the block of concern. Furthermore, a higher influence (weight) is assigned to small geographic blocks compared to large geographic blocks when the former is surrounded by fewer neighboring blocks than the latter. This aims to disclose spatial patterns in blocks regardless of their geographic size.

Spatial Hypothesis Testing

Because blocks are used as the unit of geographic analysis, spatial dependence between two blocks, j and k, can be written as follows:

$$\text{cov}[I_j, I_k] \neq 0$$
$$\text{cov}[\varepsilon_j, \varepsilon_k] \neq 0$$

Using the estimated residuals from Equation (1), tests for the presence of spatial dependence either in the form of an endogenous spatial lag or in the form of residual spatial autocorrelation are conducted. The two null hypotheses are:

$$H_0 : \rho = 0 \quad [lag]$$
$$H_{0^*} : \lambda = 0 \quad [residual]$$

via a Lagrange Multiplier (LM) test that is distributed as follows:

$$LM = nR^2 \sim \chi_1^2$$

where:

R^2 = the unadjusted coefficient of determination for the regression of the estimated residuals in Equations (2) and (3), respectively, and

n = number of blocks in the study area

χ_1^2 = chi-square distribution

C.2 Empirical Results

The block-low-income model was estimated using data pertaining to a section of the proposed SH 130 in Travis County, Texas. Because SH 130 is expected to impact a sizable area adjacent to the corridor, the impacted area was defined by a 6-mile wide buffer along the proposed alignment (see Figure C.1). According to the Final Environmental Impact Statement for SH 130 (U.S. Department of Transportation & Texas Department of Transportation, 2001), this area covers the footprints of all potential ecological, mobility, safety, social, economic, and cultural impacts (i.e., the potential EJ concerns) associated with the proposed road.

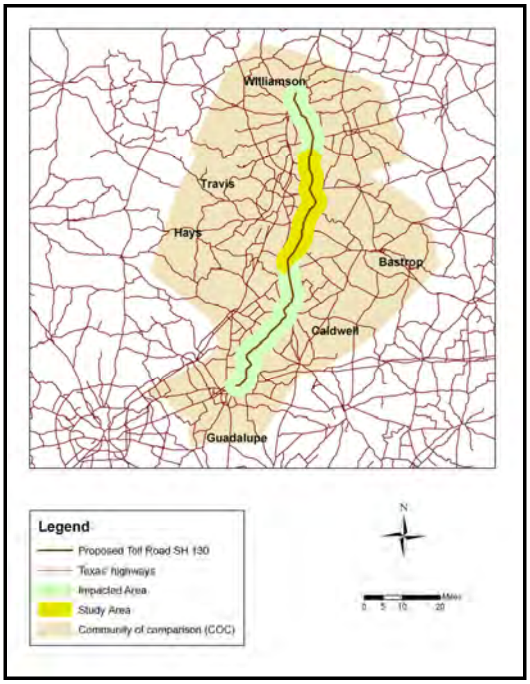

Figure C.1 Study Area

The first step in the model estimation was to identify demographic variables for the study area that were available at both the census block group and block levels from the U.S. Census data products. Secondly, several regression models were estimated using the OLS estimation approach and the "best" OLS model was chosen. Subsequently, a number of indicators were calculated to test for spatial dependence in the observed values and OLS residuals. The Moran's I statistic showed that the assumption of independently distributed residuals was not violated. A close examination of the spatial distribution of the regression residuals, however, revealed significant clusters of low-income populations in three census blocks. The spatial lag and error models were estimated to account for the spatial pattern in the final model[xi]. This section of the report presents the empirical results and the conclusions.

[xi] GeoDa™ – software to conduct exploratory spatial data analysis (ESRA) – was used to analyze and visualize global and local measures of spatial autocorrelation in the residuals and to incorporate spatial regression terms in the *block-low-income* regression model.

C.2.1 Potential Explanatory Variables

Based on the literature and prior knowledge about the impact of certain variables on an individual's income, potential explanatory demographic variables available at both the census block group and block levels were identified from the Census 2000 Summary File (SF 1). Table C.1 lists the explanatory variables that were considered in estimating the OLS model.

Table C.1 Potential Explanatory Variables

Variable Name (Code)		Variable Name
Households with one or more persons under 18 years (P019002)		HH-W-18Y
Households with one or more persons over 65 years		HH-W-65Y
Occupied housing units: owner occupied (H004001)		HHT-OOC
Family households (P026002)	2-person households (P026003)	HH-F-2
	3-person households (P026004)	HH-F-3
	4-person households (P026005)	HH-F-4
	5-person households (P026006)	HH-F-5
	6-person households (P026007)	HH-F-6
	7-or-more person households (P026008)	HH-F-7M
Non-family households (P026009)	1-person households (P0260010)	HH-NF-1
	2-person households (P0260011)	HH-NF-2
	3-person households (P0260012)	HH-NF-3
	4-person households (P0260013)	HH-NF-4
	5-person households (P0260014)	HH-NF-5
	6-person households (P0260015)	HH-NF-6
	7-or-more person households (P0260016)	HH-NF-7M

C.2.2 Multiple Regression Model

Eight OLS models were estimated and relevant comparisons were made between restricted and unrestricted models (see Table C.2). A number of alternative variable specifications were tested, such as: family households with two or more persons (HH-F-2M), family households with four or more persons (HH-F-4M), non-family households with two or more persons (HH-NF-2M), and non-family households with three or more persons (HH-F-3M).

Table C.2 Block-Income Model Specifications

Variable	Model 1		Model 2		Model 3		Model 4	
	B	t-value	B	t-value	B	t-value	B	t-value
CONSTANT	26.469	0.684	45.836	1.103	54.456	1.326	50.913	1.33
HH-W-18Y	3.502	2.005	2.459	1.412	2.674	1.536	1.751	8.186
HH-W-65Y	0.531	0.516	2.431	2.538	2.566	2.686	1.974	3.643
HH-OOC	-0.841	-2.803	-1.195	-5.727	-1.151	-5.585	-1.103	-6.049
Family households:								
HH-F-2	0.994	1.026	-0.593	-0.787	-0.981	-1.454	-0.977	-1.525
HH-F-3	-3.867	-1.632						
HH-F-4	-2.078	-1.059						
HH-F-5	-3.388	-1.201						
HH-F-6	1.471	0.519						
HH-F-7M	2.363	0.700						
HH-F-2M			-0.657	-0.401	-0.802	-0.488		
HH-F-4M								
Non-family households:								
HH-NF-1	-0.467	-0.488	-0.716	-0.829	-0.775	-0.896		
HH-NF-2	4.676	1.741	2.167	0.84				
HH-NH-3	-3.626	-0.438						
HH-NF-4	2.250	0.123						
HH-NF-5	-37.408	-1.105						
HH-NF-6	17.099	0.471						
HH-NF-7M	25.656	0.517						
HH-NF-3M			9.233	1.776				
HH-NF-2M					3.847	1.812	2.979	2.092
Adjusted R^2	0.839		0.751		0.749		0.759	
SSR	1,390,391.20		1,231,146.30		1,216,847.30		1,207,299.10	
SSE	129,881.75		289,126.63		303,425.69		312,973.92	
SST	1,520,272.95		1,520,272.93		1,520,272.99		1,520,273.02	
			Model 1 vs. Model 2		Model 1 vs. Model 3		Model 1 vs. Model 4	
SSE(restricted)			289,126.63		303,425.69		312,973.92	
SSE(unrestricted)			129,881.75		129,881.75		129,881.75	
# of restrictions			8		9		11	
N			35		35		35	
M			17		17		17	
Fstat			2.76		2.67		2.31	
Fcrit (.05, # restrict, *n*)			2.22		2.16		2.07	
Conclusion:			Reject Ho Model 1 is preferred		Reject Ho Model 1 is preferred		Reject Ho Model 1 is preferred	

Table C.2 Block-Low-Income Model Specifications (continued)

Variable	Model 5		Model 6		Model 7		Model 8	
	B	t-value	B	t-value	B	t-value	B	t-value
CONSTANT	44.829	1.471	47.325	1.557	44.275	1.532	68.743	1.776
HH-W-18Y	3.602	3.116	3.785	3.316	3.362	10.684	1.897	9.107
HH-W-65Y	0.977	1.478	0.933	1.414	0.763	1.577	1.824	3.677
HH-OOC	-0.772	-4.075	-0.897	-5.855	-0.906	-6.070	-1.278	-8.972
Family households:								
HH-F-2	1.014	1.334	1.396	2.017	1.482	2.294		
HH-F-3	-3.912	-2.187	-4.469	-2.584	-3.953	-3.662		
HH-F-4	-2.390	-2.135	-2.945	-2.881	-2.663	-3.790		
HH-F-5	-2.335	-1.013						
HH-F-6	-1.303	-6.100						
HH-F-7	1.996	0.957						
HH-F-2M								
HH-F-4M			-0.444	-0.386				
Non-family households:								
HH-NF-1								
HH-NF-2								
HH-NF-3								
HH-NF-4								
HH-NF-5								
HH-NF-6								
HH-NF-7								
HH-NF-3M								
HH-NF-2M								
Adjusted R^2	0.855		0.855		0.859		0.732	
SSR	1,358,138.40		1,345,152.50		1,344,186.10		1,148,392.80	
SSE	162,134.60		175,120.49		176,086.89		371,880.16	
SST	1,520,273.00		1,520,272.99		1,520,272.99		1,520,272.96	
	Model 1 vs. Model 5		Model 5 vs. Model 6		Model 6 vs. Model 7		Model 7 vs. Model 8	
SSE(restricted)	162,134.60		175,120.49		176,086.89		371,880.16	
SSE(unrestricted)	129,881.75		162,134.60		175,120.49		176,086.89	
# of restrictions	7		2		1		3	
N	35		35		35		35	
M	17		10		8		7	
Fstat	0.64		1.00		0.15		10.38	
Fcrit (.05, # restrict, *n*)	2.29		3.27		4.12		2.87	
Conclusion:	Fail to reject Ho Model 5 is preferred		Fail to reject Ho Model 6 is preferred		Fail to reject Ho Model 7 is preferred		Reject Ho Model 7 is preferred	

Table C.3 shows the “best” OLS model (Model 7). Some key observations regarding this model include the following:

- The explanatory variables are very significant determinants of individual income at the block group level as is evident from the large t-statistic values. All explanatory variables are statistically significant at the 95 percent confidence level (critical $t_{0.05, 35} = 2.030$), except the variable that represents households with one or more persons over 65 years which is statistically significant at the 85 percent confidence level (critical $t_{0.15, 35} = 1.472$).
- The explanatory variables provide a fairly high level of explanation. Roughly 86 percent of the observed variation in low-income individuals is explained by the simple linear regression model relationship between the dependent variable and the explanatory variables.
- The signs of the explanatory variables are as expected. The number of low-income individuals increases as the number of households with persons under 18 years, the number of households with persons over 65 years, or and the number of two-person family households increases. On the other hand, the number of low-income individuals decreases as the number of housing units that are occupied by owners or family households with three and four persons increases.
- In terms of the magnitude of the coefficients, the “number of children per household” and the “three-person family household” variables have the effect.
- Unequal variance in the regression errors (i.e., heteroskedasticity) is suggested by the highly significant White test (critical $\chi^2_{0.05,6} = 12.59$).

Table C.3 Best “OLS” Model

Variable	Coefficient (β)	t-value
Constant	44.275	1.532
Households with one or more people under 18 years	3.362	10.684
Households with one or more people over 65 years	0.763	1.577
Occupied housing units: owner occupied	-0.906	-6.070
2-person family households	1.482	2.294
3-person family households	-3.953	-3.662
4-person family households	-2.663	3.790
Adjusted R^2 =	0.859	
SSR (residual sum of the squares) =	1,344,186	
SSE (error sum of the squares) =	176,087	
SST (total sum of the squares) =	1,520,273	
F-level =	35.62 (p-value < 0.05)	
White test =	22.466	

C.2.3 Examination of the Residuals

The Moran scatter plot (see Figure C.2) shows the residuals within the study area by type of spatial autocorrelation (i.e., high-high, high-low, low-high, low-low). The Monte Carlo test was applied using 999 permutations to test the significance of the global autocorrelation. This number of permutations provided stable results. The low value of Moran's I (0.0520) indicates that the assumption of independently distributed residuals is not violated. Subsequently, the spatial distribution of the significant regression residuals was examined. Examining the regression residuals can assist in revealing a pattern of heterogeneity across the study area. This knowledge can subsequently be used to improve the model and undertake further hypothesis testing. The mapped residuals and the LISA values were used to reveal a pattern of heterogeneity across the study area.

The significance map of the residuals (see Figure C.3) shows the blocks within the study area where the LISA values are significant. The cluster map of the residuals (see Figure C.4) shows in which of the Moran scatter plot quadrants each significant residual falls. Significant local clustering of like values (i.e., high-high and low-low) are present in two blocks (p-value = 0.05). The OLS model is underestimating the number of individuals below the poverty level in these two blocks. In one block a significant local clustering (p-value = 0.01) of an unlike value (e.g., low-high) is present. The OLS model is over-estimating the number of individuals below the poverty level in this block.

Global Moran's Index	
Low values surrounded by high values (low-high)	***High values surrounded by high values (high-high)***
Low values surrounded by low values (low-low)	***High values surrounded by low values (high-low)***

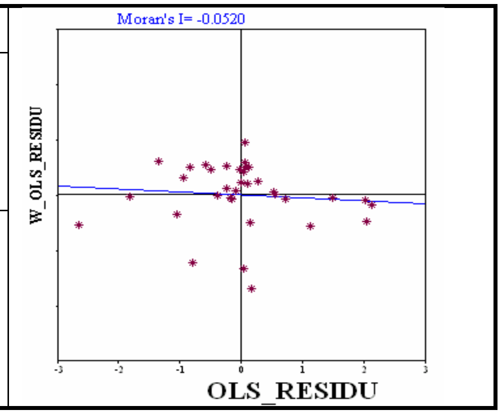

Figure C.2 Moran Scatter Plot of Residuals (after 999 permutations)

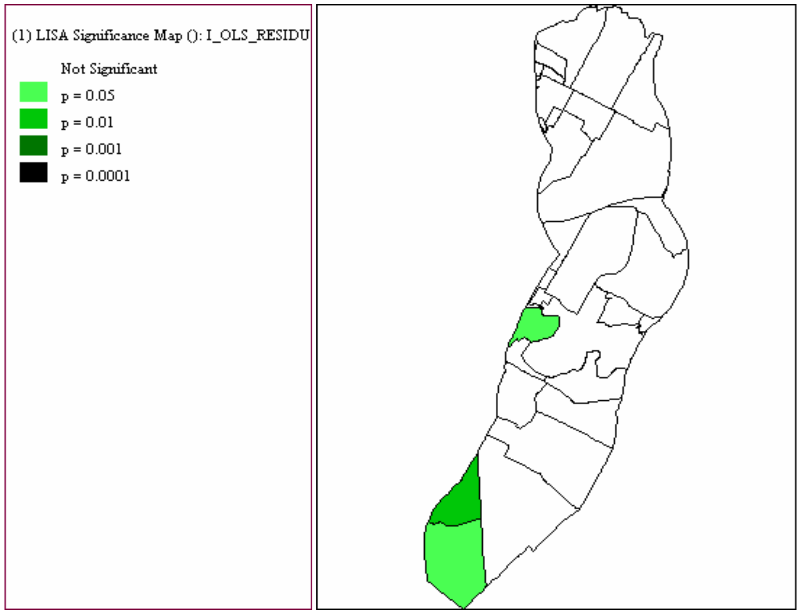

Figure C.3 LISA Significance Map of Residuals (after 999 permutations)

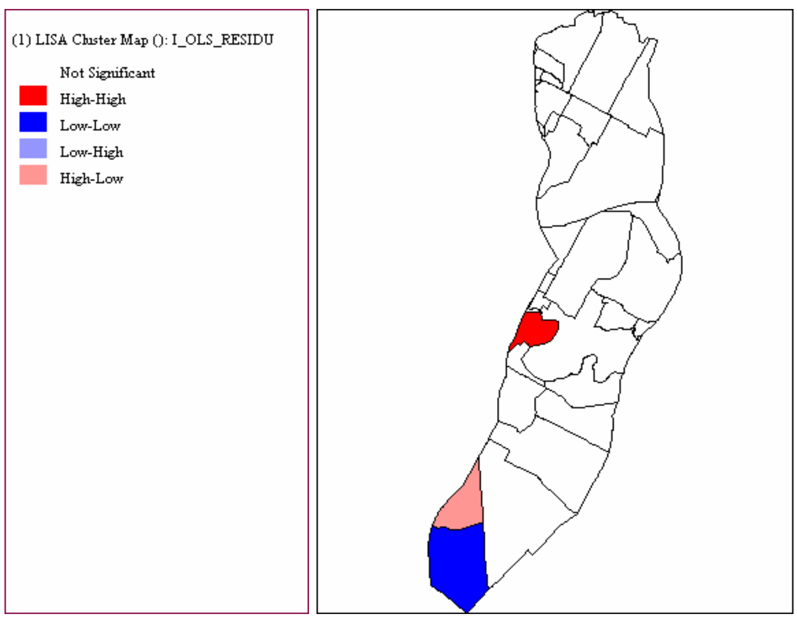

Figure C.4 LISA Cluster Map of Residuals (after 999 permutations)

C.2.4 Spatial Models

The results of the spatial dependence tests of the "best" OLS model are presented in Table C.4. Because the Lagrange Multiplier tests for spatial dependence were not highly significant (critical $\chi^2_{0.05,1} = 3.841$), independently distributed observed values and residuals can be assumed. As indicated in the previous section, three blocks within the study area, however, showed a cluster pattern. Therefore, the spatial lag and spatial error models were estimated to determine to what extent these models can account for the identified spatial pattern.

Table C.4 Spatial Dependence Test Results

Test	Value	P-value
Robust Lagrange Multiplier (lag)	0.0423686	0.8369188
Robust Lagrange Multiplier (error)	0.1975287	0.656723

Examining the residuals from the spatial error model showed much less correlation globally (see Figure C.5). The cluster and significant LISA maps (Figures C.6 and C.7), however, still revealed clusters of significantly similar residuals.

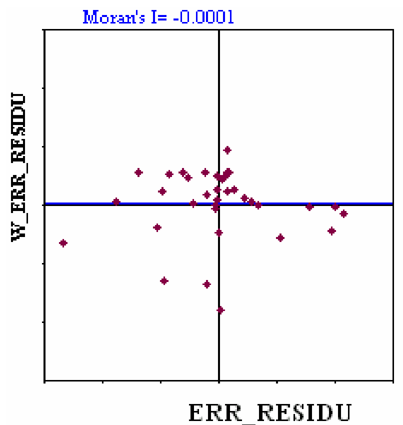

Figure C.5 Moran Scatter Plot of Error Residuals (after 999 permutations)

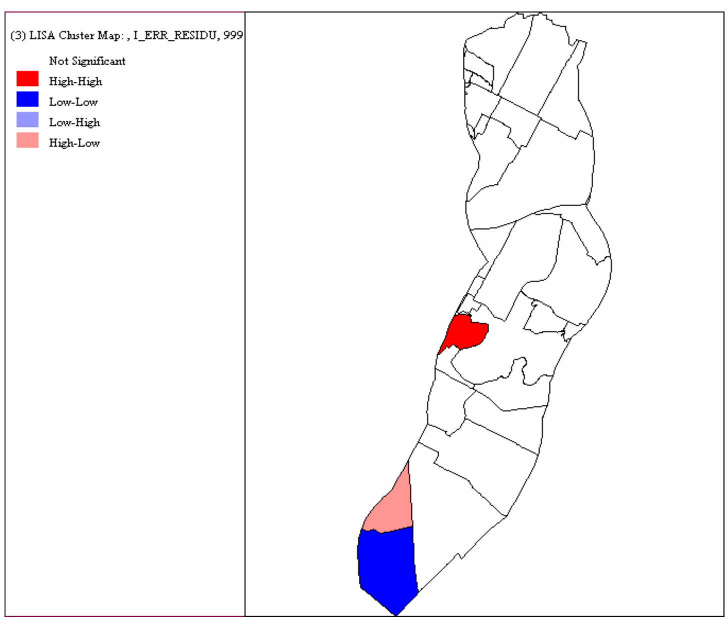

Figure C.6 LISA Significance Map of Error Residuals (after 999 permutations)

Figure C.7 LISA Cluster Map of Error Residuals (after 999 permutations)

Table C.5 contains the estimation results for the “best” OLS, spatial lag, and spatial error models.

Table C.5 Estimation Results

Variable	“Best” OLS Model		Spatial Lag Model		Spatial Error Model	
	Coefficient	**P-value**	**Coefficient**	**P-value**	**Coefficient**	**P-value**
CONSTANT	44.2746	0.1368	47.7929	0.2291	49.4730	0.0538
HH-W-18Y	3.3618	0.0000	3.3777	0.0000	3.3593	0.0000
HH-W-65Y	0.7633	0.1261	0.7577	0.0812	0.7233	0.0886
HHT-OOC	-0.9059	0.000	-0.9081	0.0000	-0.9070	0.0000
HH-F-2	1.4815	0.0295	1.4851	0.0108	1.4053	0.0113
HH-F-3	-3.9525	0.0010	-3.9858	0.0001	-3.8135	0.0000
HH-F-4	-2.6626	0.0007	-2.6722	0.0000	-2.7131	0.0000
WI			-0.0155*	0.9134		
$W\varepsilon$					-0.1339**	0.5611

* ρ
** λ

The key findings from the estimation results can be summarized as follows:

- The difference in the magnitude of the coefficients of the three models is small.
- All the coefficients are statistically significant at the 5 percent level, with the exception of the number of households with one or more people over 65 years. In the spatial models, this explanatory variable is statistically significant at the 10 percent level.

- The magnitude and p-values for the ρ and λ coefficients reveal that the spatial context has a relatively insignificant effect on the OLS model specification. Specifically, low-income individuals in neighboring blocks seem to have no effect on the low-income individuals in the block of concern and relevant explanatory variables were not omitted in the OLS specification.
- The residuals of the spatial error model present marginally less correlation than the OLS residuals. Subsequently, the spatial distribution of the target low-income population within the study area was mapped using the estimates from both the "best" OLS and the spatial error models (see following section).

C.2.5 Spatial Distribution of Low-Income Populations

As explained before, the number of low-income individuals was estimated at the block level using both the "best" OLS and spatial error models. Applying the threshold approach, the spatial distribution of target and non-target low-income populations was mapped based on the classic "OLS" model and the spatial model (see Figure C.8).

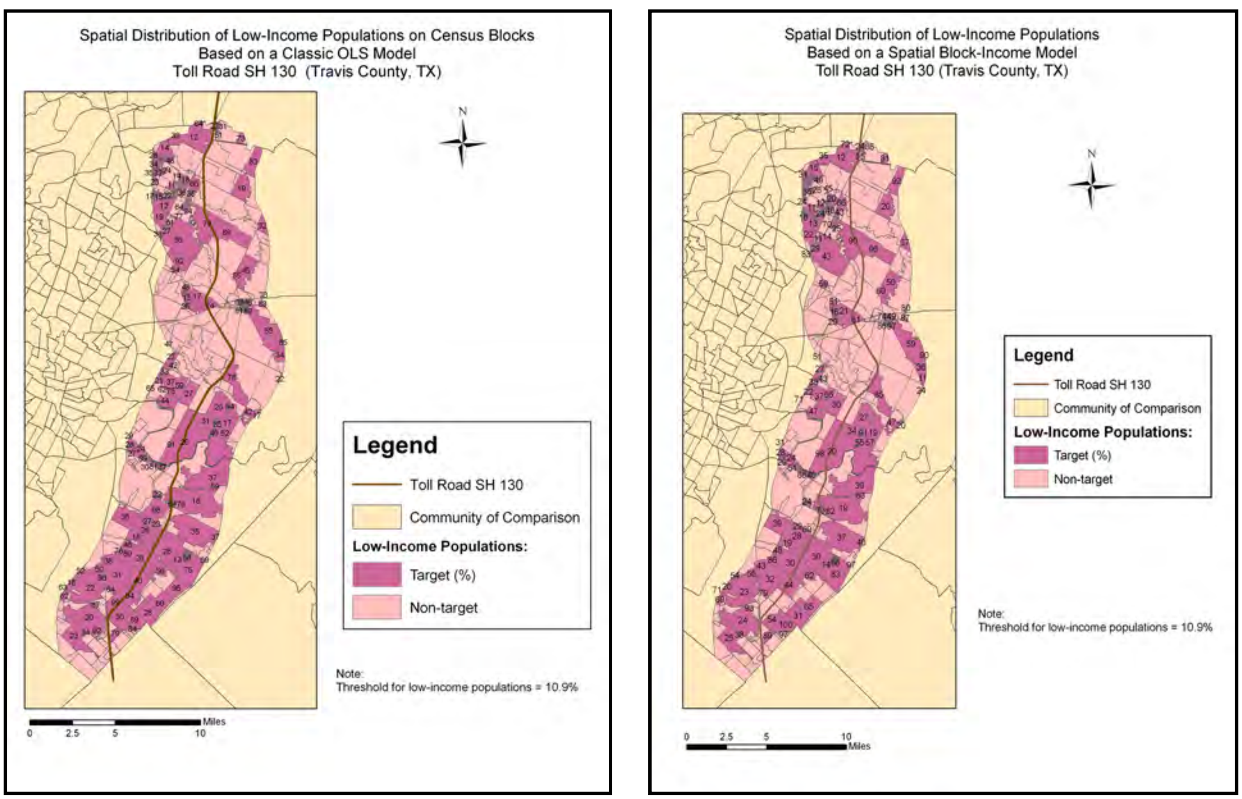

Figure C.8 Spatial Distribution of Low-Income Population at the Block Level

The following observations can be made after comparing the distribution of low-income populations estimated by the classic OLS model and the spatial model:

- The spatial block-low-income model predicts higher percentages of low-income populations than the “best” OLS model.
- The differences between target and non-target blocks pertain to very small geographic blocks.
- In the case of both models, the target low-income population is predicted to reside mostly in the southern portion of the study area.

C.3 Conclusions

In general, the classic OLS estimates are sensitive to the model specification and the presence of spatially correlated estimation errors. If observations are not independent, it may result in some coefficients being considered significant when in fact they are not. If there is spatial autocorrelation in the residuals, the model might overestimate or underestimate the observed values. The approach presented in this appendix thus demonstrates the importance of assessing the spatial context of observations in an effort to estimate an improved model that accounts for spatial autocorrelation. Spatial econometric models thus extend regression analysis to account for the fact that data used in model estimation often relates to specific geographic areas and therefore may exhibit a certain spatial pattern.

If spatial autocorrelation exists in the data, the OLS parameters are inefficient, and significance tests are unreliable. The spatial models assist in revealing the explanatory variables that are statistically significant after accounting for the spatial autocorrelation. If spatial autocorrelation exists in the residuals due to omitted explanatory variables, it is recommended that the missing variables be identified to explain the spatial pattern in the residuals.

Using the 2000 U.S. Census Data available at the census block group and block levels, the “best” OLS model was estimated at the block group level for the impacted area of a section of the proposed SH 130 in Travis County, Texas. The empirical results disclosed that the “best” OLS model did not violate the assumptions of independently distributed observed values and residuals. Close examination of the OLS residuals, however, revealed that three blocks within the study area exhibited a potentially significant cluster pattern. Two spatial models were estimated to improve the understanding of this spatial pattern. However, the spatial lag and spatial error models revealed the insignificance of the spatial context of the data for the study area. The residuals of the spatial error model, however, presented marginally less correlation than the OLS residuals. The results from the empirical application should, however, not be generalized to other study areas. On the contrary, the existence of a spatial pattern should be examined on a case-by-case basis.

Appendix D: Environmental Justice Concentration Zones

This appendix describes an innovative approach that overcomes some of the limitations of the threshold approach in identifying the concentration levels of Environmental Justice (EJ) individuals at the project level. The approach uses spatial autocorrelation tools and GIS modeling in vector and raster data structures to characterize the EJ communities by concentration levels and define EJ concentration zones within the impacted area. The described approach is tested by using data for the section of the SH130 toll road that traverses Travis County, Texas.

D.1 Methodology

The approach consists of five steps. First, the spatial distribution of minority and low-income populations is estimated at the census block level using U.S. Census Data and a spatial block-low-income model. Second, local measures of spatial autocorrelation for minority and low-income populations are computed for each census block within the impacted area. The impacted area covers the footprints of all potential ecological, mobility, safety, social, economic, and cultural impacts (i.e., the potential EJ concerns) associated with the proposed investment. Third, based on the spatial cluster patterns within the impacted area, the EJ concentration levels (i.e., for minority and low-income populations, respectively) are conceptualized. These concentration levels and their associated p-values are mapped using vector models. Fourth, using a raster environment, the concentration levels of minority and low-income populations are combined into a single raster model. The outcome is a map in which each cell has a value that represents its concentration level. Finally, these values and specified spatial connectivity criteria are used to define EJ concentration zones. These concentration zones thus consist of a group of cells that shares the same values and meets established connectivity criterion.

D.1.1 Local Measures of Spatial Autocorrelation

The fundamental property of spatially autocorrelated data is that values are not random in space and are thus spatially correlated to each other. For EJ analysis, spatial autocorrelation may be defined as the relationship among the attribute values (i.e., minority/low-income populations) that stems from the geographic arrangement of the features (i.e., census blocks) in which these values occur. The local Moran statistic (*I*) can be used to assess the level of spatial autocorrelation for each census block within the impacted area. This statistic can be calculated as follows:

$$I_i = z_i \sum_j w_{ij} z_j$$

$$\text{since} \quad z_i = \frac{(y_i - \bar{y})}{\delta}$$

where

I_i is the local Moran statistic for block i,

w_{ij} is the spatial weight between census blocks i and j;

z_i and z_j are deviations from the mean for census blocks i and j respectively,

y_i is the minority/low-income population in the census block i,

$\bar{y}$ is the sample mean, and

δ is the standard deviation of y_i.

With the exception of the spatial weight (w_{ij}), all terms can be calculated from the attribute values of the geographic features. To define the spatial relationship among census blocks, a binary connectivity matrix is constructed based on the rook's case. Rook's case refers to the boundary share. In other words, neighboring geographical features have to share a boundary with a length greater than zero. Then, the elements of the spatial weight matrix can be represented as follows:

$$w_{ij} = \begin{cases} 1 & \text{if census blocks } i \text{ and } j \text{ are contiguous}, i \neq j \\ 0 & \text{otherwise} \end{cases}$$

A high value of *I* indicates a cluster of similar values (can be high or low) while a low value of *I* refers to a cluster of dissimilar values. Since high or low *I* values may occur by chance, these values have to be compared with their expected values and interpreted given their standardized scores. A statistical test to confirm or reject the null hypothesis of no spatial dependence assuming a standard normal distribution was thus conducted (Anselin, 1988). Once the local Moran statistic is derived for each census block, different concentration levels of EJ populations can be identified within the impacted area. Specifically, the Moran scatter plot can be used to reveal cluster patterns within the impacted area by type of spatial autocorrelation (see Figure D.1). The upper right and lower left quadrants of the Moran scatter plot indicate the observations with positive spatial autocorrelation (can be high-high or low-low), while the lower right and upper left quadrants show the observations with negative spatial autocorrelation (can be high-low or low-high). Clusters of high values are labeled as "hot spots" while clusters of low values are labeled as "cold spots." These spatial cluster patterns are used to map the concentration levels of EJ populations within the impacted area.

Low values surrounded by high values (low-high)	High values surrounded by high values (high-high) ***HOT SPOTS***
Low values surrounded by low values (low-low) ***COLD SPOTS***	High values surrounded by low values (high-low)

Figure D.1 Moran Scatter Plot

GIS modeling in vector data structures was used to assemble the concentration levels and their significance for both minority and low-income populations within the impacted area.

D.1.2 EJ Concentration Zones

Using a raster environment, the impacted area is first divided into grid squares or cells, each of which has a value that represents the phenomenon of interest. Second, the vector maps are converted into raster maps by assigning to each cell a value that represents its concentration level (see Table D.1). The cell size used to convert the vector models into raster models was determined by the size of the smallest census block within the impacted area to allow the most detailed level of analysis (i.e., represent the smallest EJ community). Third, the two raster maps—one displaying the concentration levels for minority populations and the other the concentration levels for low-income populations—were combined into a single raster model that represents sixteen different levels of concentrations (see Table D.2).

Table D.1 Concentration Levels for EJ Populations

Concentration levels	Description	Cell values	
		Minority Population	Low-Income Population
*Small	Cluster of low values ("cold spot")	M_1	I_1
Medium	Scatter of low values surrounded by high values	M_2	I_2
High	Scatter of high values surrounded by low values	M_3	I_3
Extremely high	Cluster of high values ("hot spot")	M_4	I_4

*Include areas with no EJ populations

Table D.2 Cell Values of the Outcome Map Displaying the Concentration Levels of EJ Populations

Concentration level for minority population	Concentration level for low-income population			
	Small	Medium	High	Extremely high
Small	C_{11}	C_{12}	C_{13}	C_{14}
Medium	C_{21}	C_{22}	C_{23}	C_{24}
High	C_{31}	C_{32}	C_{33}	C_{34}
Extremely high	C_{41}	C_{42}	C_{43}	C_{44}

Note: $C_{11} = M_1 + I_1$, $C_{32} = M_3 + I_2$, and so on

The EJ concentration zones were compiled using the raster outcome map displaying the sixteen possible different concentration levels (i.e., cell values) of EJ populations and specified connectivity criteria. Connectivity refers to the eight nearest neighboring cells that share a boundary greater than zero with the cell of concern. The eight nearest neighbors are the cells that are directly to the right or left, above or below, or are diagonal to the cell of concern. Cells are thus grouped into concentration zones if they have the same value and if they meet the spatial requirement of connectivity specified. The final outcome is a map that illustrates the EJ concentration zones with their corresponding concentration levels.

D.2 Empirical Results

D.2.1 Impacted Area

The approach presented in this paper was tested using information for a section of the SH 130 toll road in Travis County, Texas. Using U.S. Census data and a calibrated spatial block-low-income model, the minority and low-income populations were estimated at the census block level. The impacted area consisted of a total of 1,084 census blocks. Descriptive statistics for the minority and low-income populations within the impacted area are provided in Table D.3.

Table D.3 Descriptive Statistics for the EJ Population within the Impacted Area (1,084 census blocks)

Total Population (inhabitants)	Mean	Standard Deviation	Total Minority Population (inhabitants)	Mean	Standard Deviation
58,961*	54	124	28,990 (49%)	27	73
Total Population (inhabitants)	**Mean**	**Standard Deviation**	**Total Low-Income Populations (inhabitants)**	**Mean**	**Standard Deviation**
55,709**	51	104	16,876 (30%)	15	28

*Based on SF 1

**Based on the block-income model

Note: Approximately 90 percent of the minority population in the impacted area is also low-income.

D.2.2 Spatial Data Analysis

Using GeoDaTM, a software package for exploratory spatial data analysis (Anselin, 2003b), the local Moran statistic for each census block within the impacted area was estimated. Based on the spatial patterns displayed by the Moran scatter plot (see Figure D.2) census blocks were categorized by concentration levels (see Table D.4).

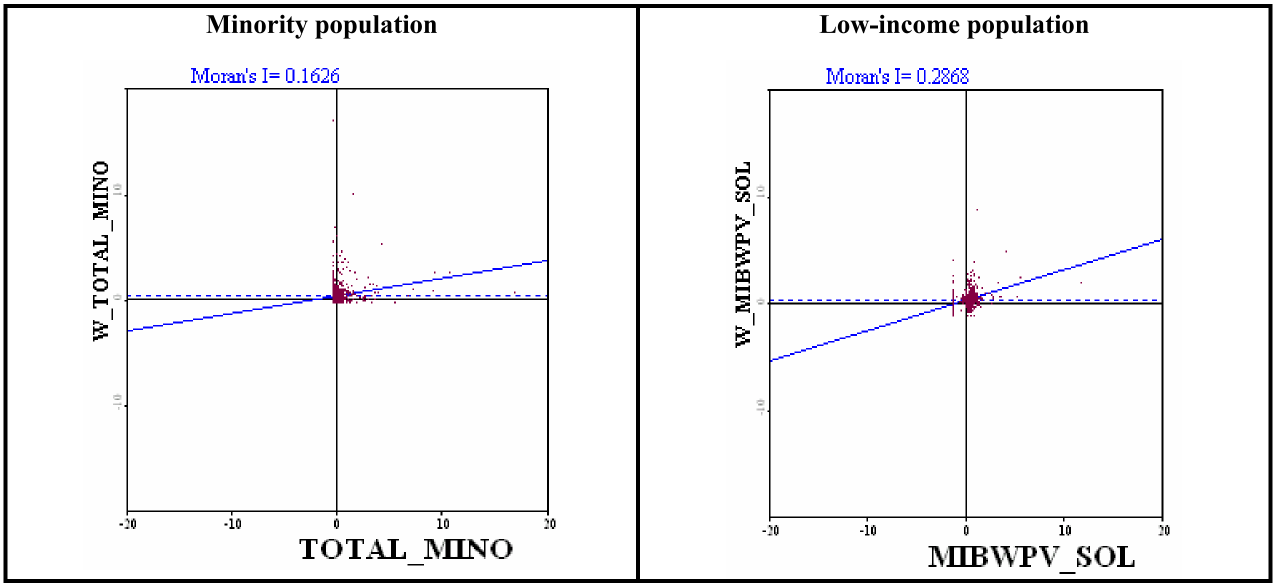

Figure D.2 Clustering Spatial Patterns for EJ Populations within the Impacted Area

The impacted area is subsequently divided into grid squares or cells. The size of the smallest census block determined the cell size used to convert the vector models into raster models. As indicated before, this is to allow the representation of the smallest EJ community.

The vector models were converted into raster models by assigning values representing the EJ concentration levels to each cell (see Table D.4). Figures D.3 and D.4 display the information contained in Table D.4 graphically. In addition to the concentration levels, the significance levels (p-values) are given.

Table D.4 Cell Values for the Raster Maps Displaying the Concentration Levels of Minority and Low-Income Populations

Concentration levels	Cell values	
	Minority Population	Low-Income Population
*Small	1	10
Medium	2	20
High	3	30
Extremely high	4	40

*Include areas with no EJ populations

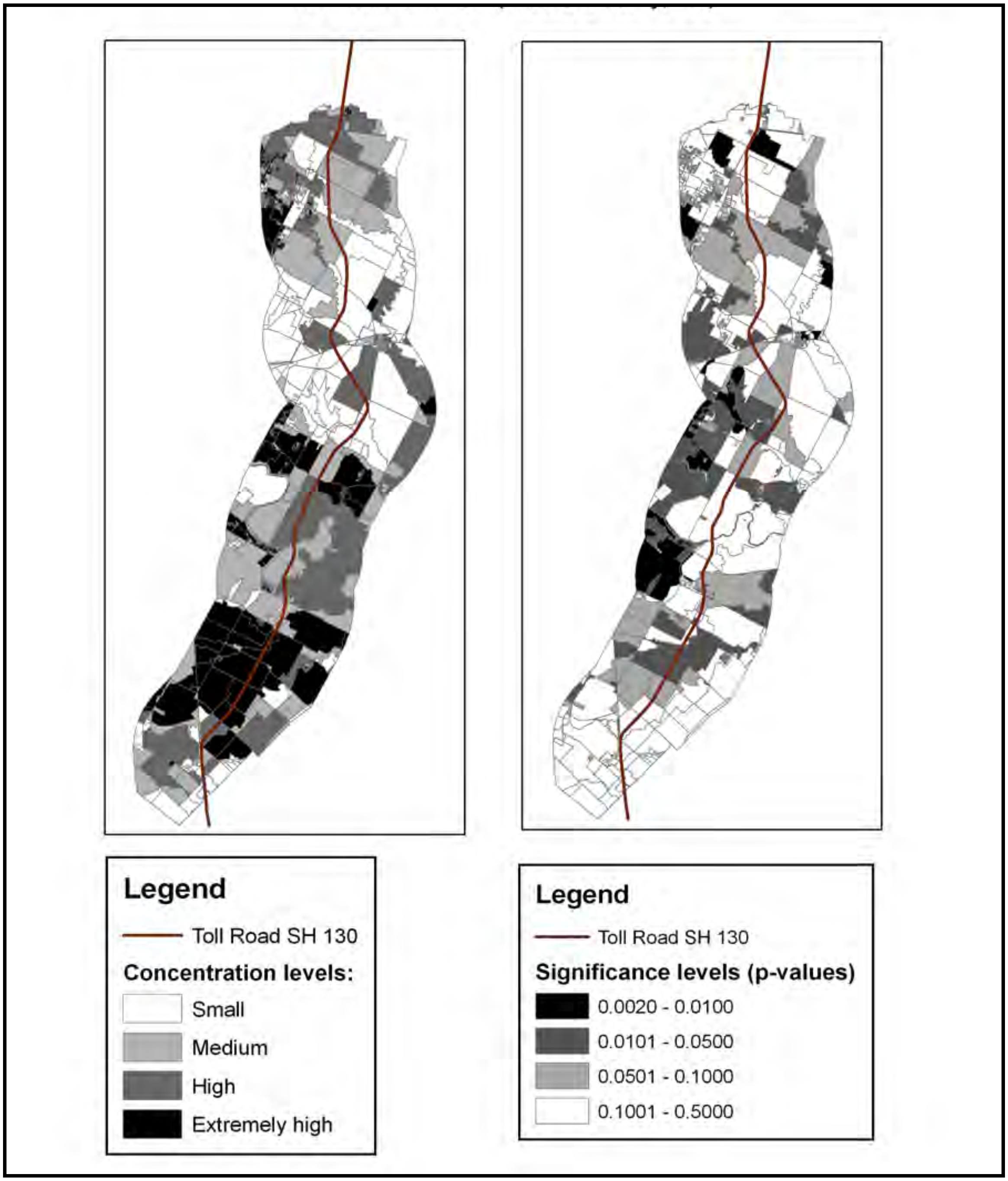

Figure D.3 Minority Population Concentration Levels within the Impacted Area

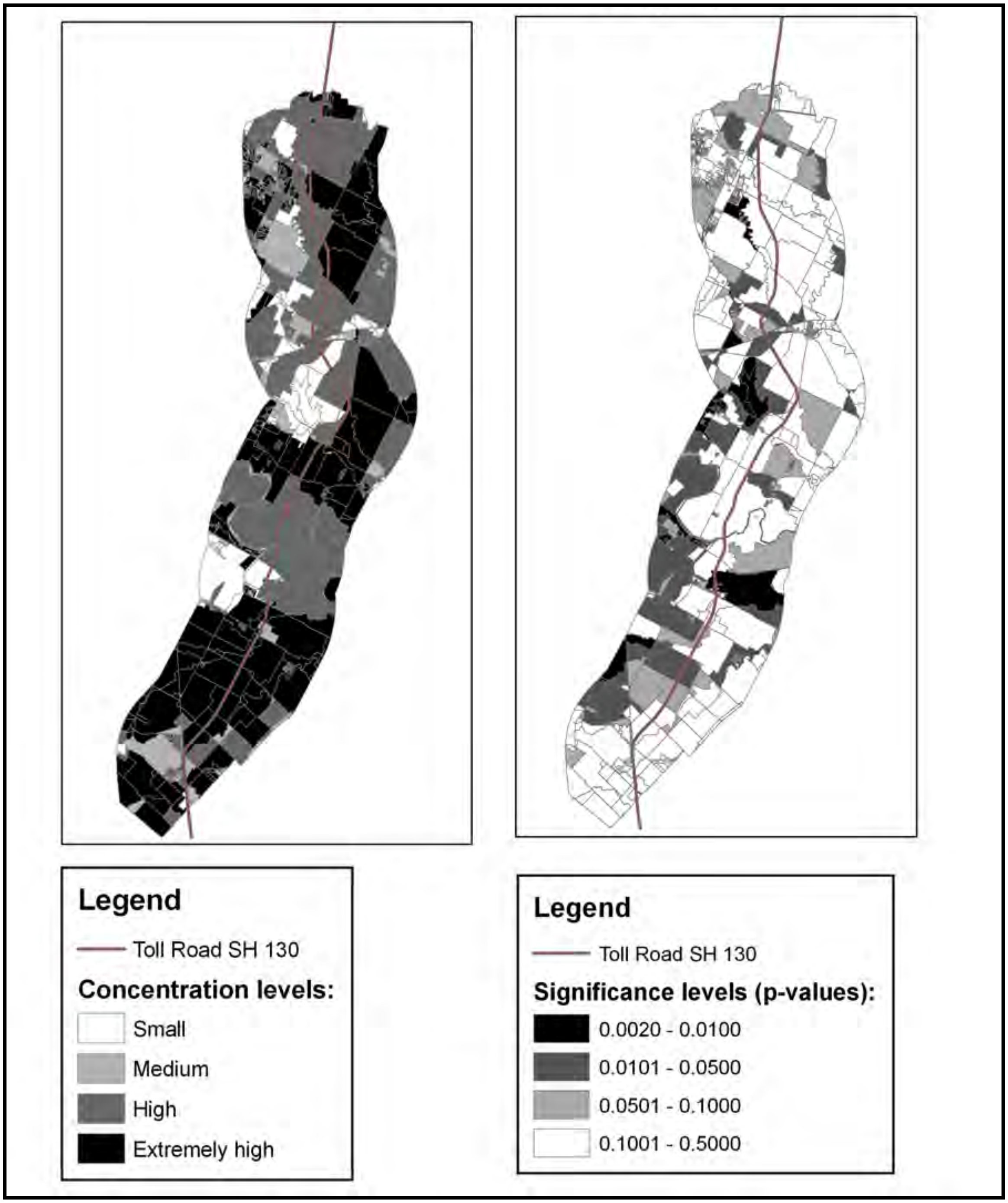

Figure D.4 Low-Income Population Concentration Levels within the Impacted Area

The two raster models were subsequently combined into a single raster reflecting all potential concentration levels of EJ populations within the impacted area (see Table D.5). Using this new outcome raster and the region group option provided by ArcMap, the EJ concentration zones were defined and their corresponding concentration levels displayed (see Figure D.5).

Table D.5 Cell Values for the Outcome Raster Map Displaying the Concentration Levels of EJ Populations

Concentration levels for minority population	Concentration levels for low-income population			
	*Small	Medium	High	Extremely high
*Small	11	21	31	41
Medium	12	22	32	42
High	13	23	33	43
Extremely high	14	24	34	44

*Include areas with no EJ populations

Figure D.5 EJ Population Concentration Levels within the Impacted Area (612 EJ Concentration Zones)

Relevant observations from Figure D.5 displaying the EJ concentration zones within the impacted area are as follows:

- Each zone, instead of corresponding to a geopolitical unit which does not necessarily represent the spatial patterns of EJ populations, is homogenous in terms of concentration levels of minority and low-income populations.
- All concentration levels are present in the impacted area with the exception of concentration level 14 (i.e., extremely high concentration of minority population and low concentration of low-income population). In addition, the presence of clusters of EJ zones with extremely high levels of both minority and low-income populations are particularly noticeable in the south, central-west, and north-west portions of the impacted area.
- The effect of the proposed road on EJ populations within the impacted area can be assessed by overlaying the EJ concentration zones with the anticipated impacts. For example, overlapping the EJ concentration zones layer with layers displaying the potential ecological, mobility, safety, social, economic, and cultural impacts (i.e., the potential EJ concerns) associated with the toll road will help to determine whether this road would burden EJ populations disproportionately as compared to non-EJ populations.
- The very small EJ concentration zones within the impacted area reveal the presence of small pockets of EJ populations. This outcome map should thus be validated through both visual inspection and the gathering of local demographic data. Agencies that administer federal income sensitive programs, such as food stamps, section 8 housing, and free/reduced price meals, may be valuable sources of information to validate these EJ concentration zones.

D.3 Relevance of EJ Concentration Zones For EJ Assessment

The proposed approach allows the analyst to compile zones displaying different concentration levels of EJ populations as opposed to a generic label of target minority/low-income populations versus non-target minority/low-income populations. Also, the proposed methodology allows for the identification of very small zones containing EJ populations, thereby fulfilling the federal requirement that all minority/low-income populations be considered in EJ analysis, irrespective of the size of the community.

Defining zones as a function of the concentration levels of EJ populations can also help DOTs to focus their community outreach efforts as follows:

- Strategic points for liaising with the community can be identified by overlapping the EJ concentration zones with layers that contain community facilities (e.g., churches, schools, community centers, and shopping). Additional places beyond churches and schools accessible to all in the affected community can thus be identified.
- The size and distribution of the EJ concentration zones provide a sense of the scale of the effort required for validating the spatial distribution of EJ communities within the impacted area. Because information for small pockets of minority populations is usually obtained from churches, community centers, and by visual inspection, the validation of small zones may be more time consuming than the larger zones.

- It is foreseen that it would be easier to identify and quantify the impacts on larger zones than on smaller zones. Therefore, care should be taken to ensure the participation of minority and low-income populations living in these small pockets to ultimately enhance the EJ assessment of toll road projects.
- The anticipated impacts on EJ communities can be displayed by overlaying the EJ concentration zones with the anticipated impacts. These map overlays can be very useful in communicating the adverse impacts and the proposed mitigation options to the public. High concentrations of minority and low-income populations require special attention when (a) EJ concerns are identified and assessed, and (b) when mitigation options are designed to lessen or offset the negative impacts.

D.4 Conclusions

This appendix describes an innovative approach for identifying the spatial distribution of EJ communities impacted by toll projects. The approach uses U.S. Census Data, spatial autocorrelation measures at the census block level, and GIS modeling in vector and raster data structures to both categorize minority and low-income populations by concentration levels and define zones as a function of EJ concentration levels and established connectivity criteria. Zones with low, medium, high, and extremely high concentrations of EJ populations can thus be defined within the impacted area. This approach therefore overcomes some of the limitations of the threshold analysis that divides the community into two groups (i.e., target EJ population and non-target EJ population) and whose results depend on the community of comparison (COC) chosen and the geographic scale of analysis used.

The results of the proposed approach can be used to define the appropriate scale (i.e., unit of geographic analysis) for EJ assessment. In many instances, the course scale of Traffic Analysis Zones (TAZs) used for travel demand modeling is inadequate for effective EJ analysis. Also, the results can be used to assess who benefits and who is burdened by the potential ecological, social, and economic impacts associated with a toll road by overlaying the EJ concentration zones with the anticipated impacts. Finally, the outcome map showing the spatial concentration of EJ communities can be used by state DOTs to focus their community outreach efforts. Specifically, this map can help an analyst to (a) identify strategic points within the impacted area for liaising with the community, (b) obtain a sense of the scale of the effort required for validating the spatial distribution of EJ communities within the impacted area, and (c) communicate the adverse impacts and the proposed mitigation options to the affected EJ communities.

Appendix E: Toll Road Impact Matrix

Additional Benefits and Burdens Imposed by Toll Roads on Communities				
Effects	**Scenario 1** Converting existing non-toll roads into toll roads	**Scenario 2** Constructing new toll roads instead of non-toll roads (assuming same road geometric and operational characteristics)	**Scenario 3** Converting planned non-toll roads into toll roads before the facility is open to the public (assuming same road geometric and operational characteristics)	**Scenario 4** Converting existing non-toll roads into toll roads but adding adjacent frontage roads as "free alternate" routes
Physical Environmental Quality Effects				
Air Quality				
Pollutants	√ Burdens - Examples: (1) traffic diverted through neighborhoods increases traffic delays resulting in increasing air contaminants in local streets, (2) stop-and-go driving conditions at the toll plaza increase carbon monoxide concentrations, (3) air pollutants increase because travel speed of toll road users is over 55 mph	√ Burdens - Example: (1) stop-and-go driving conditions at the toll plaza increase air pollutants	√ Burdens - Example: (1) stop-and-go driving conditions at the toll plaza increase air pollutants	√ Burdens - Examples: (1) traffic diverted through neighborhoods increases traffic delays resulting in increasing air contaminants in local streets, (2) stop-and-go driving conditions at the toll plaza increase carbon monoxide concentrations, (3) air pollutants increase because travel speed of toll road users is over 55 mph
	√ Benefits - Example: (1) if toll roads have lower traffic volumes and less congestion compared to non-toll roads, then the air contaminants from the former are expected to be less than those from the latter	√ Fewer Benefits - Example: (1) if toll roads have lower traffic volumes and less congestion compared to non-toll roads, then air contaminants from the former are expected to be less than those from the latter	√ Fewer Benefits - Example: (1) if toll roads have lower traffic volumes and less congestion compared to non-toll roads, then air contaminants from the former are expected to be less than those from the latter	√ Benefits - Examples: (1) the added capacity results in less congestion, which leads to fewer air contaminants. However, as demand increase, congestion on frontage roads will reduce this benefit.

Additional Benefits and Burdens Imposed by Toll Roads on Communities				
Effects	**Scenario 1** Converting existing non-toll roads into toll roads	**Scenario 2** Constructing new toll roads instead of non-toll roads (assuming same road geometric and operational characteristics)	**Scenario 3** Converting planned non-toll roads into toll roads before the facility is open to the public (assuming same road geometric and operational characteristics)	**Scenario 4** Converting existing non-toll roads into toll roads but adding adjacent frontage roads as "free alternate" routes
Regional compliance with clean air standards and conformity	√ Burdens - Example (1) to avoid the extra cost of the toll, traffic diverts to other freeways, corridors, and arterials, thus increasing traffic delays which also causes air pollution at the regional level to increase	√ Fewer Benefits - Example: (1) because toll roads attract less traffic than non-toll roads, the former provides fewer benefits in terms of pollutant reduction at the regional level than does the latter	√ Fewer Benefits - Example: (1) because toll roads attract less traffic than non-toll roads, the former provides fewer benefits in terms of pollutant reduction at the regional level than does the latter	√ Burdens – Example (1) Diversion of traffic to frontage roads will increase stop and go traffic (due to signalization) and thus pollution compared to existing non-toll road.
Reduction in Single-Occupant Vehicle (SOV) use	√ Benefits - Example: (1) for people who cannot afford the toll, toll roads encourage the use of alternative transportation modes such as mass transit, paratransit, and ridesharing, which in turn helps protect the air quality by reducing vehicle air contaminants	√ Benefits - Example: (1) for people who cannot afford the toll, toll roads encourage the use of alternative transportation modes such as mass transit, paratransit, and ridesharing, which in turn helps protect the air quality by reducing vehicle air contaminants	√ Benefits - Example: (1) for people who cannot afford the toll, toll roads encourage the use of alternative transportation modes such as mass transit, paratransit, and ridesharing, which in turn helps protect the air quality by reducing vehicle air contaminants	√ Benefits - Example: (1) for people who cannot afford the toll, toll roads encourage the use of alternative transportation modes such as mass transit, paratransit, and ridesharing, which in turn helps protect the air quality by reducing vehicle air contaminants

Additional Benefits and Burdens Imposed by Toll Roads on Communities				
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Noise				
Sensitive site noise contour levels	√ Burdens - Examples: (1) heavy vehicles diverted onto local streets increase neighborhood noise levels, (2) if the additional right-of-way for the toll plaza reduces the distance between sources (e.g., car, trucks) and receivers (e.g., houses, schools, hospitals), then the noise level at the receivers increases, (3) high speed limits on toll roads increase traffic noise levels, negatively impacting sensitive sites (e.g., hospitals) adjacent to the facility	√ Burdens - Examples: (1) if additional right-of-way for the toll plaza reduces the distance between sources (e.g., cars, trucks) and receivers (e.g., houses, schools, hospitals), then the noise level at receivers increases, (2) high speed limits on toll roads increase traffic noise levels which negatively impact sensitive sites (e.g., hospitals) adjacent to the facility	√ Burdens - Examples: (1) if additional right-of-way for the toll plaza reduces the distance between sources (e.g., cars, trucks) and receivers (e.g., houses, schools, hospitals), then the noise level at receivers increases, (2) high speed limits on toll roads increase traffic noise levels which negatively impact sensitive sites (e.g., hospitals) adjacent to the facility	√ Burdens - Examples: (1) if additional right-of-way for the toll plaza reduces the distance between sources (e.g., cars, trucks) and receivers (e.g., houses, schools, hospitals), then the noise level at receivers increases, (2) high speed limits on toll roads increase traffic noise levels which negatively impact sensitive sites (e.g., hospitals) adjacent to the facility
	√ Benefits - Example: (1) traffic noise levels on toll roads are lower than on non-toll roads because of lower traffic volumes	√ Benefits - Example: (1) traffic noise levels on toll roads are lower than on non-toll roads because of lower traffic volumes	√ Benefits - Example (1) traffic noise levels on toll roads are lower than on non-toll roads because of lower traffic volumes	√ Benefits - Example: (1) traffic noise levels on toll roads are lower than on non-toll roads because of lower traffic volumes

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Water Resources				
Surface water quality	√ Burdens - Examples: (1) traffic diverted through neighborhood contributes to increased levels of water runoff pollution on local streets, (2) spillage of material transported by heavy vehicles that are diverted through local streets contaminates surface water, (3) impervious surfaces created by construction of toll plazas contaminate surface water	√ Burdens - Example: (1) impervious surfaces created by construction of toll plazas contaminates surface water	√ Burdens - Example: (1) impervious surfaces created by construction of toll plazas contaminates surface water	√ Burdens - Example: (1) impervious surfaces created by construction of toll plazas contaminates surface water
	√ No additional benefits	√ No additional benefits	√ No additional benefits	√ No additional benefits
Ground water quality	√ No additional benefits/burdens	No additional benefits/burdens	No additional benefits/burdens	√ No additional benefits/burdens
Flood plains	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens
Wetlands	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens
Ecosystems				
Vegetation	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens
Wildlife	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens
Threatened and endangered species	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens

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Soils Resources				
Direct effects on prime farmland	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens
Hazardous Materials				
Influences of existing/abandoned landfill sites	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens
Influences of known/potential hazardous materials sites	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens	√ No additional benefits/burdens

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Mobility and Safety Effects				
Highway/Roadway				
Travel patterns (origin-destination pairs, mode choice, route assignment)	√ Burdens - Examples: (1) lower-income drivers are "priced out" of making certain trips because of the extra toll cost, (2) to reduce trip cost, people are forced to use less desirable (to the user) modes (public transportation, bicycling, walking), (3) drivers are forced to use congested non-toll roads because they cannot afford the toll, (4) people change where they go to shop because the route is tolled, (5) businesses and land developments based on non-toll design might be negatively impacted (changed access, re-directed traffic) because of toll design	√ No additional burdens	√ Burdens – Example: (1) Geometric changes (e.g. ramp changes) might impact travel patterns of adjacent EJ communities, (2) businesses and land developments based on non-toll design might be negatively impacted (changed access, re-directed traffic) because of toll design	√ Burdens – Example: (1) Geometric changes (e.g. ramp changes) might impact travel patterns of adjacent EJ communities, (2) businesses and land developments based on non-toll design might be negatively impacted (changed access, re-directed traffic) because of toll design
	√ Benefits - Examples: (1) drivers that must be punctual at work and in picking up children from day care use toll roads to bypass congestion, (2) toll roads encourage mode shifts if tolling is coupled with improvements to competing transportation modes	√ Fewer Benefits - Example: (1) lower-income drivers are "priced out" of making certain trips because of the extra cost of the toll	√ Fewer Benefits - Example: (1) lower-income drivers are "priced out" of making certain trips because of the extra cost of the toll	√ Benefits - Example: (1) drivers that must be punctual at work and in picking up their children from day care, use toll roads to bypass congestion

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Effects on Service (e.g., average travel/delay time, running speed, trip length, traffic levels of service, queue lengths and duration)	√ Burdens - Examples: (1) travel time of non-toll road users increases because of the "congestion spillover" caused by non-toll routes, (2) drivers have to travel longer distances because of controlled toll road access	√ No additional burdens	√ Burdens – Example: (1) Geometric changes (e.g. ramp changes) might impact service to adjacent EJ communities, (2) businesses and land developments based on non-toll design might be negatively impacted (changed access, re-directed traffic) because of toll design	√ Burdens - Example: (1) congestion at the entrance and exit points of the frontage roads reduces the traffic benefits of the added capacity, (2) businesses and land developments based on non-toll design might be negatively impacted (changed access, re-directed traffic) because of toll design
	√ Benefits - Examples: (1) travel speeds for toll road users improve compared to when the road was not tolled, (2) drivers are willing to pay the toll to save travel time	√ Fewer Benefits - Examples: (1) because toll roads almost always have better travel speeds than non-toll roads, travel times from the former are expected to be better than those from the latter, (2) drivers have to travel longer distances because of controlled toll road access	√ Fewer Benefits - Examples: (1) because toll roads almost always have better travel speeds than non-toll roads, travel times from the former are expected to be better than those from the latter, (2) drivers have to travel longer distances because of the toll road access control	√ Fewer Benefits - Examples: (1) travel speeds for toll road users improve compared to when the road was not tolled, (2) frontage road users have better travel speeds because of the added capacity initially
System capacity (person trips)	√ Benefits - Example: transportation system capacity could increase if carpooling and transit ridership increase √ Fewer Benefits - Example: reduced capacity relative to non-toll road due to prices set to maintain a good level-of-service	√ Benefits - Example: transportation system capacity could increase if carpooling and transit ridership increase √ Fewer Benefits - Example: reduced capacity relative to non-toll road due to prices set to maintain a good level-of-service	√ Benefits - Example: transportation system capacity could increase if carpooling and transit ridership increase √ Fewer Benefits - Example: reduced capacity relative to non-toll road due to prices set to maintain a good level-of-service	√ Benefits - Example: transportation system capacity could increase if carpooling and transit ridership increase √ Fewer Benefits - Example: reduced capacity relative to non-toll road due to prices set to maintain a good level-of-service

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Vehicle occupancy	√ Benefits - Example: reducing single-occupancy vehicle (SOV) use if carpooling and transit ridership are encouraged	√ Benefits - Example: reducing single-occupancy vehicle (SOV) use if carpooling and transit ridership are encouraged	√ Benefits - Example: reducing single-occupancy vehicle (SOV) use if carpooling and transit ridership are encouraged	√ Benefits - Example: reducing single-occupancy vehicle (SOV) use if carpooling and transit ridership are encouraged
Accessibility (Refers to the number and types of destinations available to the population. It is usually measured as the number of destinations by type that can be reached within a designated travel time or trip cost)	√ Burdens - Examples: (1) lower-income drivers are "priced out" of making shopping or recreational trips because of the extra cost of the toll, (2) commuters are forced to pay the toll because their workplaces are not accessible by other transportation modes, (3) toll road impacts business access for both customers and deliveries	√ Burdens – Example: (1) Geometric changes (e.g. ramp changes) might impact access	√ Burdens – Example: (1) Geometric changes (e.g. ramp changes) might impact access	√ No additional burdens
	√ Benefit - Example: (1) Because toll roads almost always improve access to destinations, drivers who can afford the toll improve their accessibility to workplaces, educational centers, health care services, and shopping centers within a specific time budget	√ Fewer Benefits - Example: (1) Because toll roads almost always improve access to destinations, drivers who cannot afford the toll receive fewer benefits from tolled facilities	√ Fewer Benefits - Example: (1) Because toll roads almost always improve access to destinations, drivers who cannot afford the toll receive fewer benefits from tolled facilities	√ Benefit - Example: (1) Because toll roads almost always improve access to destinations, drivers who can afford the toll improve their accessibility to workplaces, educational centers, health care services, and shopping centers within at specific time budget

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Safety	√ Burdens - Example: (1) vehicle/bike/pedestrian accident risk on local streets increases because of the diverted traffic through neighborhoods, (2) vehicle weaving maneuvers at toll entrance and exit points increase risk of traffic accidents	√ Burdens - Example: (1) vehicle weaving maneuvers at toll entrance and exit points increase risk of traffic accidents	√ Burdens - Example: (1) vehicle weaving maneuvers at toll entrance and exit points increase risk of traffic accidents	√ Burdens - Example: (1) vehicle weaving maneuvers at toll entrance and exit points increase risk of traffic accidents
	√ Fewer Benefits - Example: (1) traffic accidents decrease because of decreased congestion	√ Fewer Benefits - Example: (1) traffic accidents decrease because of decreased congestion	√ Fewer Benefits - Example: (1) traffic accidents decrease because of decreased congestion	√ Fewer Benefits - Example: (1) traffic accidents decrease because of decreased congestion
Transit Service Effects				
Service (i.e., service coverage, travel times, hours and frequency of service, transfers, reliability, comfort, costs)	√ Burdens - Examples: (1) toll road access control results in both longer transit routes and higher transit travel times, (2) bus comfort declines because of increased ridership from travelers who cannot afford the toll, (3) "congestion spillover" increases transit travel times on non-toll roads, (4) transit fares of bus routes using the toll increase to account for the extra cost of the toll	√ Burdens - Example: (1) toll road access control results in both longer transit routes and higher transit travel times, (2) transit fares of bus routes using the toll road increase to account for the extra cost of the toll	√ Burdens - Example: (1) toll road access control results in both longer transit routes and higher transit travel times, (2) transit fares of bus routes using the toll road increase to account for the extra cost of the toll	√ Burdens - Example: (1) congestion on frontage roads increases transit travel times
	√ Benefit - Example: (1) nearly all toll roads have better travel speeds than non-toll roads, thus resulting in shorter transit travel times	√ Benefit - Example: (1) nearly all toll roads have better travel speeds than non-toll roads, thus resulting in shorter transit travel times	√ Benefit - Example: (1) nearly all toll roads have better travel speeds than non-toll roads, thus resulting in shorter transit travel times	√ Benefit - Example: (1) nearly all toll roads have better travel speeds than non-toll roads, thus resulting in shorter transit travel times

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Ridership	√ Benefit - Example: (1) toll roads encourage the use of transit service among people who cannot afford the toll	√ Benefits - Example: (1) toll roads encourage the use of transit service among people who cannot afford the toll	√ Benefits - Example: (1) toll roads encourage the use of transit service among people who cannot afford the toll	√ No additional benefits/burdens
Other Forms of Transportation Effects				
Bicycle use	√ Burdens - Example: (1) vehicle/bicycle accident risks on local streets increase because of the diverted traffic through neighborhoods	√ No additional burdens	√ No additional burdens	√ No additional benefits/burdens
	√ Benefit - Example (1) travelers who cannot afford the toll may become bicycle users	√ Benefits - Example (1) travelers who cannot afford the toll may become bicycle users	√ Benefits - Example (1) travelers who cannot afford the toll may become bicycle users	
Pedestrian use	√ Burdens - Example: (1) vehicle/pedestrian accident risks on local streets increase due to the diverted traffic through neighborhoods	√ No additional burdens	√ No additional burdens	√ No additional benefits/burdens
	√ Benefit - Example (1) walking may increase because people who cannot afford the toll use pedestrian facilities to gain access to bus stops	√ Benefit - Example (1) walking may increase because people who cannot afford the toll use pedestrian facilities to gain access to bus stops	√ Benefit - Example (1) walking may increase because people who cannot afford the toll use pedestrian facilities to gain access to bus stops	

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Social & Economic Effects				
Neighborhood Effects				
Displacement of residential properties	√ Burdens - Examples: (1) the additional right-of-way to build the toll plaza results in the displacement of residential properties, (2) residents may be displaced because their neighborhoods become more suitable for commercial development around the toll plazas, (3) residents relocate to avoid the toll road when they travel to work	√ Burdens - Examples: (1) the additional right-of-way to build the toll plaza results in the displacement of residential properties, (2) residents may be displaced because their neighborhoods become more suitable for commercial development around the toll plazas, (3) residents relocate to avoid the toll road when they travel to work	√ Burdens - Examples: (1) the additional right-of-way to build the toll plaza results in the displacement of residential properties, (2) residents may be displaced because their neighborhoods become more suitable for commercial development around the toll plazas, (3) residents relocate to avoid the toll road when they travel to work	√ Burdens - Examples: (1) the additional right-of-way to build the toll plaza results in the displacement of residential properties, (2) residents may be displaced because their neighborhoods become more suitable for commercial development around the toll plazas, (3) residents relocate to avoid the toll road when they travel to work
Neighborhood cohesion, social interaction	√ Burdens - Examples: (1) residents may be "priced out" of certain social trips because of the higher toll costs, (2) toll access control separates members of the community because of longer travel distances, (3) the acquisition of additional right-of-way for the toll plazas disrupts community cohesion	√ Burdens - Example: (1) the acquisition of additional right-of-way for the toll plazas disrupts community cohesion	√ Burdens - Example: (1) the acquisition of additional right-of-way for the toll plazas disrupts community cohesion	√ Burdens - Example: (1) the acquisition of additional right-of-way for the toll plazas disrupts community cohesion
	√ No additional benefits	√ No additional benefits	√ No additional benefits	√ No additional benefits
Visual intrusion or obstruction	√ Burdens - Example: (1) views of pleasant settings or landscapes may be obscured by the toll plaza	√ Burdens - Example: (1) views of pleasant settings or landscapes may be obscured by the toll plaza	√ Burdens - Example: (1) views of pleasant settings or landscapes may be obscured by the toll plaza	√ Burdens - Example: (1) views of pleasant settings or landscapes may be obscured by the toll plaza

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Access* to work	√ Burdens - Example: (1) access to work decreases for those who cannot afford the toll and are therefore forced to travel on congested alternative routes to their workplaces	√ Fewer Benefits - Example: (1) toll roads provide less access to work than non-toll roads if drivers spend more time to get to their workplaces	√ Fewer Benefits - Example: (1) toll roads provide less access to work than non-toll roads if drivers spend more time to get to their workplaces	Burdens - Example: (1) access to work decreases for those who cannot afford the toll and are therefore forced to use the frontage roads, resulting in, their spending more time to get to their workplaces
	√ Benefits - Example: (1) access to work improves for those who can afford the toll and therefore get to work in a shorter period of time than before, when the road was not tolled	√ Benefits - Example: (1) access to work improves for those who can afford the toll if job opportunities increase within a certain travel time budget	√ Benefits - Example: (1) access to work improves for those who can afford the toll if job opportunities increase within a certain travel time budget	√ Benefits - Example: (1) access to work improves for those who can afford the toll and therefore get to work in a shorter time than before, when the road was not tolled
Access* to sensitive sites (health care centers and educational facilities)	√ Burdens - Examples: (1) toll road access control results in longer travel distances to access hospitals, (2) students have to use less desirable transit modes to access community colleges, (3) community members may be "priced out" of certain trips, for example to public libraries	√ Fewer Benefits - Example: (1) toll roads provide less access to educational facilities than non-toll roads if those who cannot afford the toll spend more time getting to school	√ Fewer Benefits - Example: (1) toll roads provide less access to educational facilities than non-toll roads if those who cannot afford the toll spend more time getting to school	√ Fewer Benefits - Example: (1) toll roads provide less access to educational facilities than non-toll roads if those who cannot afford the toll spend more time getting to school
	√ Benefits - Example: (1) toll roads provide more access to health care centers than non-toll roads for drivers who can afford the toll, if they can access more physician clinics within a certain travel time	√ Benefits - Example: (1) toll roads provide more access to health care centers than non-toll roads for drivers who can afford the toll, if they can access more physician clinics within a certain travel time	√ Benefits - Example: (1) toll roads provide more access to health care centers than non-toll roads for drivers who can afford the toll, if they can access more physician clinics within a certain travel time	√ Benefits - Example: (1) toll roads provide more access to health care centers for drivers who can afford the toll, if they can access more physician clinics within a certain travel time

***Accessibility is defined as the number of opportunities - also called activity sites - accessible within a certain distance, travel time or trip cost**

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Access* to recreational places (parks, rivers, swimming pools, tennis courts, etc.)	√ Burdens - Example: (1) toll road access control results in longer travel distances to recreational places	√ No additional burdens	√ No additional burdens	√ No additional burdens
	√ Benefits - Example: (1) access to recreational places improves for those who can afford the toll, if they can access more parks within a certain travel time budget	√ Benefits - Example: (1) toll roads provide better access to recreational places than non-toll roads if drivers who can afford the toll, can access more recreational places within a certain travel time budget	√ Benefits - Example: (1) toll roads provide better access to recreational places than non-toll roads if drivers who can afford the toll, can access more recreational places within a certain travel time budget	√ Benefits - Example: (1) toll roads provide better access to recreational places than non-toll roads if drivers who can afford the toll, can access more recreational places within a certain travel time budget
Neighborhood traffic patterns	√ Burdens - Example: (1) traffic volume increases on local streets due to diverted traffic, (2) access to business might change	√ Fewer Benefits - Example: (1) toll roads provide less traffic relief from neighborhood streets than non-toll roads	√ Fewer Benefits - Example: (1) toll roads provide less traffic relief from neighborhood streets than non-toll roads	√ No additional benefits/burdens

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Land and residential property values	√ Burdens - Examples: (1) property market values decrease because the diverted traffic onto local streets increases air pollution and traffic noise in neighborhoods, (2) residential property values increase because toll roads provide better accessibility, and as a result, land close to toll road nodes may become desirable for commercial purposes	√ Burdens - Examples: (1) residential property values increase because toll roads provide better accessibility, and as a result, land close to toll road nodes may become desirable for commercial purposes	√ Burdens - Examples: (1) residential property values increase because toll roads provide better accessibility, and as a result, land close to toll road nodes may become desirable for commercial purposes	√ Burdens - Examples: (1) residential property values increase because toll roads provide better accessibility, and as a result, land close to toll road nodes may become desirable for commercial purposes
	√ Benefits - Example: (1) residential property values increase because toll roads provide better accessibility	√ Benefits - Example: (1) residential property values increase because toll roads provide better accessibility	√ Benefits - Example: (1) residential property values increase because toll roads provide better accessibility	√ Benefits - Example: (1) residential property values increase because toll roads provide better accessibility
Pedestrian and bicycle safety	√ Burdens - Examples: (1) changes in traffic patterns on local streets can transform a pedestrian-safe environment into one in which pedestrians are at a greater risk of injury, (2) changes in traffic patterns on local streets can transform a bicycle-safe environment into one in which bicycle users are at a greater risk of injury	√ Fewer Benefits - Example: (1) nearly all toll roads attract less traffic than non-toll roads from neighborhood streets, thus resulting in potentially fewer pedestrian and bicycle safety benefits	√ Fewer Benefits - Example: (1) nearly all toll roads attract less traffic than non-toll roads from neighborhood streets, thus resulting in potentially fewer pedestrian and bicycle safety benefits	√ No additional benefits/burdens

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Neighborhood quality/safety	√ Benefit - Example: (1) frequent police patrols on toll roads may enhance public perception of security in adjacent neighborhoods, (2) higher toll road travel speeds compared to non-toll roads may improve neighborhood access to fire, rescue, and public safety services	√ Benefit - Example: (1) frequent police patrols on toll roads may enhance public perception of security in adjacent neighborhoods, (2) higher toll road travel speeds compared to non-toll roads may improve neighborhood access to fire, rescue, and public safety services	√ Benefit - Example: (1) frequent police patrols on toll roads may enhance public perception of security in adjacent neighborhoods, (2) higher toll road travel speeds compared to non-toll roads may improve neighborhood access to fire, rescue, and public safety services	√ Benefit - Example: (1) frequent police patrols on toll roads may enhance public perception of security in adjacent neighborhoods, (2) higher toll road travel speeds compared to non-toll roads may improve neighborhood access to fire, rescue, and public safety services
Local Business Effects				
Displacement of businesses/public properties	√ Burdens - Example: (1) local businesses have to close because toll access control may decrease business access	√ Benefits - Example: (1) local businesses can prevail if toll roads keep "big box" stores out of market	√ Benefits - Example: (1) local businesses can prevail if toll roads keep "big box" stores out of market, (2) local businesses have to close if toll access control decrease business access	√ No additional burdens

Additional Benefits and Burdens Imposed by Toll Roads on Communities				
Effects	**Scenario 1** Converting existing non-toll roads into toll roads	**Scenario 2** Constructing new toll roads instead of non-toll roads (assuming same road geometric and operational characteristics)	**Scenario 3** Converting planned non-toll roads into toll roads before the facility is open to the public (assuming same road geometric and operational characteristics)	**Scenario 4** Converting existing non-toll roads into toll roads but adding adjacent frontage roads as "free alternate" routes
Local employment	√ Burdens - Examples: (1) employment decreases if local businesses have to close because toll road limits access to clients, (2) employment decreases if local businesses have to scale down operations because toll road limits access to clients	√ No additional burdens	√ No additional burdens	√ No additional burdens
	√ Benefits - Examples: (1) employment increases if diverted traffic results in new customers and the expansion of neighborhood businesses, (2) employment at industries and businesses located at toll road nodes increases because toll roads provide fast and reliable access compared to non-toll roads	√ Benefits - Examples: (1) local employment increases because new businesses open at toll road nodes, (2) employment at industries and businesses located at toll road nodes increases because toll roads provide fast and reliable access compared to non-toll roads	√ Benefits - Examples: (1) local employment increases because new businesses open at toll road nodes, (2) employment at industries and businesses located at toll road nodes increases because toll roads provide fast and reliable access compared to non-toll roads	√ Benefits - Examples: (1) employment at businesses on frontage roads increases because the toll road provides them with better access and exposure, (2) employment at industries and businesses located at toll road nodes increases because toll roads provide them with fast and reliable access
Business access and deliveries	√ Burdens - Examples: (1) toll road access control may increase cost of deliveries, (2) customers have to pay tolls to shop at businesses	√ Fewer Benefits - Example: (1) access to businesses is reduced on toll roads compared to non-toll roads due to toll road access control	√ Fewer Benefits - Example: (1) access to businesses is reduced on toll roads compared to non-toll roads due to toll road access control	√ Benefits - Example: (1) businesses on frontage roads scale up operations because of increased access and exposure resulting from increased traffic on frontage roads
Land and commercial property values	√ Benefits - Examples: (1) traffic volumes on local streets may increase exposure of local businesses, and as a result, the market value of these properties may increase, (2) property values increase if toll road nodes attract "upscale" developments and leisure businesses	√ Benefits - Example: (1) property values increase if toll road nodes attract "upscale" developments and leisure businesses	√ Benefits - Example: (1) property values increase if toll road nodes attract "upscale" developments and leisure businesses	√ Benefits - Examples: (1) market value of commercial properties may increase because frontage roads provide better access and exposure, (2) property values increases if toll road nodes attract "upscale" developments and leisure businesses

Additional Benefits and Burdens Imposed by Toll Roads on Communities				
Effects	**Scenario 1** Converting existing non-toll roads into toll roads	**Scenario 2** Constructing new toll roads instead of non-toll roads (assuming same road geometric and operational characteristics)	**Scenario 3** Converting planned non-toll roads into toll roads before the facility is open to the public (assuming same road geometric and operational characteristics)	**Scenario 4** Converting existing non-toll roads into toll roads but adding adjacent frontage roads as "free alternate" routes
Economic Development Effects				
Job creation	√ Benefits - Examples: (1) new "upscale" developments may locate at toll road nodes because toll roads provide them with fast and reliable access, (2) local communities receive a share of the jobs and contracts generated by the conversion and operation of the toll road	√ Benefits - Examples: (1) new "upscale" developments may locate at toll road nodes because toll roads provide them with fast and reliable access, (2) local communities receive a share of the jobs and contracts generated by the operation of the toll road	√ Benefits - Examples: (1) new "upscale" developments may locate at toll road nodes because toll roads provide them with fast and reliable access, (2) local communities receive a share of the jobs and contracts generated by the conversion and operation of the toll road	√ Benefits - Examples: (1) new "upscale" developments may locate at toll road nodes because toll roads provide them with fast and reliable access, (2) local communities receive a share of the jobs and contracts generated by the conversion and operation of the toll road, (3) local businesses expand because frontage roads provide them with better access and exposure because of increased traffic on frontage roads
Changes in available job types	√ Benefits - Example: (1) High-tech firms and leisure businesses may locate at toll road nodes because toll roads provide them with fast and reliable access	√ Benefits - Example: (1) High-tech firms and leisure businesses may locate at toll road nodes because toll roads provide them with fast and reliable access	√ Benefits - Example: (1) High-tech firms and leisure businesses may locate at toll road nodes because toll roads provide them with fast and reliable access	√ Benefits - Example: (1) High-tech firms and leisure businesses may locate at toll road nodes because toll roads provide them with fast and reliable access

Additional Benefits and Burdens Imposed by Toll Roads on Communities				
Effects	**Scenario 1** Converting existing non-toll roads into toll roads	**Scenario 2** Constructing new toll roads instead of non-toll roads (assuming same road geometric and operational characteristics)	**Scenario 3** Converting planned non-toll roads into toll roads before the facility is open to the public (assuming same road geometric and operational characteristics)	**Scenario 4** Converting existing non-toll roads into toll roads but adding adjacent frontage roads as "free alternate" routes
Changes in property values	√ Burdens - Examples: (1) property market values decrease because the diverted traffic onto local streets increases air pollution and traffic noise in neighborhoods, (2) higher property values in the vicinity of the toll road nodes may result in tolling being viewed by low-income residents as the denial of residential space	√ Burdens - Example: (1) higher property values in the vicinity of the toll road nodes may result in tolling being viewed by low-income residents as the denial of residential space	√ Burdens - Example: (1) higher property values in the vicinity of the toll road nodes may result in tolling being viewed by low-income residents as the denial of residential space	√ Burdens - Example: (1) higher property values in the vicinity of the toll road nodes may result in tolling being viewed by low-income residents as the denial of residential space
	√ Benefits - Examples: (1) traffic volumes on local streets may increase exposure of businesses, increasing the market value of these properties, (2) property values increase if toll road nodes attract "upscale" developments and leisure businesses	√ Benefits - Example: (1) property values increase if toll road nodes attract "upscale" developments and leisure businesses	√ Benefits - Example: (1) property values increase if toll road nodes attract "upscale" developments and leisure businesses	√ Benefits - Example: (1) property values increase if toll road nodes attract "upscale" developments and leisure businesses
Tax revenues	√ Benefits - Examples: (1) new dense developments at toll road nodes (with work, shopping, and leisure destinations within close proximity) will have a positive effect on tax revenues, (2) higher property values in the vicinity of toll roads will have a positive effect on tax revenues	√ Benefits - Examples: (1) new dense developments at toll road nodes (with work, shopping, and leisure destinations within close proximity) will have a positive effect on tax revenues, (2) higher property values in the vicinity of toll roads will have a positive effect on tax revenues	√ Benefits - Examples: (1) new dense developments at toll road nodes (with work, shopping, and leisure destinations within close proximity) will have a positive effect on tax revenues, (2) higher property values in the vicinity of toll roads will have a positive effect on tax revenues	√ No additional benefits/burdens

Additional Benefits and Burdens Imposed by Toll Roads on Communities				
Effects	**Scenario 1** Converting existing non-toll roads into toll roads	**Scenario 2** Constructing new toll roads instead of non-toll roads (assuming same road geometric and operational characteristics)	**Scenario 3** Converting planned non-toll roads into toll roads before the facility is open to the public (assuming same road geometric and operational characteristics)	**Scenario 4** Converting existing non-toll roads into toll roads but adding adjacent frontage roads as "free alternate" routes
Cultural Effects				
Archaeological sites	No additional benefits/burdens	No additional benefits/burdens	No additional benefits/burdens	No additional benefits/burdens
Cultural resources (e.g., historic sites, historic landmarks)	√ Burdens - Examples: (1) if the additional right-of-way for the toll plaza displaces a historic site, (2) if toll road access control makes access to cultural resources difficult or unpleasant (e.g., longer travel times)	√ Burdens - Example: (1) if the additional right-of-way for a toll plaza displaces a historic site	√ Burdens - Example: (1) if the additional right-of-way for a toll plaza displaces a historic site	√ Burdens - Examples: (1) if the additional right-of-way for the toll plaza displaces a historic site, (2) if toll road access control makes access to cultural resources difficult or unpleasant (e.g., longer travel times)
	√ Benefits - Example: (1) access to cultural places improves for those who can afford the toll if they can access more historic sites within a certain travel time budget	√ Fewer Benefits - Example: (1) if toll road improves access to cultural resources, members of the community who cannot afford the toll receive fewer benefits from the tolled facility	√ Fewer Benefits - Example: (1) if toll road improves access to cultural resources, members of the community who cannot afford the toll receive fewer benefits from the tolled facility	√ Benefits - Example: (1) toll roads provide better access to cultural resources than non-toll roads if drivers who can afford the toll can access more cultural resources within a certain travel time budget

Appendix F: Analysis Methodologies and Tools to Measure Additional Environmental Justice Impacts Imposed by Toll Roads

This appendix presents a quantitative approach for measuring the magnitude of the additional impacts imposed by a toll road on EJ communities relative to a non-toll road project. Specifically, the appendix explains the calculation of a number of indexes that can be used to measure the impacts imposed by toll roads relative to non-toll roads and the statistical tests to assess whether EJ communities are disproportionately impacted. The *indexes* can be used to assess impacts on accessibility, air and noise quality, residential and commercial property values, and pedestrian and bicycle safety. This appendix further describes and evaluates analysis tools that can be used to calculate the indexes in terms of data requirements, expertise required, potential data sources, limitations, robustness, and cost.

F.1 Measuring the Additional Impacts Imposed

The overall objective of the environmental justice evaluation methodology (EJEM) is to determine whether a toll road would burden EJ populations disproportionately compared to a non-toll road. This requires: (a) measuring the impacts (both positive and negative) by EJ concentration zones imposed by the non-toll road and toll road (alternatives 1 and 2, respectively), (b) determining whether the measured impacts with the toll road (alternative 2) are statistically significantly higher than the measured impacts with the non-toll road (alternative 1) by EJ concentration level, and (c) if a statistically significant impact is imposed by the toll road, the analyst subsequently needs to determine whether the impact imposed on zones with high[12] and medium concentrations of EJ populations are statistically significantly higher than the impact imposed on zones with low concentrations[13] of EJ populations.

The statistical test to determine whether there is a statistically significant difference between the impacts imposed by the toll road compared to the non-toll road is the "paired *t* test", based on paired data analysis. In essence, the test determines whether the mean difference between the quantified impacts of the non-toll road and toll road alternatives is statistically significant for zones with low, medium, and high concentrations of EJ populations. To test whether the mean difference is statistically significant, a one-sample *t* test (based on $n-1$ degrees of freedom) on the differences is carried out. The statistical test is described in Box F.1.

[12] In this appendix, zones with extremely high and high concentrations of EJ populations are referred to as zones with high concentrations of EJ populations.

[13] In this appendix, zones with no or small concentrations of EJ populations are referred to as zones with low concentrations of EJ populations.

Box F.1 Analysis of Paired Data Using a One Sample *t* Test

Does the data suggest that zones with low/medium/high concentrations of EJ populations are disproportionately burdened by the toll road compared to the non-toll road at a α significance level?

$$\text{Null hypothesis}: \quad H_o : \mu_k^D = 0$$

$$\text{Test statistic value}: \quad t = \frac{\bar{d}_k}{s_k^D / \sqrt{n_k}}$$

Alternative hypothesis	Rejection region for approximate level α test
$H_a : \mu_k^D > 0$	$t \geq t_{\alpha,n-1}$
$H_a : \mu_k^D < 0$	$t \leq -t_{\alpha,n-1}$

where

$\mu_k^D = \mu_k^2 - \mu_k^1$ = the mean difference between impacts imposed by alternatives 2 and 1 on the "*k*" concentration level of EJ populations

$\bar{d}_k$ = sample mean of the differences within pairs $(d'_j s)$ for the "*k*" concentration level of EJ populations since:

$d_j = I_j^2 - I_j^1$ = difference between *measured impacts* imposed by alternatives 2 and 1 respectively pertain to observation "*j*" $(j \in k)$

I_j^A = *measured impact* imposed by alternative *A* pertain to observation "*j*" $(j \in k)$

A = super-index for alternative (*A* = 1, 2)

s_k^D = standard deviation of the differences within pairs $(d'_j s)$ for the "*k*" concentration levelof EJ populations

n_k = number of observations with "*k*" concentration level of EJ populations

k = sub-index for EJ concentration level (*k* = low, medium, high)

If H_o can be rejected at a α significance level, it can be concluded that zones with low/medium/high concentrations of EJ populations are disproportionally burdened by the toll road condition compared to the non-toll road.

Given that a statistically significant impact (i.e., benefit or burden) is imposed by the toll road, the statistical test to determine whether the impact on zones with high and medium concentrations of EJ populations is significantly higher than on zones with no or low concentrations of EJ populations is a "large-sample test" based on differences between population proportions. Assuming a normal distribution, a statistically significant difference exists if the observed difference in the proportion of the impacted zones with high and medium concentrations of EJ populations and the proportion of the impacted zones with no or low concentrations of EJ populations cannot be explained by chance alone. The statistical test is described in Box F.2.

Box F.2 Inferences Concerning a Difference between Population Proportions

	EJ Concentration Levels		
	Low	Medium	High
Alternative 2 (toll road)	I_{low}^2	I_{medium}^2	I_{high}^2
Number of zones	N_{low}	N_{medium}	N_{high}
Proportions	$\hat{p}_{low}^2 = \frac{I_{low}^2}{N_{low}}$	$\hat{p}_{medium}^2 = \frac{I_{medium}^2}{N_{medium}}$	$\hat{p}_{high}^2 = \frac{I_{high}^2}{N_{high}}$

$$\hat{p}_{ml} = \frac{N_{medium}}{N_{medium} + N_{low}} \hat{p}_{medium}^2 + \frac{N_{low}}{N_{medium} + N_{low}} \hat{p}_{low}^2 \qquad \hat{q}_{ml} = 1 - \hat{p}_{ml}$$

$$\hat{p}_{hl} = \frac{N_{high}}{N_{high} + N_{low}} \hat{p}_{high}^2 + \frac{N_{low}}{N_{medium} + N_{low}} \hat{p}_{low}^2 \qquad \hat{q}_{hl} = 1 - \hat{p}_{hl}$$

where:

I_k^A = *Impact* for the *k* concentration level of EJ populations and alternative *A*

N_k = number of zones/population/properties/road segments with *k* concentration level of EJ populations

p_k^A = Impact proportion for the *k* concentration level of EJ populations and alternative *A*

k = sub-index for EJ concentration level (*k* = low, medium, high);

A = super-index for alternative (*A* = 1, 2)

Hypothesis Testing

Does the data suggest that the impact imposed on zones with <u>medium/high</u> concentrations of EJ populations is higher than on zones with no or low concentrations of EJ populations at a α significance level?

Null hypothesis $H_o : p_{medium}^2 - p_{low}^2 = 0$

Alternative hipotheses $H_a : p_{medium}^2 - p_{low}^2 > 0$

Test statistic value (large samples): $z = \frac{\hat{p}_{medium}^2 - \hat{p}_{low}^2}{\sqrt{\hat{p}_{ml}\hat{q}_{ml}\left(1/n_{medium} + 1/n_{low}\right)}}$

Rejection region *for approximate level* α *test*: $z \geq z_\alpha$

Null hypothesis $H_o : p_{high}^2 - p_{low}^2 = 0$

Alternative hypothesis $H_a : p_{high}^2 - p_{low}^2 > 0$

Test statistic value (large samples): $z = \frac{\hat{p}_{high}^2 - \hat{p}_{low}^2}{\sqrt{\hat{p}_{hl}\hat{q}_{hl}\left(1/n_{high} + 1/n_{low}\right)}}$

Rejection region *for approximate level* α *test*: $z \geq z_\alpha$

If H_o can be rejected at a α significance level, it can be concluded that zones with <u>medium/high</u> concentrations of EJ populations are disproportionally impacted by the toll road compared to zones with low concentrations of EJ populations.

F.2 Mobility Impacts

This section details the calculation of a number of accessibility indices that can be used to measure the benefits and burdens imposed by toll roads (relative to non-toll roads) on impacted EJ communities. Accessibility refers to the numbers and types of destinations (i.e., jobs, educational facilities, healthcare facilities, and recreational facilities) available to EJ communities within an established travel time threshold and given a specific transportation mode.

F.2.1 Accessibility to Work Index

The *accessibility to work index for zone i* (E_i) is defined as the number of employment opportunities (i.e., jobs) available to the population (in zone *i*) within an established travel time threshold and given a specific transportation mode.

F.2.1.1 Data and Sources

To calculate the *accessibility to work index*, information about the number of employment opportunities (i.e., jobs) within the area impacted by the toll road is required. The employment information needed may be obtained from a number of public and private sources:

- Metropolitan Planning Organizations (MPOs) use employment data at the Traffic Analysis Zone (TAZ) level in their travel demand-forecasting models (i.e., trip generation, trip distribution, mode choice, and traffic assignment),
- Chambers of Commerce collect information about local businesses,
- ESRI's community data catalog (ESRI: Community Tapestry) contains proprietary business data for more than 10 million U.S. businesses, including the following: business name and location, franchise code, industrial classification code, number of employees, and sales volume (current as of January 2005) (ESRI: Business Data).

The data obtained from both public and private data sources should, however, be validated and complimented through field surveys (e.g., windshield surveys), especially if the proposed toll road project has raised concerns about an EJ community's access to work.

F.2.1.2 Approach

The following steps are recommended to calculate whether zones with medium and high concentrations of EJ populations will incur a disproportionate burden in terms of employment opportunities compared to zones with low concentrations of EJ populations with the toll road relative to the non-toll road (i.e., alternatives 2 and 1, respectively):

Step 1: Compile the EJ concentration zones within the impacted area.

Step 2: Determine the travel time threshold (e.g., 15 min, 20 min, 25 min, 30 min, 40 min, 45 min or 1 hour) and transportation mode (e.g., car or transit) for the analysis.

Step 3: Collect data on the number of employment opportunities accessible within the travel time threshold and transportation mode for each EJ concentration zone within the impacted area.

Step 4: Use a land use model (e.g., UrbanSim) to estimate changes in land use resulting from the non-toll and toll roads. Based on model results, estimate employment impacts associated with both alternatives (e.g., new jobs generated at toll road nodes or interchanges and along connectors).

Step 5: Use a travel demand model (e.g., TransCAD) to estimate E_i^A. E_i^A = the number of employment opportunities that can be reached within the established travel time threshold and transportation mode (e.g., number of jobs that can be reached within 30 minutes by car) for each EJ concentration zone given alternatives 1 (i.e., non-toll road) and 2 (i.e., toll road).

Step 6: Determine whether the toll road imposes a statistically significant impact in terms of accessibility to employment by EJ concentration level relative to the non-toll alternative by applying the "paired t test", based on paired data analysis (i.e., calculate $d_i = E_i^2 - E_i^1 =$ difference between *accessibility to work index*[14] for alternatives 2 and 1, respectively, for zone *i*).

Step 7: If a statistically significant impact is imposed by the toll road, determine whether zones with medium and high concentrations of EJ populations incur statistically significantly higher impacts (in terms of reduced accessibility to employment) than zones with low concentrations of EJ populations by estimating the *accessibility to work index for each EJ concentration level (i.e., low, medium, and high)* given the toll road $\left(E_k^2\right)$ as follows:

$$E_k^2 = \sum_{i \in k} E_i^2$$

where:

E_i^2 = *accessibility to work index for zone i* with the toll road (alternative 2)

Apply the "large sample test" based on differences between population proportions given that $I_k^A = E_k^2$, $N_k =$ number of zones with *k* concentrations of EJ populations, and $p_k^A =$ proportion of employment opportunities given alternative 2 for the *k* concentration of EJ populations.

F.2.1.3 Robustness and Limitations

Calculating the accessibility to work index requires expertise in travel demand models, land use models, Geographic Information Systems (GISs), and spatial analysis. It is also assumed that (a) the travel demand model can consider the travel time impacts imposed by the toll road and that (b) the land use model can be used to estimate new employment generated at nodes (i.e., interchanges) and along connectors with the toll and non-toll roads. The robustness of the approach is thus a function of the extent to which the travel demand and land use models can differentiate the travel time and employment impacts associated with the toll road. The two

[14] Number of jobs available to the population (in zone *i*) within an established travel time threshold and given a specific transportation mode.

commercial software packages available to calculate the *accessibility to work index* are TransCAD (Caliper Corp.) and UrbanSim (UrbanSIM Home). The cost of TransCAD varies between $3,000 and $10,000 (based on 2005 data); UrbanSim is available free of charge.

F.2.2 Accessibility to Educational Facilities Index

The *accessibility to educational facilities index for zone i* (T_i) is defined as the number of educational facilities (i.e., schools, colleges, universities, and libraries) available to the population (in zone *i*) within an established travel time threshold and given a specific transportation mode.

F.2.2.1 Data and Sources

To calculate the *accessibility to educational facilities index*, information about the number of educational institutions (i.e., schools, colleges, universities, and libraries) within the area impacted by the toll road is required. The required information for EJ may be obtained from a number of public and private sources:

- MPOs typically identify special generators, including universities and colleges, within their jurisdictions when estimating the number of trips generated with their travel demand-forecasting models.
- School districts are repositories of school data in their jurisdictions.
- Some cities have developed GIS data files that illustrate the spatial location of schools, colleges, and libraries. For example, the City of Austin's GIS Data Sets' webpage (City of Austin, 2005) provides map data files that illustrate the geographic location of educational institutions in Austin.
- Proprietary data about educational facilities can be obtained from ESRI (ESRI Home Page). For example, *ESRI Data & Map* (ESRI Data and Maps) contains map data files of schools and colleges at different geographic scales.
- Finally, other sources of information that should be explored include Google Earth® (Google Earth Home Page) and Google Maps® (Google Maps Home Page).

The data obtained from these public and private sources should, however, be validated and complimented through field surveys (e.g., windshield surveys), especially if the proposed toll road project has raised concerns about an EJ community's access to educational facilities.

F.2.2.2 Approach

The following steps are recommended to calculate whether zones with medium and high concentrations of EJ populations will incur a disproportionate burden in terms of access to educational facilities compared to zones with low concentrations of EJ populations with the non-toll road relative to the toll road (i.e., alternatives 1 and 2, respectively):

Step 1: Compile the EJ concentration zones within the impacted area.

Step 2: Determine the travel time threshold (e.g., 15 min, 20 min, 25 min, 30 min, 40 min, 45 min or 1 hour) and transportation mode (e.g., car or transit) for the analysis.

Step 3: Collect data on the number of educational facilities accessible within the travel time threshold and transportation mode for each EJ concentration zone within the impacted area.

Step 4: Use a land use model (e.g., UrbanSim) to estimate changes in land use resulting from the non-toll and toll roads. Based on model results, estimate changes in the number and location of educational facilities with both alternatives (e.g., new colleges or relocation of university campuses at toll road nodes or interchanges and along connectors).

Step 5: Use a travel demand model (e.g., TransCAD) to estimate T_i^A. T_i^A = the number of educational facilities that can be reached within the established travel time threshold and transportation mode (e.g., number of schools that can be reached within 30 minutes by car) for each EJ concentration zone given alternatives 1 (i.e., non-toll road) and 2 (i.e., toll road).

Step 6: Determine whether the toll road imposes a statistically significant impact in terms of accessibility to educational facilities by EJ concentration level relative to the non-toll alternative by applying the "paired t test" based on paired data analysis (i.e., calculate $d_i = T_i^2 - T_i^1 =$ difference between *accessibility to educational facilities index*[15] for alternatives 2 and 1, respectively, for zone *i*).

Step 7: If a statistically significant impact is imposed by the toll road, determine whether zones with medium and high concentrations of EJ populations incur statistically significantly higher impacts (in terms of reduced accessibility to educational facilities) than zones with low concentrations of EJ populations by estimating the *accessibility to educational facilities index for each EJ concentration level (i.e., low, medium, and high)* given the toll road $\left(T_k^2\right)$ as follows:

$$T_k^2 = \sum_{i \in k} T_i^2$$

where:

T_i^2 = *accessibility to educational facilities index for zone i* with the toll road (alternative 2)

Apply the "large sample test" based on differences between population proportions given that $I_k^A = T_k^2, N_k =$ number of zones with *k* concentrations of EJ populations, and $p_k^A =$ proportion of educational facilities given alternative 2 for the *k* concentration of EJ populations.

[15] Number of educational facilities available to the population (in zone *i*) within an established travel time threshold and given a specific transportation mode.

F.2.2.3 Robustness and Limitations

Calculating the *accessibility to educational facilities* index requires expertise in travel demand models, land use models, Geographic Information Systems (GISs), and spatial analysis. It is also assumed that (a) the travel demand model can consider the travel time impacts imposed by the toll road and that, (b) the land use model can be used to estimate new educational facilities or the relocation of educational facilities at nodes (i.e., interchanges) and along connectors with the toll and non-toll roads. The robustness of the approach is thus a function of the extent to which the travel demand and land use models can differentiate the travel time impacts and the location of educational facilities associated with the toll road. The two commercial software packages available to calculate the *accessibility to educational facilities index* are TransCAD (Caliper Corp.) and UrbanSim (UrbanSim Home). The cost of TransCAD varies between $3,000 and $10,000 (based on 2005 data); UrbanSim is available free of charge.

F.2.3 Accessibility to Healthcare Facilities

The *accessibility to healthcare facilities index for zone i* (H_i) is defined as the number of healthcare facilities (i.e., hospitals, community health centers, and clinics) available to the population (in zone *i*) within an established travel time threshold and given a specific transportation mode.

F.2.3.1 Data and Sources

To calculate the accessibility to healthcare facilities index, information about the number of healthcare facilities (i.e., hospitals, community health centers, and clinics) within the area impacted by the toll road is required. The required information for EJ may be obtained from a number of public and private sources:

- MPOs typically identify special generators, such as hospitals, within their jurisdictions when estimating the number of trips generated with their travel demand-forecasting models.
- Some cities have developed GIS data files that illustrate the spatial location of hospitals and health clinics. For example, the City of Austin's GIS Data Sets' webpage (City of Austin, 2005) provides map data files that illustrate the geographic location of hospitals in Austin.
- Proprietary data about medical centers can be obtained from ESRI (ESRI Home Page). For example, *ESRI Data & Map* (ESRI Data and Maps) contains map data files of hospitals and medical centers at different geographic scales.
- Finally, other sources of information that should be explored include Google Earth® (Google Earth Home Page) and Google Maps® (Google Maps Home Page).

The data obtained from these public and private sources should, however, be validated and complimented through field surveys (e.g., windshield surveys), especially if the proposed toll road project has raised concerns about an EJ community's access to healthcare facilities.

F.2.3.2 Approach

The following steps are recommended to calculate whether zones with medium and high concentrations of EJ populations will incur a disproportionate burden in terms of access to healthcare facilities compared to zones with low concentrations of EJ populations with the non-toll road relative to the toll road (i.e., alternatives 1 and 2, respectively):

Step 1: Compile the EJ concentration zones within the impacted area.

Step 2: Determine the travel time threshold (e.g., 15 min, 20 min, 25 min, 30 min, 40 min, 45 min or 1 hour) and transportation mode (e.g., car or transit) for the analysis.

Step 3: Collect data on the number of healthcare facilities accessible within the travel time threshold and transportation mode for each EJ concentration zone within the impacted area.

Step 4: Use a land use model (e.g., UrbanSim) to estimate changes in land use resulting from the non-toll and toll roads. Based on model results, estimate changes in the number and location of healthcare facilities with both alternatives (e.g., new hospitals or relocation of clinics at toll road nodes or interchanges and along connectors).

Step 5: Use a travel demand model (e.g., TransCAD) to estimate H_i^A. H_i^A = the number of healthcare facilities that can be reached within the established travel time threshold and transportation mode (e.g., number of clinics that can be reached within 30 minutes by car) for each EJ concentration zone given alternatives 1 (i.e., non-toll road) and 2 (i.e., toll road).

Step 6: Determine whether the toll road imposes a statistically significant impact in terms of accessibility to healthcare facilities by EJ concentration level relative to the non-toll alternative by applying the "paired t test", based on paired data analysis (i.e., calculate $d_i = H_i^2 - H_i^1$ = difference between *accessibility to healthcare facilities index*[16] for alternatives 2 and 1, respectively for zone *i*).

Step 7: If a statistically significant impact is imposed by the toll road, determine whether zones with medium and high concentrations of EJ populations incur statistically significantly higher impacts (in terms of reduced accessibility to healthcare facilities) than zones with low concentrations of EJ populations by estimating the *accessibility to healthcare facilities index for each EJ concentration level (i.e., low, medium, and high)* given the toll road $\left(H_k^2\right)$ as follows:

$$H_k^2 = \sum_{i \in k} H_i^2$$

where:

[16] Number of healthcare facilities available to the population (in zone *i*) within an established travel time threshold and given a specific transportation mode.

H_i^2 = *accessibility to healthcare facilities index for zone i* with the toll road (alternative 2)

Apply the "large sample test" based on differences between population proportions given that $I_k^A = H_k^2$, $N_k =$ number of zones with k concentrations of EJ populations, and $p_k^A =$ proportion of healthcare facilities given alternative 2 for the k concentration of EJ populations.

F.2.3.3 Robustness and Limitations

Calculating the *accessibility to healthcare facilities* index requires expertise in travel demand models, land use models, Geographic Information Systems (GISs), and spatial analysis. It is also assumed that (a) the travel demand model can consider the travel time impacts imposed by the toll road and that (b) the land use model can be used to estimate new healthcare facilities or the relocation of healthcare facilities at nodes (i.e., interchanges) and along connectors with the toll and non-toll roads. The robustness of the approach is thus a function of the extent to which the travel demand and land use models can differentiate the travel time impacts and the number of healthcare facilities associated with the toll road. The two commercial software packages available to calculate the *accessibility to healthcare facilities index* are TransCAD (Caliper Corp.) and UrbanSim (UrbanSim Home). The cost of TransCAD varies between $3,000 and $10,000 (based on 2005 data); UrbanSim is available free of charge.

F.2.4 Accessibility to Shopping Centers

The *accessibility to shopping centers index for zone i* (S_i) is defined as the number of shopping facilities available to the population (in zone *i*) within an established travel time threshold and given a specific transportation mode.

F.2.4.1 Data and Sources

To calculate the *accessibility to shopping facilities index*, information about the number of shopping facilities (i.e., malls) within the area impacted by the toll road is required. The required information for EJ may be obtained from a number of public and private sources:

- MPOs typically identify special generators, such as regional shopping malls, within their jurisdictions when estimating the number of trips generated with their travel demand-forecasting models.
- Proprietary data about major shopping malls can be obtained from ESRI (ESRI Home Page). Specifically, ESRI's *Directory of Major Malls (DMM)* (ESRI: Shopping Center Locator) includes information about more than 3,900 major shopping centers and malls with a gross leasable area of 225,000 square feet or more.
- Finally, other sources of information that should be explored include Google Earth® (Google Earth Home Page) and Google Maps® (Google Maps Home Page.

The data obtained from these public and private sources should, however, be validated and complimented through field surveys (e.g., windshield surveys), especially if the proposed toll road project has raised concerns about an EJ community's access to shopping facilities.

F.2.4.2 Approach

The following steps are recommended to calculate whether zones with medium and high concentrations of EJ populations will incur a disproportionate burden in terms of access to shopping facilities compared to zones with low concentrations of EJ populations with the non-toll road relative to the toll road (i.e., alternatives 1 and 2, respectively):

Step 1: Compile the EJ concentration zones within the impacted area.

Step 2: Determine the travel time threshold (e.g., 15 min, 20 min, 25 min, 30 min, 40 min, 45 min or 1 hour) and transportation mode (e.g., car or transit) for the analysis.

Step 3: Collect data on the number of shopping facilities accessible within the travel time threshold and transportation mode for each EJ concentration zone within the impacted area.

Step 4: Use a land use model (e.g., UrbanSim) to estimate changes in land use resulting from the non-toll and toll roads. Based on model results, estimate changes in the number and location of shopping facilities with both alternatives (e.g., new shopping centers at toll road nodes or interchanges and along connectors).

Step 5: Use a travel demand model (e.g., TransCAD) to estimate S_i^A. S_i^A = the number of shopping facilities that can be reached within the established travel time threshold and transportation mode (e.g., number of malls that can be reached within 30 minutes by car) for each EJ concentration zone given alternatives 1 (i.e., non-toll road) and 2 (i.e., toll road).

Step 6: Determine whether the toll road imposes a statistically significant impact in terms of accessibility to shopping facilities by EJ concentration level relative to the non-toll alternative by applying the "paired t test", based on paired data analysis (i.e., calculate $d_i = S_i^2 - S_i^1$ = difference between *accessibility to shopping facilities index*[17] for alternatives 2 and 1, respectively, for zone *i*).

Step 7: If a statistically significant impact is imposed by the toll road, determine whether zones with medium and high concentrations of EJ populations incur statistically significantly higher impacts (in terms of reduced accessibility to shopping facilities) than zones with low concentrations of EJ populations by estimating the *accessibility to shopping facilities index for each EJ concentration level (i.e., low, medium, and high)* given the toll road $\left(S_k^2\right)$ as follows:

$$S_k^2 = \sum_{i \in k} S_i^2$$

where:

[17] Number of shopping facilities available to the population (in zone *i*) within an established travel time threshold and given a specific transportation mode.

S_i^2 = *accessibility to shopping facilities index for zone i* with the toll road (alternative 2)

Apply the "large sample test" based on differences between population proportions given that $I_k^A = S_k^2, N_k =$ number of zones with *k* concentrations of EJ populations, and $p_k^A =$ proportion of shopping facilities given alternative 2 for the *k* concentration of EJ populations.

F.2.4.3 Robustness and Limitations

Calculating the *accessibility to shopping facilities* index requires expertise in travel demand models, land use models, Geographic Information Systems (GISs), and spatial analysis. It is also assumed that (a) the travel demand model can consider the travel time impacts imposed by the toll road and that (b) the land use model can be used to estimate new shopping facilities or the relocation of shopping facilities at nodes (i.e., interchanges) and along connectors with the toll and non-toll roads. The robustness of the approach is thus a function of the extent to which the travel demand and land use models can differentiate the travel time impacts and the number of shopping facilities associated with the toll road. The two commercial software packages available to calculate the *accessibility to shopping facilities index* are TransCAD (Caliper Corp.) and UrbanSim (UrbanSim Home). The cost of TransCAD varies between $3,000 and $10,000 (based on 2005 data); UrbanSim is available free of charge.

F.2.5 Accessibility to Recreational Facilities

The *accessibility to recreational facilities index for zone i* (R_i) is defined as the number of recreational facilities (e.g., parks, pools, and playgrounds) available to the population (in zone *i*) within an established travel time threshold and given a specific transportation mode.

F.2.5.1 Data and Sources

To calculate the *accessibility to recreational facilities index*, information about the number of recreational facilities (e.g., parks, pools, and playgrounds) within the area impacted by the toll road is required. The required information for EJ may be obtained from a number of public sources:

- MPOs typically identify special generators, such as regional recreational facilities, within their jurisdictions when estimating the number of trips generated with their travel demand-forecasting models.
- Some cities have developed GIS data files that illustrate the spatial location of recreational facilities. For example, the City of Austin's GIS Data Sets' webpage (City of Austin, 2005) provides map data files that illustrate the geographic location of city parks, county parks, and recreation centers in Austin.
- Finally, other sources of information that should be explored include Google Earth® (Google Earth Home Page) and Google Maps® (Google Maps Home Page).

The data obtained from these public and private sources should, however, be validated and complimented through field surveys (e.g., windshield surveys), especially if the proposed toll road project has raised concerns about an EJ community's access to recreational facilities.

F.2.5.2 Approach

The following steps are recommended to calculate whether zones with medium and high concentrations of EJ populations will incur a disproportionate burden in terms of access to recreational facilities compared to zones with low concentrations of EJ populations with the non-toll road relative to the toll road (i.e., alternatives 1 and 2, respectively):

Step 1: Compile the EJ concentration zones within the impacted area.

Step 2: Determine the travel time threshold (e.g., 15 min, 20 min, 25 min, 30 min, 40 min, 45 min or 1 hour) and transportation mode (e.g., car or transit) for the analysis.

Step 3: Collect data on the number of recreational facilities accessible within the travel time threshold and transportation mode for each EJ concentration zone within the impacted area.

Step 4: Use a land use model (e.g., UrbanSim) to estimate changes in land use resulting from the non-toll and toll roads. Based on model results, estimate changes in the number and location of recreational facilities with both alternatives (e.g., new recreational centers at toll road nodes or interchanges and along connectors).

Step 5: Use a travel demand model (e.g., TransCAD) to estimate R_i^A. R_i^A = the number of recreational facilities that can be reached within the established travel time threshold and transportation mode (e.g., number of county parks that can be reached within 30 minutes by car) for each EJ concentration zone given alternatives 1 (i.e., non-toll road) and 2 (i.e., toll road).

Step 6: Determine whether the toll road imposes a statistically significant impact in terms of accessibility to recreational facilities by EJ concentration level relative to the non-toll alternative by applying the "paired t test," based on paired data analysis (i.e., calculate $d_i = R_i^2 - R_i^1$ = difference between *accessibility to recreational facilities index*[18] for alternatives 2 and 1, respectively, for zone *i*).

Step 7: If a statistically significant impact is imposed by the toll road, determine whether zones with medium and high concentrations of EJ populations incur statistically significantly higher impacts (in terms of reduced accessibility to recreational facilities) than zones with low concentrations of EJ populations by estimating the *accessibility to recreational facilities index for each EJ concentration level (i.e., low, medium, and high)* given the toll road $\left(R_k^2\right)$ as follows:

$$R_k^2 = \sum_{i \in k} R_i^2$$

[18] Number of recreational facilities available to the population (in zone *i*) within an established travel time threshold and given a specific transportation mode.

where:

R_i^2 = *accessibility to recreational facilities index for zone i* with the toll road (alternative 2)

Apply the "large sample test" based on differences between population proportions given that $I_k^A = R_k^2, N_k =$ number of zones with k concentrations of EJ populations, and $p_k^A =$proportion of recreational facilities given alternative 2 for the k concentration of EJ populations.

F.2.5.3 Robustness and Limitations

Calculating the *accessibility to recreational facilities* index requires expertise in travel demand models, land use models, Geographic Information Systems (GISs), and spatial analysis. It is also assumed that (a) the travel demand model can consider the travel time impacts imposed by the toll road and that (b) the land use model can be used to estimate the number of recreational facilities with the toll and non-toll roads. The robustness of the approach is thus a function of the extent to which the travel demand and land use models can differentiate the travel time impacts and the number of recreational facilities associated with the toll road. The two commercial software packages available to calculate the *accessibility to recreational facilities index* are TransCAD (Caliper Corp.) and UrbanSim (UrbanSim Home). The cost of TransCAD varies between $3,000 and $10,000 (based on 2005 data); UrbanSim is available free of charge.

F.3 Physical and Environmental Quality Effects

This section explains the calculation of a number of air quality and noise indices that can be used to measure the benefits and burdens imposed by toll roads (compared to non-toll roads) on impacted EJ communities given the four defined toll scenarios.

F.3.1 Air Quality Index

The *air quality at grid g index* (*AQI_g*) is defined as the pollutant concentrations (expressed in ppm) at the grid level (i.e., cells) associated with toll roads and non-toll roads. Tools available to estimate pollutant concentrations are **CALRoads View, Mobile 6.2**, **CAMx**, and **Surfer® 8**.

F.3.1.1 Data and Sources

CALRoads View, an air dispersion modeling package, can be used for predicting the pollutant concentrations near roadways for an unlimited number of grids in a region (Lakes Environmental Software). The modeling package combines the features of three mobile source dispersion models: CALINE4 (Coe et al, 1998), CAL3QHC (U.S. EPA, 1995), and CAL3QHCR. CALRoads View estimates the concentration of carbon monoxide (CO), particulate matter (PM), nitrogen dioxide (NO_2), and inert gases in ppm at ½ hr, 1-hr and 8-hr intervals at the grid level. The required input data and potential data sources to run CALRoads View are presented in Tables F.1, F.2, and F.3.

Table F.1. CAL3QHC/ CAL3QHCR: Input Data Variables and Potential Data Sources

Variables		Potential Data Sources
Meteorological	Average Time [min]	User Input
	Surface Roughness Coefficient [cm]	Field Data
	Settling Velocity [cm/s]	Determined by analyst
	Deposition Velocity [cm/s]	Determined by analyst
	Wind Speed [m/s]	Field Data
	Stability Class [1 to 6 = A to F]	Determined by analyst
	Mixing Height [m]	Determined by analyst
Site	Roadway Coordinates [X,Y,Z] [m or ft]	Field Data
	Roadway Width [m or ft]	Field Data
	Receptor Coordinates [X,Y,Z] [m or ft]	Field Data
Traffic	Traffic Volume [each link] [veh/hr]	Field Data
	Traffic Speed [each link] [mi/hr]	Field Data
	Average Signal Cycle Length [each intersection] [s]	Field Data
	Average Red Time Length [each approach] [s]	Field Data
	Clearance Lost Time [s]	Field Data
	Saturation Flow Rate [veh/hr]	Field Data
	Signal Type [pre-timed, actuated, or semi-actuated]	Field Data
	Arrival Rate [worst, below average, average, above average, best progression]	Field Data
Emissions	Composite Running Emission Factor [each free flow link] [g/vehicle mile]	MOBILE6.2
	Idle Emission Factor [each queue link] [g/vehicle-hour]	MOBILE6.2
	Background Concentration levels of CO & PM	Field Data

Source: U.S. EPA (1995)

Table F.2. CALINE4: Input Data Variables and Potential Data Sources

Variables		Potential Data Sources
Job Parameters	Run Type	User Input
	Aerodynamic Roughness Coefficient	Table G.6
Model Information	Link/Receptor Geometry Units	Field Data
	Altitude above Sea Level	Field Data
	Number of Links	Field Data
	Averaging Interval	User Input
	Link Type	Field Data
	Link Height	Field Data
Link Activity	Traffic Volume	Field Data
	Emission Factor	EMFAC model or MOBILE6.2
Run Conditions	Mixing Zone Width	Field Data
	Wind Speed	Field Data
	Wind Direction	Field Data
	Wind Direction Standard Deviation	Field Data
	Atmospheric Stability Class	Field Data
	Mixing Height	User Input (< 10 m)
	Ambient Temperature	Field Data
	Ambient Pollutant Concentration	Field Data
Receptor Conditions	Number of Receptors	Field Data
	Endpoint Coordinates	Field Data

Source: Coe et al (1998)

Table F.3. Aerodynamic Roughness Coefficient

Roughness Coefficient (cm)	Landscape Type
0.002	Sea, paved areas, snow-covered flat plain, tide flat, smooth desert
0.5	Beaches, pack ice, morass, snow-covered fields
3	Grass prairie or farm fields, tundra, airports, heather
10	Cultivated areas with low crops and occasional obstacles (such as bushes)
25	High crops, crops with varied height, scattered obstacles (such as trees or hedgerows), vineyards
50	Mixed far fields and forest clumps, orchards, scattered buildings
100	Regular coverage with large obstacles, open spaces roughly equal to obstacle heights, suburban houses, villages, mature forests
≥ 200	Centers of large towns or cities, irregular forests with scattered clearings.

Source: Stull, R.B. (1995)

The **MOBILE 6.2** model can be used to estimate emissions from on-road mobile sources, such as passenger cars, trucks, heavy trucks, buses, and motorcycles (U.S. EPA, 2003). MOBILE 6.2 uses a fleet-wide average emission rate for each class or type of vehicle to estimate an emission rate for the region. In addition, the emissions rate per unit time and the daily, annual, or hourly vehicle travel (e.g., VMT/day, VMT/year, or VMT/hr) is needed. The data required to run

MOBILE 6.2 and potential data sources are shown in Table F.4. The model results are expressed in grams per vehicle miles traveled (g/VMT).

Table F.4. MOBILE6.2: Input Data Variables and Potential Data Sources

Variable	Potential Data Source
Month (January, July)	Field Data
Hourly temperature	Field Data
Altitude (high, low)	Field Data
Weekend/weekday	Field Data
Fuel characteristics (Reid vapor pressure, sulfur content, oxygenate content, etc.)	Field Data
Humidity and solar load	Field Data
Registration (age) distribution by vehicle class	Field Data
Annual mileage accumulation by vehicle class	Field Data
Diesel sales fractions by vehicle class and model year	Field Data
Average speed distribution by hour and roadway	User Input
Distribution of vehicle miles traveled by roadway type	Field Data
Engine starts per day by vehicle class and distribution by hour	Field Data
Engine start soak time distribution by hour	Field Data
Trip end distribution by hour	Field Data
Average trip length distribution	User Input
Hot soak duration	Field Data
Distribution of vehicle miles traveled by vehicle class	Determined by analyst
Full, partial, and multiple diurnal distribution by hour	Determined by analyst
Inspection and maintenance (I/M) program description	Field Data
Anti-tampering inspection program description	Field Data
Stage II refueling emissions inspection program description	Field Data
Natural gas vehicle fractions	Field Data
HC species output	Field Data
Particle size cutoff	Field Data
Emission factors for PM and HAPs	Field Data
Output format specifications and selections	Field Data
Background concentration levels of , PM_{10}, $PM_{2.5}$, CO, NO_2, and SO_2 for purpose of calibration.	Field Data
Non-residential land use data for generating contours using TransCAD	Field Data

Source: U.S. EPA (2003)

Once the emissions rates for the region are determined (using Mobile 6.2), a regional dispersion model, such as CAMx, can be used to forecast pollutant concentrations on a regional scale (ENVIRON, 2004). Table F.5 presents the data required to run CAMx and potential data sources. The results from the model are expressed in ppm for each grid.

Once the pollutant concentrations (in ppm) are estimated at the grid level from either CALRoads or Mobile 6.2 and CAMx, commercial software packages, such as Surfer® 8, can then be used to generate pollutant contours for the impacted region (Golden Surface Inc.). The input data required for Surfer® 8 are the coordinates of the receptors and the estimated pollutant concentrations in ppm. The output data from Surfer® 8 are the pollutant contours in a raster structure.

Table F.5. CAMx: Input Data Variables and Potential Data Sources

Variable	Potential Data Source
Meteorology	Supplied by meteorological model
3-Dimensional Gridded Fields:	
Horizontal Wind Components	
Temperature	
Pressure	
Water Vapor	
Vertical Diffusivity	
Clouds/Rainfall	
Air Quality	Obtained from measured ambient data
Gridded Initial Concentrations	
Gridded Boundary Concentrations	
Time/Space Constant Top Concentrations	
Emissions	Supplied by an emissions model
Elevated Point Sources	
Gridded Sources:	
Low-level Point	
Mobile	
Area/Non-road Mobile	
Biogenic	
Geographic	Provided by land use/land cover maps
Gridded Land Use/Surface Cover	
Gridded Surface UV Albedo Codes	
Ozone Column and Photolysis Rates	Ozone column from TOMS Data Photolysis rates from radioactive model
Vertical Grid Structure	
Atmospheric Radioactive Properties	
Gridded Haze Opacity Codes	
Gridded Ozone Column Codes	
Photolysis Rates Lookup Table	

F.3.1.2 Approach

The following steps are recommended to calculate whether grids in medium and high EJ concentration zones will incur a disproportionate burden in terms of air quality (i.e., number of people exposed to a pollution threshold that exceeds the National Ambient Air Quality Standards) compared to grids in low EJ concentration zones with a non-toll road relative to a toll road (i.e., alternatives 1 and 2, respectively).

Step 1: Determine air quality standards for each analyzed pollutant. The National Ambient Air Quality Standards (NAAQS) are summarized in Table F.6. Some states and regions have, however, adopted stricter air quality standards.

Table F.6. National Ambient Air Quality Standards (NAAQS)

Pollutant	Statistic	Standard Value*	Standard type
Ozone (O_3)	1-hour average	0.12 ppm (235 µg/m^3)	Primary & secondary
	8-hour average	0.08 ppm (157 µg/m$^{3)}$	Primary & secondary
Particulate (PM_{10})**	Annual arithmetic mean	50 µg/m^3	Primary & secondary
	24-hour average	150 µg/m^3	Primary & secondary
Particulate ($PM_{2.5}$)***	Annual arithmetic mean	15 µg/m^3	Primary & secondary
	24-hour average	65 µg/m^3	Primary & secondary
Carbon monoxide (CO)	8-hour average	9 ppm (10 mg/m^3)	Primary
	1-hour average	35 ppm (40 mg/m^3)	Primary
Nitrogen dioxide (NO_2)	Annual arithmetic mean	0.053 ppm (100 µg/m^3)	Primary & secondary
Sulfur dioxide	Annual arithmetic mean	0.030 ppm (80 µg/m^3)	Primary
	24-hour average	0.14 ppm (365 µgm^3)	Primary
	3-hour average	0.50 ppm (1300 µg/m^3)	Secondary

* Parenthetical value is an approximately equivalent concentration.
** Particles with aerodynamic diameters of 10 micrometers or less
*** Particles with aerodynamic diameters of 2.5 micrometers or less
Source: U.S. EPA (2003)

Step 2: Compile the EJ concentration zones within the impacted area.

Step 3: Collect all input data required for the selected model(s) for alternatives 1 and 2.

Step 4: Run the selected model(s) to estimate the individual pollutant concentrations in ppm for all the grids in the impacted area for the non-toll and toll road alternatives (i.e., AQI_g^1 and AQI_g^2, respectively).

Step 5: Use Surfer® 8 to map the individual pollutant concentration levels at the grid level for the impacted area with the non-toll and toll road alternatives, respectively. Categorize the grids by EJ concentration level by overlaying the Surfer® 8 model results with the EJ concentration zones.

Step 6: Determine whether the toll road imposes a statistically significant air quality impact (in terms of each of the individual pollutants) by EJ concentration level relative to the non-toll alternative by applying the "paired t test," based on paired data analysis (i.e., calculate

$d_i = AQI_g^2 - AQI_g^1$ = difference between *air quality at grid g index* (for the analyzed pollutant) by EJ concentration level for alternatives 2 and 1, respectively.

Step 7: If a statistically significant impact is imposed by the toll road, determine whether the grid population in zones with medium and high concentrations of EJ populations incur statistically significantly higher impacts (in terms of pollutant concentrations) than grid populations in zones with low concentrations of EJ populations by calculating the impacted population in each grid and applying the "large sample test" based on differences between population proportions as follows (see Box F.2):

$$\hat{p}_k^2 = \frac{NQAP_k^2}{N_k}$$

where:

$\hat{p}_k^2$ = proportion of grid population impacted by poor air quality given alternative 2 for the *k* concentrations of EJ populations

$NQAP_k^2$ = grid population impacted by poor air quality given alternative 2 for the *k* concentrations of EJ populations

N_k = total population for the *k* concentrations of EJ populations

k = sub-index for EJ concentration level (*k* = low, medium, high);

F.3.1.3 Robustness and Limitations of the Proposed Analysis Method

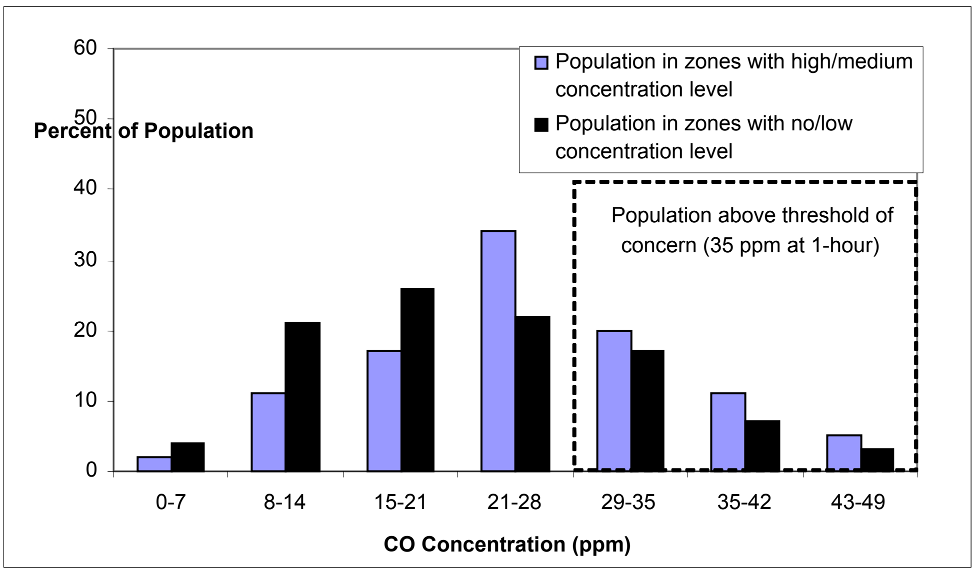
Calculating the *air quality at grid g index* requires expertise in air quality models, pollution surface analysis, GIS, and spatial analysis. CALRoads View can be used to estimate pollutant concentrations for an unlimited number of receptors and grids in a region. MOBILE 6.2 can be used for regional-scale modeling but is less appropriate for project-level analysis when site-specific real-time fleet emissions are needed (ESRI, 2005). CAMx is an air quality dispersion model that can be used to model pollutant concentrations for a whole region at a very disaggregate level. It is assumed that the selected air quality models can capture the pollutant impacts with the non-toll and toll roads. The robustness of the approach is thus a function of the extent to which the selected model(s) can differentiate pollutant concentrations associated with the two alternatives. CALRoads View and Surfer® 8 cost $995 and $599, respectively (based on 2005 data); MOBILE 6.2 and CAMx are available free of charge.

An analysis of air quality using CALRoads View is presented in Box F.3.

Box F.3 Inferences Concerning a Difference between Population Proportions

An air quality analysis using CALRoads View reveals that neighborhoods adjacent to frontage roads of toll road facilities may be exposed to high concentrations of carbon monoxide (CO) compared to neighborhoods adjacent to frontage roads of non-toll roads. The affected population groups have been identified (see Table and Figure below) by overlaying the EJ concentration zones in the impacted area with the pollution surfaces (grids).

CO Concentrations at 1-hour (ppm)	Grid Population by EJ Concentration Level	
	High/medium	**Low**
0-7	269	169
8-14	1,477	888
15-21	2,282	1,100
21-28	4,565	931
29-35	2,685	719
35-42	1,477	296
43-49	671	127
Total	**13,425**	**4,230**



Do the data suggest that the proportion of grid population impacted by poor air quality in zones with high/medium EJ concentration levels is higher than that for zones with low EJ concentration levels at a 0.01 significance level?

	Grid Population by EJ Concentration Level		Total
	High/Medium	**Low**	
Total population in the impacted area	m = 13,425	n = 4,230	17,655
Population affected by CO concentrations > 35 ppm at 1-hour	x = 4,833	y = 1,142	5,975
Sample proportion	$\hat{p}^2_{high,medium} = 0.36$	$\hat{p}^2_{low} = 0.27$	$\hat{p}_1 = 0.27$

The hypothesis of interest is $H_0 : p^2_{high} - p^2_{low} = 0$ versus $H_a : p^2_{high} - p^2_{low} > 0$. At level 0.01, H_o should be rejected if $Z \geq Z_{.01}$ =2.33. Since the value of the test statistic is 10.79, H_o must be rejected. The p-value is so minuscule that at any reasonable level α, H_o must be rejected. Therefore the data suggest that the grid population in zones with high EJ concentration level is disproportionately impacted by CO concentrations compared with the grid population in zones with low EJ concentration level at a 0.01 significance level.

F.3.2 Noise Quality Index

The *noise quality at receiver r index* (NQI_r) is defined as the traffic noise level at receiver *r* associated with toll roads and non-toll roads.

F.3.2.1 Data and Sources

The Federal Highway Administration (FHWA)'s Traffic Noise Model (TNM) can be used (a) to predict traffic noise levels near highways and (b) design noise barriers to effectively mitigate traffic noise impacts. The model predicts the noise level at specific receivers considering (a) traffic parameters, (b) road information, (c) type of terrain surface, (d) receiver coordinates, including distance between receiver and road center line, (e) the presence (or absence) of a noise barrier, and (f) if present, the height of the noise barrier. Table F.7 lists the data required to run TNM and potential data sources.

Table F.7. FHWA's TNM: Input Data and Potential Data Sources

Variables	Potential Data Source
Traffic Information	
Volume	Field Data
Vehicle classification information (based on five standard vehicle types)	Field Data
Average vehicle speeds for each vehicle type and for constant and interrupted traffic flow	Field Data
Road Information	
Horizontal and vertical alignment (X,Y, and Z coordinates of the road[s])	Shape file*
Terrain Surface Information	
Type of Surface	Field Data
Receiver Information	
Number of receivers and coordinates	Field Data
For each receiver, type and distance from center line of the road	Shape file*
Barrier Information	
Barrier Present	Field Data
Barrier Height	Field Data

* ArcView shapefiles capturing the required information can be imported into TNM (ESRI, 2005

The model output is the noise level at each receiver considered in the analysis. Noise contours can also be generated using the contour features of the software (FHWA, 2005).

F.3.2.2 Approach

The following steps are recommended to determine whether receivers (e.g., houses, office buildings, schools, hospitals, and nursing homes) in medium and high EJ concentration zones will incur a disproportionate burden in terms of noise quality compared to receivers in low EJ concentration zones with a non-toll road relative to a toll road (i.e., alternatives 1 and 2, respectively).

Step 1: Determine the noise abatement criteria (NAC) by receiver type. A decibel (dB) is the most often used noise measurement unit. The human ear has different levels of sensitivity to high-pitched and low-pitched sounds. Therefore highway traffic noise measurements are adjusted to approximate human hearing. These adjusted measurements are known as A-weighted decibels (dBA). The NAC is thus defined in hourly A-weighted decibels expressed as L_{EQ}(h) or L_{10}(h). Table F.8 lists the current FHWA NAC (FHWA, 2005).

Table F.8. FHWA's Hourly NAC (A-weighted Sound Level in dBA)

Activity Category	L_{EQ}(h)	L_{10}(h)	Description of Activity Category
A	57 (Exterior)	60 (Exterior)	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to fulfill its intended purpose.
B	67 (Exterior)	70 (Exterior)	Picnic areas, recreation areas, playgrounds, active sports areas, parks, residences, motels, hotels, schools, churches, libraries, and hospitals.
C	72 (Exterior)	75 (Exterior)	Developed lands, properties, or activities not included in Categories A or B above.
D	None	None	Undeveloped lands.
E	52 (Interior)	55 (Interior)	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, and auditoriums.

Source: FHWA 1995, p. 7.

Step 2: Compile the EJ concentration zones within the impacted area.

Step 3: Identify all receivers (e.g., houses, office buildings, schools, hospitals, and nursing homes) potentially impacted. In other words, identify all receivers within 60 m on each side of the non-toll and toll road alternatives for a lightly traveled road or within 150 m on each side of the non-toll and toll road alternatives for a heavily traveled road (Forkenbrock and Sheely, 2004).

Step 4: Collect all input data required for the model for alternatives 1 and 2.

Step 5: Estimate the noise levels at all the identified types of receivers in the impacted area for the non-toll and toll road alternatives (i.e., NQI_r^1 and NQI_r^2, respectively). Categorize the receivers by EJ concentration levels by overlaying the model results with the EJ concentration zones.

Step 6: Determine whether the toll road imposes a statistically significant noise quality impact (for each receiver type) by EJ concentration level relative to the non-toll alternative by applying the "paired t test," based on paired data analysis (i.e., calculate $d_i = NQI_r^2 - NQI_r^1$ = difference between the *noise quality at receiver r index* (for each receiver type) by EJ concentration level for alternatives 2 and 1, respectively.

Step 7: If a statistically significant impact is imposed by the toll road, determine whether the population at receivers in zones with medium and high concentrations of EJ populations incur statistically significantly higher impacts (in terms of noise levels exceeding the NAC) than populations at receivers in zones with low concentrations of EJ populations by calculating the impacted population at each receiver and applying the "large sample test" based on differences between population proportions as follows (see Box F.2):

$$\hat{p}_k^2 = \frac{NQAP_k^2}{N_k}$$

where:

$\hat{p}_k^2$ = proportion of receiver population impacted by poor noise quality given alternative 2 for the *k* concentrations of EJ populations.

$NQAP_k^2$ = receiver population impacted by poor noise quality given alternative 2 for the *k* concentrations of EJ populations

N_k = total population for the *k* concentrations of EJ populations

k = sub-index for EJ concentration level (*k* = low, medium, high)

Box F.4 provides an example to illustrate the proposed approach.

Box F.4 Inferences Concerning a Difference between Population Proportions

A traffic noise quality analysis using FHWA's TNM reveals that more receivers adjacent to a toll road facility may be exposed to noise levels that exceed the FHWA's noise abatement criteria (i.e., 67 dBA) compared to receivers adjacent to a non-toll road. The impacted population groups have been identified by overlaying the EJ concentration zones in the impacted area with the model results (see table below). Do the data suggest that the proportion of population at receivers impacted by high levels of traffic noise in zones with high/medium EJ concentration levels is higher than the proportion of the population at receivers in zones with low EJ concentration levels at a 0.05 significance level?

	Receiver Population by EJ Concentration Level		**Total**
	Low	**High/Medium Low**	
Total population in the impacted area	8,425	13,230	21,655
Population exposed to noise level > 67 dBA	3,422	4,197	7,619
Population proportion	$\hat{p}_{low}^2 = 0.41$	$\hat{p}_{high,medium}^2 = 0.45$	$\hat{p}_1 = 0.35$

The hypothesis of interest is $H_0 : p_{high}^2 - p_{low}^2 = 0$ versus $H_a : p_{high}^2 - p_{low}^2 > 0$. At level 0.05, H_o should be rejected if $Z \geq Z_{.05}$ =1.645. Since the value of the test statistic is 6.50, H_o must be rejected. The p-value is so minuscule that at any reasonable level α, H_o must be rejected. Therefore the data suggest that the population at receivers in zones with high EJ concentration level is disproportionately impacted by higher noise levels compared with the population at receivers in zones with low EJ concentration level at a 0.05 significance level.

F.3.2.3 Robustness and Limitations of the Proposed Analysis Method

Calculating the *noise quality at receiver r index* requires expertise in traffic noise models, GIS, and spatial analysis. The FHWA's TNM can estimate the traffic noise at up to 45 discrete receivers in one run. To obtain results for more than 45 receivers, multiple runs are required. Also, the TNM allows for the drawing of noise level contours. These contours can be overlaid with the EJ concentrations zones to visualize the noise impacts across the impacted area. It is thus assumed that the TNM can capture the noise impacts with the non-toll and toll road condition. The robustness of the approach is thus a function of the extent to which the TNM model can differentiate the traffic noise levels associated with the two alternatives. The FHWA's TNM (Version 2.5) costs $595 (based on 2005 data). The software is available from the McTrans Center at the University of Florida.

F.4 Economic Development Effects

This section explains how to calculate an index that can be used to measure the impact imposed by toll roads (compared to non-toll roads) on the residential and commercial property values (e.g., houses, buildings, and land) in the impacted area.

F.4.1 Residential and Commercial Property Values

The *residential and commercial property value at grid g index* (PVI_g) is defined as the differential in property values at the grid level associated with toll roads and non-toll roads. Available tools to estimate the change in property values are Property Comparison/Appraiser's Opinion and UrbanSim.

F.4.1.1 Data and Sources

Property Comparison/Appraiser's Opinion is widely used by property appraisers to determine the values of residential and commercial properties (Forkenbrock and Sheely, 2004). In conducting the analysis, an appraiser identifies recently sold properties—known as *comp*s—in the vicinity with characteristics similar to the property being appraised. The sale price is subsequently adjusted to yield the appraised value of the property in question after considering property characteristics, such as dwelling age, physical characteristics, location amenities, and downsides. The required input data and potential data sources for the Property Comparison method are listed in Table F.9. If more than one appraiser is used, a brief report should be compiled providing the range of the likely changes in the appraised property values.

Table F.9 Property Comparison: Input Data Variables and Potential Data Sources

Variables	Potential Data Sources
Physical characteristics	
Number of rooms	Field data
Floor area	Field data
Construction quality	Professional opinion (civil engineer)
Piping condition	Professional opinion (civil engineer)
Transportation access	Accessibility indices
Amenities	
School rating	Public opinion
Safety	Public opinion
Downsides	
Crime	Police records, public opinion
Noise	Public opinion

UrbanSim is a transportation and urban land use model. The theoretical basis of the model is founded in random utility maximization (RUM) theory, bid rent theory on land markets, and hedonic price theory (Waddell and Ulfarsson, 2002). UrbanSim consists of a family of models that are embedded and interact within a software architecture that facilitates the implementation of these models (see Figure F.1). Some of the processing models include: (a) *Economic and Demographic Models*, (b) a *Location Choice Model*, (c) a *Household and Employment Mobility Model*, (d) a *Real Estate Development Model*, and (e) a *Land Price Model*. The latter two models are used for estimating changes in property values.

The *Real Estate Development Model* and *Land Price Model* in UrbanSim use a multinomial logit (MNL) structure for estimating land prices. The *Real Estate Development Model* simulates developers' choices concerning where and what type of construction to undertake, including new developments and redeveloping existing structures. The steps are as follows:

- The model examines all grids/cells on which development is allowed and creates a list of possible development alternatives, including the alternative of not developing (Waddell, 2002).
- The probability for each alternative being selected is calculated using a MNL model.
- The development is then simulated using a Monte Carlo sampling process.
- Finally, the most likely characteristics of the resulting development project within the grid/cell are estimated using a development template. This template has defined probability distributions for development changes, such as the number of housing units, the square feet of residential, industrial, and government space, the improvement value, and the construction schedule (Waddell, 2002).

The *Real Estate Development Model* simulates the choices of a developer or land-owner at a single location (grid/cell) about whether to develop and what type of real estate to invest in. This decision is influenced by market information about the state of the market, such as vacancy rates. The variables included in this model are:

- characteristics of the grid/cell (i.e., current development, policy constraints, land and improvement value),
- characteristics of the site location (i.e., proximity to highways, arterials, existing development, and recent development), and
- regional accessibility to population.

The *Land Price Model* is founded in urban economic theory, which states that the value of location is reflected in the price of the land (Waddell, 2002). The model simulates changes in land prices at each grid/cell resulting from changes in the characteristics of the locations over time. The land value for each cell is calculated as the sum of the land values of the parcel fragments[19] within the cell. This cell value is used as the dependent variable in the land price model. The model is calibrated from historical data using a hedonic regression that includes the effect of site, neighborhood, accessibility, and policy effects on land prices. The model also considers the effects of short-term fluctuations in local and regional vacancy rates on overall land prices.

[19] These values originate from the tax assessor's estimates of the land value of each parcel.

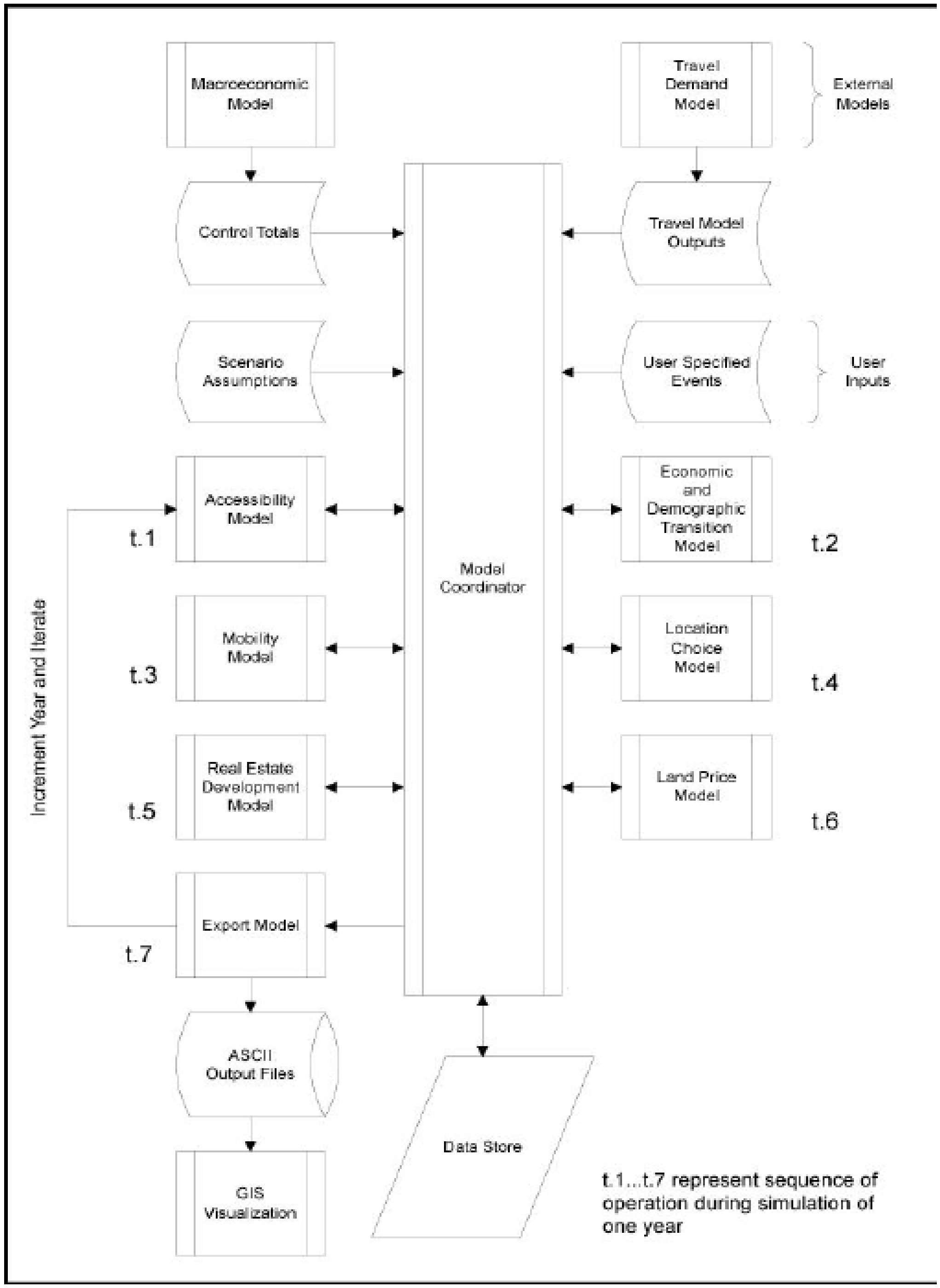


Figure F.1. UrbanSim Model Structure and Processing

Table F.10 lists the input data variables needed to estimate property values using UrbanSim. The input data for the model database, called the *data store*, require parcel files from tax assessor offices, business establishment files from the state unemployment insurance database, commercial sources, census data, GIS overlays, and a location grid. The data integration tools in UrbanSim read the *data store* and apply decision rules to synthesize missing or erroneous data. The *data store* represents location using grid cells of 150 meters x 150 meters.

The location grid allows cross referencing to other spatial features such as planning and political boundaries (e.g., city, county, traffic analysis zones). A different cell size can be specified by the analyst.

Table F.10. UrbanSIM: Input Data Variables

Variables	Sub-Variable
Household Information (HouseholdID)	Persons
	Workers
	Children
	Age of head
	Income
	GridID
Grid Information (GridID)	Total housing units
	Vacant housing units
	Total nonresidential area
	Vacant nonresidential area
	Development type
	Land value
	Environmental overlays
	Residential improvement value
	Non residential improvement value
	UGB, city, county, traffic zone
Job Information (JobID)	Sector
	GridID

F.4.1.2 Approach

The following steps are recommended to calculate whether grids in medium and high EJ concentration zones will incur a disproportionate benefit or burden in terms of property values (i.e., number of properties that significantly increase or decrease in value) compared to grids in low EJ concentration zones with a non-toll road relative to a toll road (i.e., alternatives 1 and 2, respectively).

Step 1: Compile the EJ concentration zones within the impacted area.

Step 2: Collect all input data required for the selected tool (e.g., UrbanSim) for alternatives 1 and 2.

Step 3: Run UrbanSIM to estimate the property values for all grids in the impacted area for the non-toll and toll road (i.e., PVI_g^1 and PVI_g^2, respectively). Categorize the grids by EJ concentration level by overlaying the model results with the EJ concentration zones.

Step 4: Determine if the toll road imposes a statistically significant impact on property values (for each property type, such as residential, commercial or land) by EJ concentration level relative to the non-toll alternative by applying the "paired t test," based on paired data analysis (i.e., calculate $d_i = PVI_g^2 - PVI_g^1$ = difference between *property values at grid g index* (for each property type) by EJ concentration level for alternatives 2 and 1, respectively.

Step 5: If a statistically significant impact is imposed by the toll road, determine whether properties in zones with medium and high concentrations of EJ populations incur statistically significantly higher impacts (in terms of increased or decreased property values, respectively) than properties in zones with low concentrations of EJ populations by calculating the number of properties in each grid and applying the "large sample test" based on differences between population proportions given that $N_k^- =$ total number of properties that decreased in value given alternative 2 for the *k* concentrations of EJ populations, $N_k^+ =$ total number of properties that increased in value given alternative 2 for the *k* concentrations of EJ populations, $p_k^A = PVI_k^{2-} =$ proportion of decreased property values given alternative 2 for the *k* concentration of EJ populations, and $p_k^A = PVI_k^{2+} =$ proportion of increased property values given alternative 2 for the *k* concentration of EJ populations.

F.4.1.3 Robustness and Limitations

Calculating the *residential and commercial property value at grid g index* using Property Comparison/Appraiser's Opinion requires expertise in property markets and GIS. Calculating the index using UrbanSim requires expertise in land use models, GIS, and spatial analysis.

Property Comparison/Appraiser's Opinion may yield the best property values or estimates when sophisticated models are not readily available (Forkenbrock and Sheely, 2004). The method can be implemented by consulting local professionals knowledgeable about local property markets or by hiring a firm with expertise in market studies. Although the latter option requires more effort in terms of systematic analysis, both options depend heavily on an understanding of the property markets (Forkenbrock and Sheely, 2004). The most serious limitation of this method is the need to find good *comps*, that is, comparable properties which can be used to estimate impacts on property values within an area with reasonable accuracy. Furthermore, because this technique relies solely on appraisers' judgment, care should be taken in identifying good *comps* near toll road facilities that are similar to the toll alternative being analyzed. Since human judgments can vary widely, this method may not be suitable if similar properties cannot be found. In other words, without good *comps* this method may not yield an accurate forecast of changes in property values resulting from a toll road facility.

UrbanSim is a powerful tool for conducting EJ analysis of toll road projects that require a high degree of demographic resolution, because the analysis can be conducted at the grid level. This model is, however, data intensive and requires substantial calibration. Furthermore, the literature does not provide adequate evidence to verify if the modeling effort yields accurate estimates of residential property values.

Finally, the robustness of the approach is thus a function of the extent to which the selected tools can differentiate the impact on property values associated with the two alternatives. The cost of the Property Comparison/Appraiser's Opinion technique is a function of the appraiser's fees, which could vary substantially from one appraiser to the next. UrbanSim is available free of charge.

F.5 Social Effects

This section details the calculation of the Pedestrian Danger Index (PDI) and the Bicycle Safety Index (BSI), which can be used to measure the benefits and burdens imposed by toll roads (compared to non-toll roads) on impacted EJ communities given the four toll road scenarios conceptualized.

F.5.1 Pedestrian Safety

The Surface Transportation Policy Project (STPP) developed the *Pedestrian Danger Index (PDI)* method to evaluate pedestrian safety at the county level in California (Forkenbrock and Sheely, 2004). The scale of analysis of this method was modified (i.e., EJ concentration zones instead of county level) for the purpose of this study. The *PDI* is calculated to have a normalized value of 1 to 100 with 100 being the most dangerous in terms of pedestrian safety. The *PDI* can thus be used to categorize the pedestrian safety environment in all EJ concentration zones within the area impacted by a proposed toll road.

F.5.1.1 Data and Sources

Table F.11 lists the required input data and potential data sources for estimating the PDI. The input data given the non-toll and the toll road alternatives are based on actual numbers collected from an area(s) where comparable facilities have been constructed in the past. Special attention should thus be given to ensure that the selected area(s) are in fact as similar as possible in terms of pedestrian trip distance, demographics, road geometry, traffic volume, and hazards created or relieved by the proposed non-toll and toll road alternatives, respectively.

Table F.11. Pedestrian Danger Index: Input Data and Potential Data Sources

Input Data	Potential Data Sources
Population Data	U.S. Census Data
Pedestrian Crash Data	Department of Public Safety Highway Patrol
Pedestrian Exposure Data	U.S. Census data (i.e., number of employed residents walking to work)

*Source: Forkenbrock and Sheely, (2004), pp. 156

F.5.1.2 Approach

Step 1: Compile the EJ concentration zones within the impacted area.

Step 2: Collect the required input data for the alternatives for each EJ concentration zone in the impacted area.

Step 3: Calculate the number of injuries (*NI*) for zone *i* divided by 1,000 people for alternatives 1 (i.e., non-toll road) and 2 (i.e., toll road) as follows:

$$\left(\frac{NI}{1{,}000\ people}\right)_i^A = \left(\frac{pedestrian\ death\ \&\ injury\ rate}{population}\right)_i^A \times 1{,}000$$

Step 4: For the two alternatives, calculate the pedestrian exposure rate for zone *i* as follows:

$$PER_i^A = \left(\frac{number\ of\ employed\ residents\ walking\ to\ work}{total\ number\ of\ workers} \right)_i^A$$

Step 5: For the two alternatives, estimate the unadjusted index value for zone *i* as follows:

$$UIV_i^A = \frac{\left(NI / 1{,}000\ people \right)_i^A}{PER_i^A}$$

Step 6: For the two alternatives, identify the maximum unadjusted index value in the impacted area (UIV_{Max}^1 and UIV_{Max}^2 respectively).

Step 7: Calculate the *PDI* (adjusted to reflect a scale of 1 to 100) for the non-toll and toll road alternatives, respectively, for all zones *i* within the impacted area as follows:

$$PDI_i^A = \left(\frac{UIV_i^A}{UIV_{Max}^A} \right) \times 100$$

Step 8: Determine whether the toll road imposes a statistically significant impact in terms of pedestrian safety by EJ concentration level relative to the non-toll alternative by applying the "paired t test," based on paired data analysis (i.e., calculate $d_i = PDI_i^2 - PDI_i^1 =$ difference between the *PDI* for alternatives 2 and 1, respectively for zone *i*).

Step 9: If a statistically significant impact is imposed by the toll road, determine whether zones with medium and high concentrations of EJ populations incur statistically significantly higher impacts (in terms of reduced pedestrian safety) than zones with low concentrations of EJ populations by estimating the *PDI for each EJ concentration level (i.e., low, medium, and high)* given the toll road $\left(PDI_k^2 \right)$ as follows:

$$PDI_k^2 = \sum_{i \in k} PDI_i^2$$

where:

$PDI_i^2 =$ *PDI for zone i* with the toll road (alternative 2)

Apply the "large sample test" based on differences between population proportions given that $I_k^A = PDI_k^2, N_k =$ number of zones with *k* concentrations of EJ populations, and $p_k^2 =$ Pedestrian Danger Index proportion given alternative 2 for the *k* concentration of EJ populations.

F.5.1.3 Robustness and Limitations of the Proposed Analysis Method

Calculating the *Pedestrian Danger Index* requires expertise in pedestrian safety analysis, GIS, and spatial analysis. Limited data and a lack of suitable comparison areas may, however, prevent the calculation of the PDI. For example, for the non-toll road alternative, data on pedestrian exposure and accidents might not be available. For the toll road alternative, the calculation requires that similar comparison areas in terms of demographics, specifically the degree to which the areas provide residence to EJ communities, and the characteristics of the toll road be identified. This can be problematic.

It is thus assumed that the required data can be collected and that the impacts on pedestrian safety associated with the toll road can be estimated using the PDI. The robustness of the approach is thus a function of the extent to which the PDI can capture and differentiate the pedestrian safety impacts associated with the two alternatives.

F.5.2 Bicycle Safety

The *Bicycle Safety Index* (*BSI*), developed by Davis (1987) and modified by Epperson (1994), is an approach for estimating how bicycle safety might be affected by changes in road attributes; it can be used to assess the bicycle safety environment within the area impacted by a proposed toll road.

F.5.2.1 Data and Sources

Tables F.12 and F.13 list the input data and potential data sources for estimating the *BSI*.

Table F.12. Bicycle Safety Index: Input Data Variables and Potential Data Sources

Variables	Potential Data Sources
Traffic volume (AADT)	Highway Performance Monitoring System (HPMS) Field data
Road characteristics (number of lanes, lane width, etc.)	
Pavement factors	See Table F.13
Location factors pertaining to conditions that affect the cross traffic, limit sight distance, or restrict the safe operation of bicycles	

Table F.13. Pavement and Location Factors

Pavement Factor	Value
Cracking	0.5
Patching	0.25
Weathering	0.25
Potholes	0.25
Rough road edge	0.25
Railroad crossing	0.25
Rough railroad crossing	0.5
Drainage grates	0.5
Location Factor	**Value**
Angled parking	0.75
Parallel parking	0.25
Right-turn lane (full length)	0.25
Raised median (solid)	-0.50
Raised median (left-turn bays)	-0.35
Center turn lane (scramble lane)	-0.20
Paved shoulder	-0.75
Grades, severe	0.50
Grades, moderate	0.20
Curves, frequent	0.35
Restricted sight distance	0.50
Numerous drives	0.25
Industrial land use	0.25
Commercial land use	0.25

Source: Epperson (1994).

F.5.2.2 Approach

Step 1: Compile the EJ concentration zones within the impacted area.

Step 2: Collect the required input data for the two alternatives for each road segment.

Step 3: For the two alternatives, calculate the *BSI* for each road segment *s* $\left(BSI_s^A\right)$as follows:

$$BSI_s^A = \frac{AADT_s^A}{3100 \times L_s^A} + \frac{S_s^A}{48} + \left(\frac{S_s^A}{48} \times \left(4.25 - W_s^A\right) \times 1.635\right) + PF^A + LF^A$$

where:

BSI_i^A = *Bicycle Safety Index* for road segment *s* for alternative *A*

$AADT_s^A$ = Average annual daily traffic for road segment *s* for alternative *A*

L_s^A = Number of traffic lanes for road segment *s* for alternative *A*

S_s^A = Speed limit (kilometers per hour) for road segment *s* for alternative *A*

L_s^A = Width of the outside lane (meters) for road segment *s* for alternative *A*

PF^A = Sum of pavement factors for alternative *A* (see Table F.13)

LF^A = Sum of location factors for alternative *A* (see Table F.13)

Step 4: Categorize the road segments by EJ concentration level by overlaying the results with the EJ concentration zones.

Step 5: Determine whether the toll road imposes a statistically significant impact in terms of bicycle safety by EJ concentration level relative to the non-toll alternative by applying the "paired t test," based on paired data analysis (i.e., calculate $d_i = BSI_s^2 - BSI_s^1$ = difference between the *BSI for road segment s* for alternatives 2 and 1, respectively). Table F.14 provides interpretations of BSI values.

Table F.14. Interpretation of *BSI* Values

Index range	Classification	Description
0 to 3	Excellent	Denotes an extremely favorable roadway for safe bicycle operation
3 to 4	Good	Refers to roadway conditions still conducive to safe bicycle operation, but not quite as unrestricted
4 to 5	Fair	Pertains to roadway conditions of marginal desirability for safe bicycle operation
5 or above	Poor	Indicates roadway conditions of questionable desirability for bicycle operation

Source: Epperson (1994)

Step 6: If a statistically significant impact is imposed by the toll road, determine whether zones with medium and high concentrations of EJ populations incur statistically significantly higher impacts (in terms of reduced bicycle safety) than zones with low concentrations of EJ populations by estimating the *BSI for each EJ concentration level (i.e., low, medium, and high)* given the toll road $\left(BSI_k^2\right)$ as follows:

$$BSI_k^2 = \sum_{i \in k} BSI_s^2$$

where:

BSI_s^2 = *BSI for road segment s* with the toll road (alternative 2)

Apply the "large sample test" based on differences between population proportions given that $I_k^A = BSI_k^2$, N_k = number of road segments in zones with *k* concentrations of EJ populations, and p_k^2 = *BSI* proportion given alternative 2 for the *k* concentration of EJ populations.

F.5.2.3 Robustness and Limitations of the Proposed Analysis Method

Calculating the *Bicycle Safety Index* requires expertise in bicycle safety analysis, GIS, and spatial analysis. Limited data may, however, prevent the calculation of the BSI. It is thus assumed that the required data can be obtained and that the impacts on bicycle safety associated with the toll road can be estimated using the BSI. The robustness of the approach is thus a function of the extent to which this index can capture and differentiate the bicycle safety impacts associated with the two alternatives.

Appendix G: Telephone Survey of Community-Based Organizations in Impacted Environmental Justice Communities

In January and February of 2006, religious groups, schools, and neighborhood associations serving environmental justice (EJ) communities potentially impacted by the proposed toll road system in Central Texas were surveyed by phone. The survey design, methodology, response rates, major findings, and concluding remarks are presented in this Appendix.

G.1 Survey Design

G.1.1 Survey Objective

To obtain preliminary guidance for designing community outreach effort, community-based organizations (i.e., religious groups, schools, and neighborhood associations) serving EJ communities potentially impacted by the proposed toll road system in Central Texas were identified. The objectives of contacting these community-based organizations were the following:

- To determine the minority and low-income populations served by the organization,
- To establish the existing level of awareness about proposed toll roads and the potential impacts these facilities could impose on EJ communities,
- To determine each organization's willingness to participate in and facilitate future EJ community outreach efforts,
- To identify the outreach activities preferred by each EJ community (e.g., formal meetings, informal meetings, focus groups, telephone surveys, personal interviews, and questionnaires by mail), and
- To identify community leaders.

G.1.2 Target Population and Sampling Units

Since the proposed toll road system in Central Texas is expected to impact a sizable area adjacent to the toll roads, the impacted area was defined by a 6-mile wide buffer along the proposed alignments (see Figure G.1). It was assumed that this impacted area covers the footprints of all potential ecological, mobility, safety, social, economic, and cultural impacts (i.e., the potential EJ concerns) associated with the proposed toll road system. The target population is the community-based associations located within the impacted area.

The contact details for religious groups, schools, and neighborhood associations within the impacted area were obtained using Geographic Information Systems (GISs) and the web. This required the following steps: first, zip codes within the impacted area were identified by map overlays. Second, the zip code layer was overlaid with the EJ concentrations levels composed to identify churches, schools, and neighborhood associations that were thought to serve EJ communities. Third, the web was used to compile a contact list of all churches, schools, and neighborhood associations within the impacted area. The list contained each organization's name, physical address, telephone and fax numbers, and contact names (if available). Finally, the list of organizations was mapped in GIS. In total, the target population consisted of 494 units broken down into 230 religious groups, 197 schools, and 67 neighborhood associations (see Table G.1).

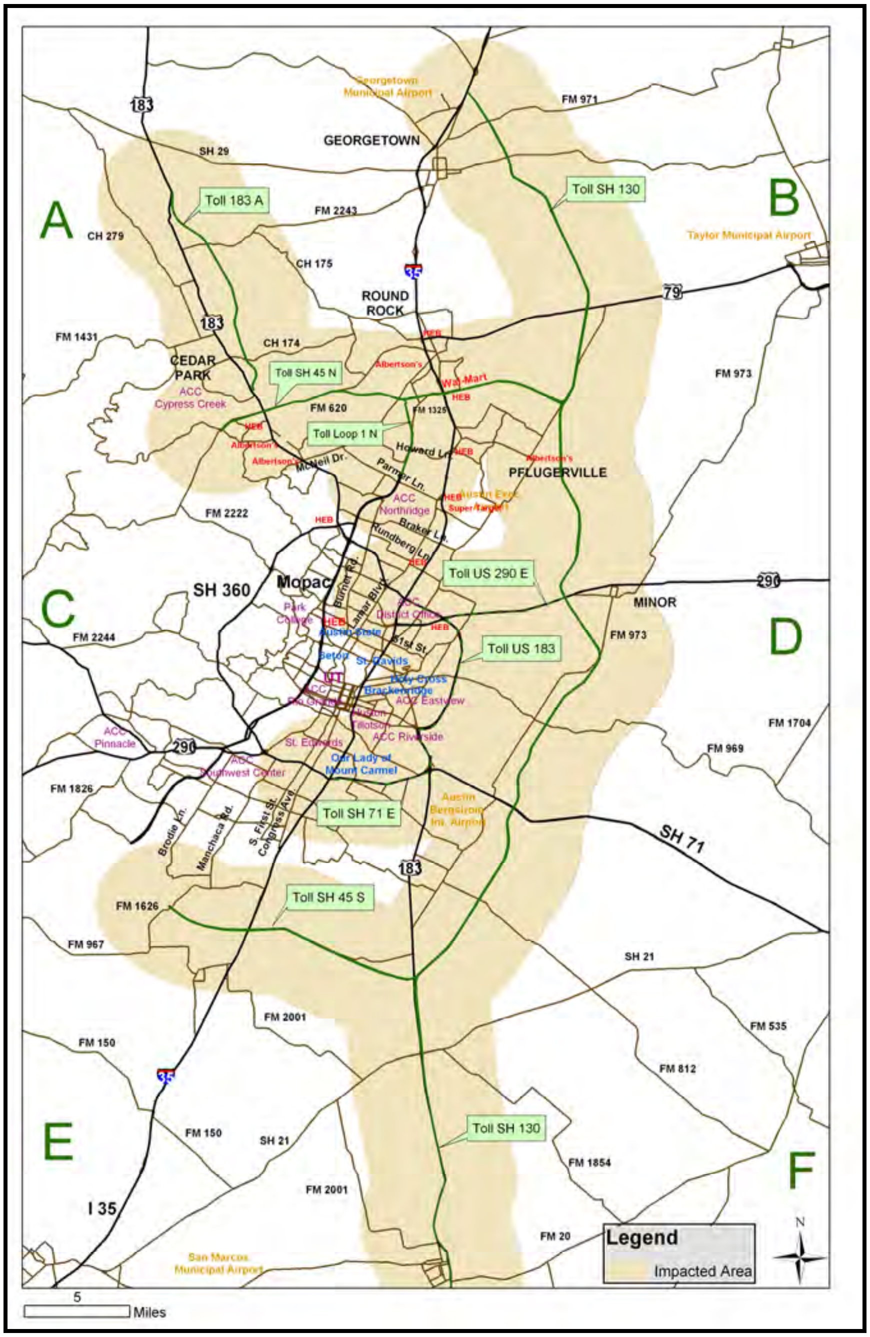


Figure G.1 Impacted Area

Table G.1. Target Population

Community-Based Organizations	Total Units	Percentage
Religious Groups	230	46 %
Schools	197	40 %
Neighborhood Associations	67	14 %
TOTAL =	494	100 %

G.1.3 Sampling Method

Stratified random sampling with proportional allocation was used as the sampling method to ensure that the sample reflected the population with respect to the stratification variable (i.e., type of community-based organization). Furthermore, proportional allocation ensured that each unit in the sample represented the same number of units in the population.

G.1.4 Survey Methodology

In-person telephone interviews were conducted to minimize respondent burden and increase participation. Telephone survey methodology generally ensures higher response rates because the respondent can perform the task of providing the information orally without further burden (Lawson, 2002). Telephone surveys also provide opportunities for clarifying the purpose of the survey, the use of the collected information, and the meaning of the questions. Although telephone surveys typically require callbacks and specific calling hours, the method provides higher response rates than other survey techniques such as mail questionnaires.

G.1.5 Survey Forms

Figures G.2, G.3, and G.4 present the three questionnaires used to survey the religious groups, schools, and neighborhood associations, respectively. Although the questionnaires were customized for each type of organization, the questions were essentially the same.

Survey Administered to Religious Groups

Interviewer: Good morning/afternoon. My name is ___________ and I am a research assistant at the University of Texas at Austin. I am currently working on a project that is looking at the impact of toll roads on surrounding communities. Particularly, I am interested in involving vulnerable communities in the planning of such toll road facilities. Since your congregation can potentially be impacted, I would like to get your input. Would you be willing to answer a 7 question survey?

1. Where within the Austin metropolitan area does a majority of your congregation reside? (North, East, South, West, Central, Northeast, Southeast, Northwest, Southwest)

   Note: The interviewer should have previous general knowledge of the geographic location of the religious group that he/she is interviewing. The interviewer should have a map during the interview to aid in identifying the congregation boundaries.

2. How many people are in your congregation? _______

3. Ethnic and racial minorities are generally defined as African Americans, Asian Americans, Hispanics, and Native Americans (i.e., American Indian and Alaska Native). Based on this, what percentage in your congregation would you consider minorities? _________ %

4. A poor family is generally defined as a family of four with a total household income of less than $19,350. Based on this, what percentage of your congregation would you consider poor? _________ %

5. How aware do you think your congregation is regarding the proposed toll roads in the City of Austin and surrounding?
   ___Very aware ___ Moderately aware ____Slightly aware ___ Unaware

6. Do you think that your congregation will be impacted by the toll roads planned for Central Texas?
   ___ Yes ____ No

7. In the future, would you be interested in participating in community outreach activities (i.e. outreach booths, neighborhood meetings, school meetings, etc.) to help gather information about the potential positive and negative impacts that the proposed toll roads may have on the members of your congregation?
   a. If yes, what are the best means for informing your community regarding proposed toll roads? ____

Interviewer : Thank you for taking time out of your schedule to help me with this survey today. I will ensure that every comment is noted appropriately. If you have any questions regarding the survey or this research please feel free to contact ___________ by email at ____ or by phone at ______________. Once again, thank you and have a great day.

Figure G.2 Questionnaire Used for Religious Groups

Survey Administered to Schools Districts

Interviewer: Good morning/afternoon. My name is ________________ and I am a research assistant at the University of Texas at Austin. I am currently working on a project that is looking at the impact of toll roads on surrounding communities. Particularly, I am interested in involving vulnerable communities in the planning of such toll road facilities. Since families within your school can potentially be impacted, I would like to get your input. Would you be willing to answer a 7 question survey?

1. Where within the Austin metropolitan area does a majority of the families served by your school reside? (North, East, South, West, Central, Northeast, Southeast, Northwest, Southwest)

   Note: The interviewer should have previous general knowledge of the geographic boundaries of the school district that he/she is interviewing. The interviewer should have a map during the interview to aid in identifying the school boundaries.

2. How many students are in your school district? __________

3. Ethnic and racial minorities are generally defined as African Americans, Asian Americans, Hispanics, and Native Americans (i.e. American Indian, and Alaska Native). Based on this, what percentage of the families serviced by your school district would you estimate is considered minority? _________ %

4. A poor family is generally defined as a family of four with a total household income of less than $19,350. Based on this, what percentage of the families served by your school district would you consider poor? _________ %

5. How aware do you think families in the school district limits are regarding the proposed toll roads in the City of Austin and surroundings?
   ___Very aware ___ Moderately aware ____Slightly aware ___ Unaware

6. Do you think that the families served by your school district will be impacted by the toll roads planned for the City of Austin and surrounding? ___ Yes ____ No

7. In the future, would you be interested in participating in community outreach activities (i.e. outreach booths, neighborhood meetings, school meetings, etc.) to help gather information about the potential positive and negative impacts that the proposed toll roads may have on the families served by your school district?
   a. If yes, what are the best means for informing your community regarding proposed toll roads? ____

Interviewer: Thank you for taking time out of your schedule to help me with this survey today. I will ensure that every comment is noted appropriately. If you have any questions regarding the survey or this research please feel free to contact _____________ by email at ____________________________________ or by phone at ________________. Once again, thank you and have a great day.

Figure G.3 Questionnaire Used for Schools

Survey Administered to Neighborhood Associations

Interviewer: Good morning/afternoon. My name is ________________ and I am a research assistant at the University of Texas at Austin. I am currently working on a project that is looking at the impact of toll roads on surrounding communities. Particularly, I am interested in involving vulnerable communities in the planning of such toll road facilities. Since the members of your neighborhood association can potentially be impacted, I would like to get your input. Would you be willing to answer a 7 question survey?

1. What are the geographic boundaries of your neighborhood association? (North, East, South, West, Central, Northeast, Southeast, Northwest, Southwest)

   Note: The interviewer should have previous general knowledge of the geographic boundaries of the neighborhood association that he/she is interviewing. The interviewer should have a map during the interview to aid in identifying the neighborhood boundaries.

2. What is the approximate total population within your neighborhood association limits?

3. Ethnic and racial minorities are generally defined as African Americans, Asian Americans, Hispanics, and Native Americans (i.e., American Indian and Alaska Native). Based on this, what percentage of the population within your neighborhood association limits would you consider minority? _________ %

4. A poor family is generally defined as a family of four with a total household income of less than $19,350. Based on this, what percentage of the population within your neighborhood association limits would you consider poor? ________ %

5. How aware do you think the members of your neighborhood association are regarding the proposed toll roads in the City of Austin and surrounding?
   ___Very aware ___ Moderately aware ____Slightly aware ___ Unaware

6. Do you think that the members of your neighborhood association will be impacted by the toll roads planned in the city of Austin and surroundings? ____ Yes ____ No

7. In the future, would you be interested in participating in community outreach activities (i.e. outreach booths, neighborhood meetings, school meetings, etc.) to help gather information about the potential positive and negative impacts that the proposed toll roads may have on your neighborhood?
   a. If yes, what are the best means for informing your community regarding proposed toll roads?
   ____

Interviewer: Thank you for taking time out of your schedule to help me with this survey today. I will ensure that every comment is noted appropriately. If you have any questions regarding the survey or this research please feel free to contact _________________ by email at ____ or by phone at _________________. Once again, thank you and have a great day.

Figure G.4 Questionnaire Used for Neighborhood Associations

G.2 Pilot Survey

A pilot survey was administered in early January 2006 to gather information and to formulate the design and administration of the main survey. The pilot survey allowed the testing of the following aspects of survey approach:

- Data collection method. How easy or difficult it is to collect the required data using the selected survey method (i.e., telephone interviews).
- Question wording. To determine not only whether respondents understand the questions as the survey designer does, but also that every respondent understands each question the same.
- Nonresponse rate. The number of refusals or nonreachable contacts from the pilot survey offered a means to estimate the main survey response rate (given the same sampling method and survey approach for both the pilot survey and the main survey). Causes of nonresponse were noted to adjust the survey administration process (e.g., the best times to phone the school district officials were noted). The pilot nonresponse rate was also used to determine the total number of units to be sampled for the main survey.

G.2.1 Sample Size

A 3% simple random sample (SRS) with proportional allocation was taken within each stratum (see Table G.2). This means that each religious group in the sample represents 33 religious groups in the population; each school in the sample represents 33 schools in the population; and each neighborhood association in the sample represents 33 neighborhood associations in the population.

Table G.2. Pilot Survey: Sample Size

Community-Based Organizations (Stratum)	Total Units	Sampled Units (3% of total units)
Religious Groups	230	7
Schools	197	6
Neighborhood Associations	67	2
TOTAL =	494	15

G.2.2 Effective Response Rate

Table G.3 provides the detailed response information for the pilot survey. Table G.4 presents the calculation of the effective response rate for the pilot survey.

Table G.3. Pilot Survey: Response Information

Community-Based Organizations	Sampled Units (3% of Total Units)	Refusal Units	Non-reachable Units	Completed Survey Units
Religious Groups	7	2 (29%)	4 (57%)	1 (14%)
Schools	6	0 (0%)	4 (67%)	2 (33%)
Neighborhood Associations	3	0 (0%)	1 (33%)	2 (67%)
TOTAL =	15	2 (14%)	8 (53%)	5 (33%)

Table G.4. Pilot Survey: Effective Response Rate

	Figures
A. Sample size	**15**
B. Refusal units	**2**
C. Nonreachable units (unsuccessful callback/voicemail)	**8**
D. Qualified surveyed units = A – (B + C)	**5**
E. Effective response rate = D/A	**33%**

Overall, the pilot survey achieved a 33% effective response rate. On average, the telephone survey was thus considered an appropriate data collection method to reach religious groups, school officials, and neighborhood associations.

G.2.3 Lessons Learned

G.2.3.1 Religious Groups

The religious groups were surprisingly unresponsive (see Table G.3). Of the seven churches contacted during the pilot survey, two refused to complete the survey, two telephone numbers were disconnected, two never answered and the interviewer went straight to the voicemail, and the remaining religious group completed the survey. This respondent found question 1 to be extremely difficult to answer. Congregation members could come from any part of the city and were not constrained by geographic boundaries. The respondent could only remark that 25% of the congregation came from Northwest Austin while the rest of the congregation resided throughout the city. Question 1 was subsequently reworded (see Box G.1).

Box G.1 Question 1

In the pilot survey*: What are the geographic boundaries of the area that your congregation resides in?*

In the main survey*: Where within the Austin metropolitan area does a majority of your congregation reside? (North, East, South, West, Central, Northwest, Southwest, Northeast, Southeast)*

Note: The interviewer used a map during the interview to aid in identifying the geographic boundaries of the congregation.

G.2.3.2 School Officials

Two responses were obtained from the sample of six schools (see Table G.3). Two of the remaining four sampled units had telephone numbers that were forwarded to voicemails and two required repeated call backs with the result that these four units were never reached.

Because the school secretary is most likely to answer the phone, the interviewer should quickly identify himself and subsequently ask to speak to the school administrator rather than allowing the secretary to forward the call to someone who may or may not be the appropriate person to answer the questionnaire.

The two school district respondents answered question 4 (i.e., percent of poor households served by the school district) based upon the percentage of students enrolled in the free lunch program. This was the easiest way for them to identify the number of poor students enrolled in their school.

Question 7 had to be reworded because it raised some concerns (see Box G.2). The two respondents were concerned about being politically involved. They were willing to distribute information about toll roads but did not want to take a position on toll road development in Central Texas.

Box G.2 Question 7

In the pilot survey*: In the future, would you be interested in participating in community outreach activities and providing input on issues related to proposed toll roads?*

In the main survey*: In the future, would you be interested in participating in community outreach activities (i.e. outreach booths, neighborhood meetings, school meetings, etc.) to help gather information about the potential positive and negative impacts that a proposed toll road may have on the families served by your school district?*

Finally, it was learned that the best times to call school administrators were in the morning between 9 a.m. and 12 p.m. or in the afternoon between 3:30 p.m. and 4:30 p.m. The busiest time of the day for school administrators is between 2:00 p.m. and 3:30 p.m.

G.2.3.3 Neighborhood Associations

Two of the three sampled neighborhood associations completed the survey (see Table G.3). Since it appeared that many of the neighborhood association contact numbers were home telephone numbers, the best time to call was during evening hours.

The two neighborhood association respondents identified geographic boundaries of their associations with reference to nearby roads. However, these were sometimes vague and confusing (e.g., just past the hill by Webberville Rd). Thus, to clarify the meaning of this question, it was reworded similarly to that of Box G.1.

Similar to the school official respondents, the neighborhood association respondents were unsure about the meaning of question number 7. One respondent asked if that meant taking a political position on toll roads and the other asked if it meant supporting having someone speak with the neighborhood as a group. Thus, to clarify the meaning of this question, it was reworded similarly to the wording in the text box above.

G.3 Main Survey

During the 3-week period between January 23 and February 7, the main survey was administered to a SRS of religious groups, schools, and neighborhood associations from the list of community organizations that was previously compiled.

G.3.1 Sample Size

A 20% SRS with proportional allocation was taken in each stratum (see Table G.5). This means that each religious group in the sample represents five religious groups in the population; each school in the sample represents five schools in the population; and each neighborhood association in the sample represents five neighborhood associations in the population.

Table G.5. Main Survey: Sample Size

Community-Based Organizations (Stratum)	Total Units	Sampled Units (20% of Total Units)
Religious Groups	230	46
Schools	197	39
Neighborhood Associations	67	13
TOTAL =	494	98

G.3.2 Effective Response Rate

Table G.6 provides the detailed response information for the main survey. Sampled religious groups, schools, and neighborhood associations with a wrong or disconnected telephone number were discarded and replaced by another randomly sampled unit with a valid telephone number (i.e., random sampling with replacement). Also, a unit was classified as not reachable after contact was attempted on five separate occasions without success. Table G.7 details the calculation of the effective response rate. The main survey yielded a 51% effective response rate (higher than the response rate achieved in the pilot survey).

Table G.6. Main Survey: Response Information

Community-Based Organizations	Sampled Units (20% of Total Units)	Refusal Units	Non-reachable Units	Completed Survey Units	Response Rate
Religious Groups	46	5 (11%)	16 (35%)	25 (54%)	54 %
Schools	39	8 (20%)	14 (36%)	17 (44%)	44 %
Neighborhood Associations	13	0 (0%)	5 (38%)	8 (62%)	62 %
TOTAL =	98	13 (13%)	35 (36%)	50 (51%)	51%

Table G.7. Main Survey: Effective Response Rate

	Figures
A. Sample size	**98**
B. Refusal units	**13**
C. Non-reachable units (unsuccessful callback/voicemail)	**35**
D. Qualified surveyed units = A – (B + C)	**50**
E. Effective response rate = D/A	**51%**

G.4 Main Survey Results

G.4.1 Community-Based Organizations

The descriptive statistics relating to Question 2 (i.e., number of people served by the organization) are summarized in Table G.8. Histograms showing the frequency distribution of the number of people served by the community-based organizations are presented in Figure G.5. Table G.8 shows that on average religious groups serve the most people. Figure G.5, however, reveals that religious groups exhibit the greatest variability in terms of number of people served when compared to schools, and neighborhood associations.

Table G.8. Number of People Served: Descriptive Statistics

Community-Based Organizations	Descriptive Statistics			
	Number of Respondents	Number of People Served	Average	Standard Deviation
Religious Groups	25	24,712	988	1,396
Schools	17	12,086	711	324
Neighborhood Associations	7	4,572	653	564

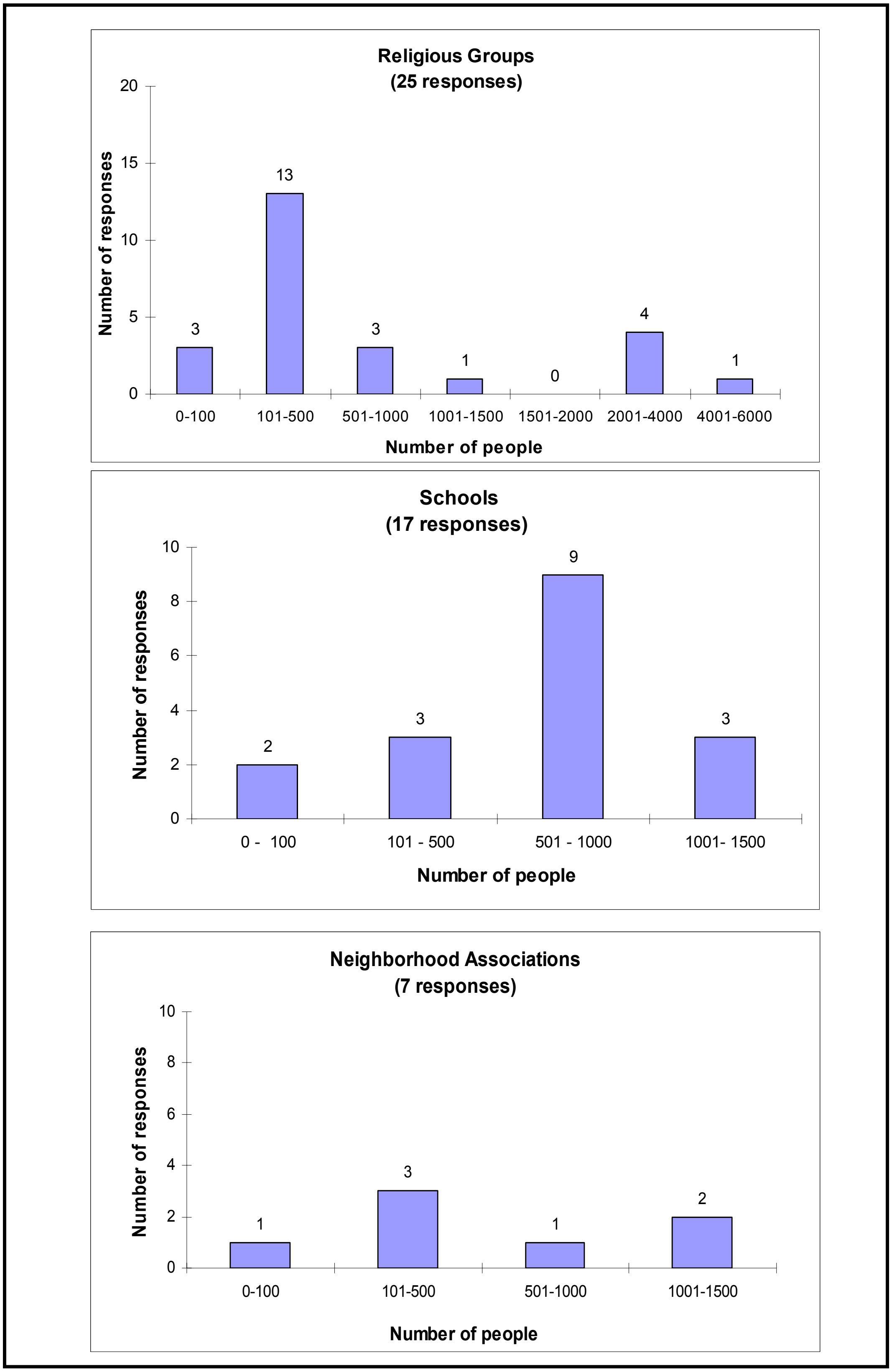


Figure G.5. Number of People Served by Community-Based Organizations

G.4.2 Percent of Minority and Low-Income Population in Community-Based Organizations

Figure G.6 provides the histograms of the percent of minority and low-income populations represented in the surveyed community-based organizations. These histograms can be used to identify those organizations that represent a large percentage of minority and low-income populations to serve as "avenues" for informing and involving EJ communities in subsequent EJ community outreach activities.

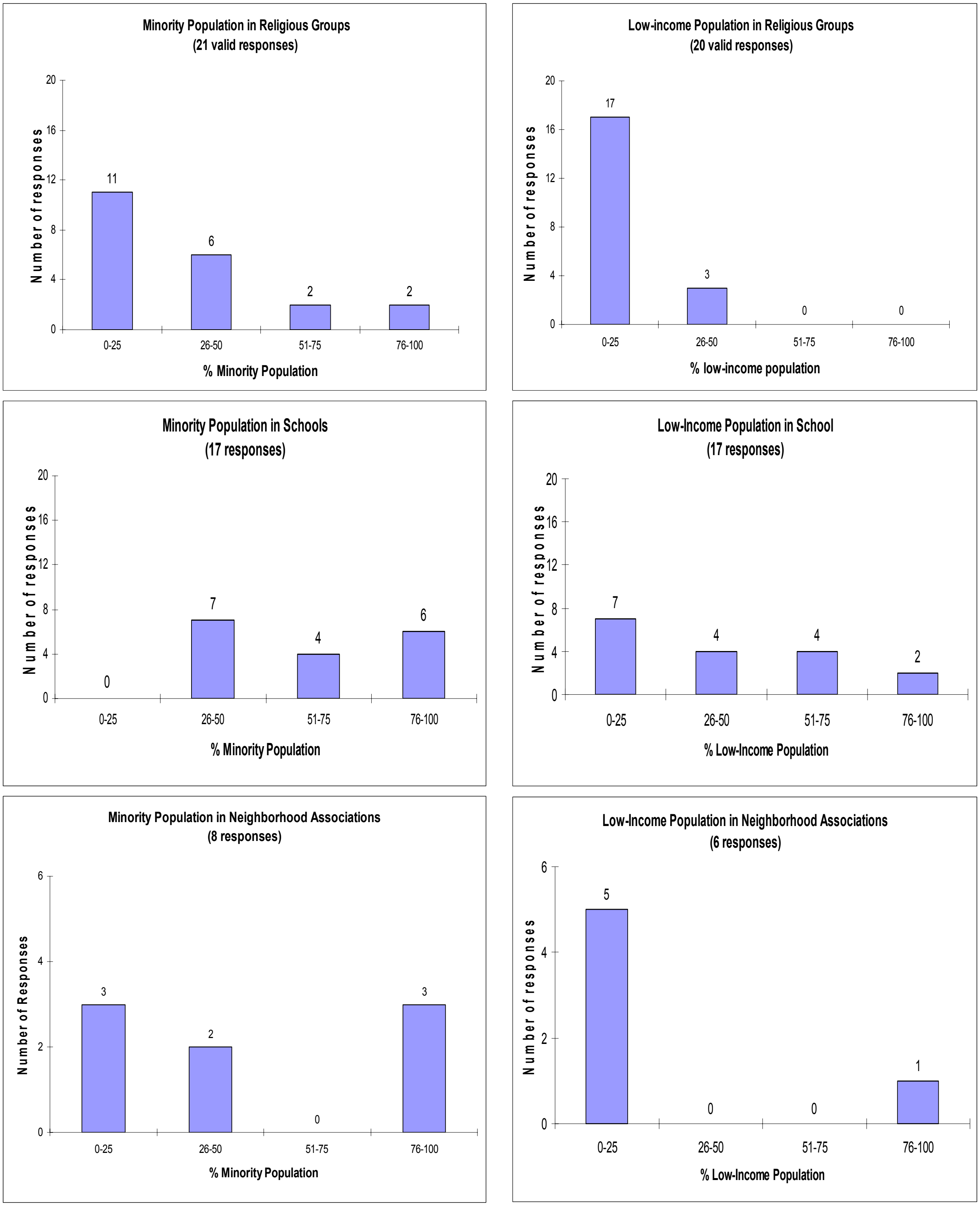
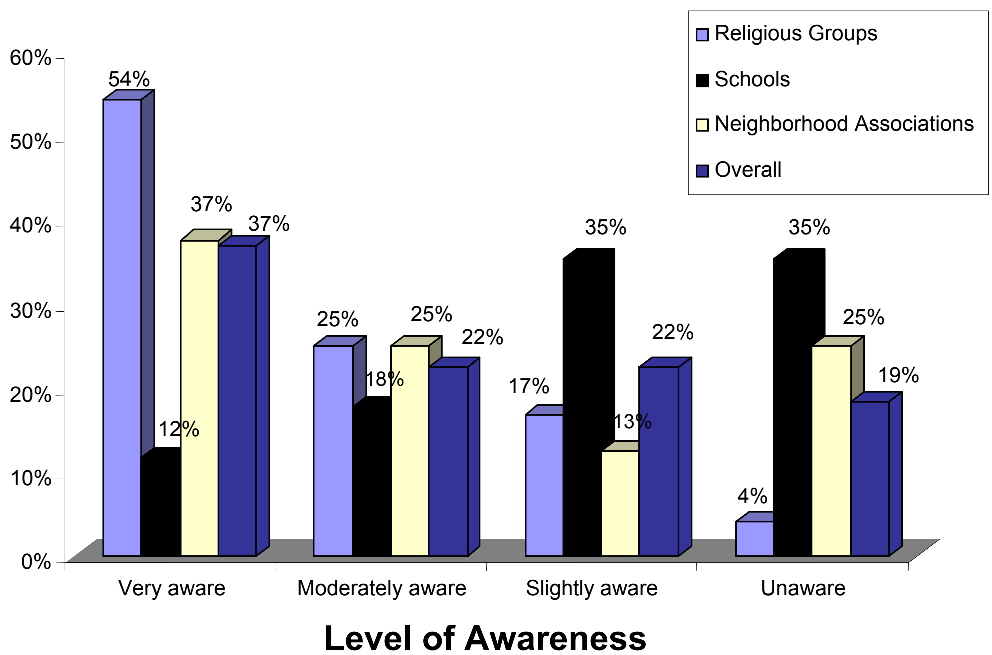


Figure G.6. Percentage of Minority and Low-Income Populations Represented in the Community-Based Organizations

G.4.3 Level of Awareness of Community-Based Organizations Regarding ProposedToll Roads

Figure G.7 illustrates the level of awareness of the members of the community-based organizations as perceived by the respondents interviewed. Based on forty-nine valid responses, most members of the religious groups (54%) and the neighborhood associations (37%) were aware of the proposed toll road system whereas schools (12%) were the least aware of the proposed toll facilities. Overall, more than one-third of the surveyed organizations were very aware regarding the planned toll road system in Central Texas.

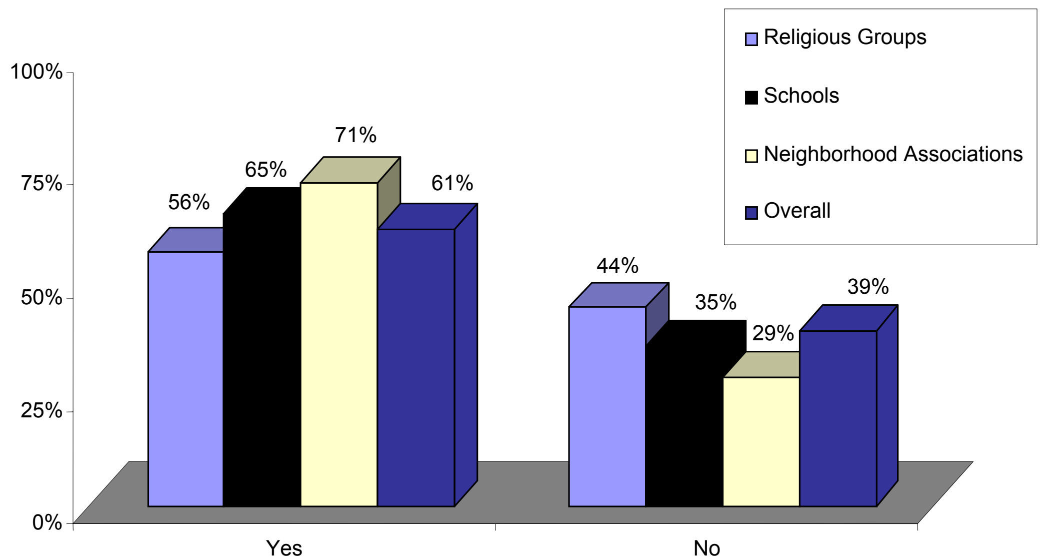


Level of awareness	Religious Groups		Schools		Neighborhood Associations		Overall	
	Responses	%	Responses	%	Responses	%	Responses	%
Very aware	13	54	2	12	3	37	18	37
Moderately aware	6	25	3	18	2	25	11	22
Slightly aware	4	17	6	35	1	13	11	22
Unaware	1	4	6	35	2	25	9	19
Total Valid Responses	24	100	17	100	8	100	49	100

Figure G.7. Level of Awareness of the Proposed Toll Roads

G.4.4 Impacts of Toll Roads

Figure G.8 illustrates whether the respondents thought the proposed toll road system in Central Texas will impact their constituents. Based on forty-nine valid responses, more than 60% of the respondents indicated that the proposed toll roads will impact their constituents.

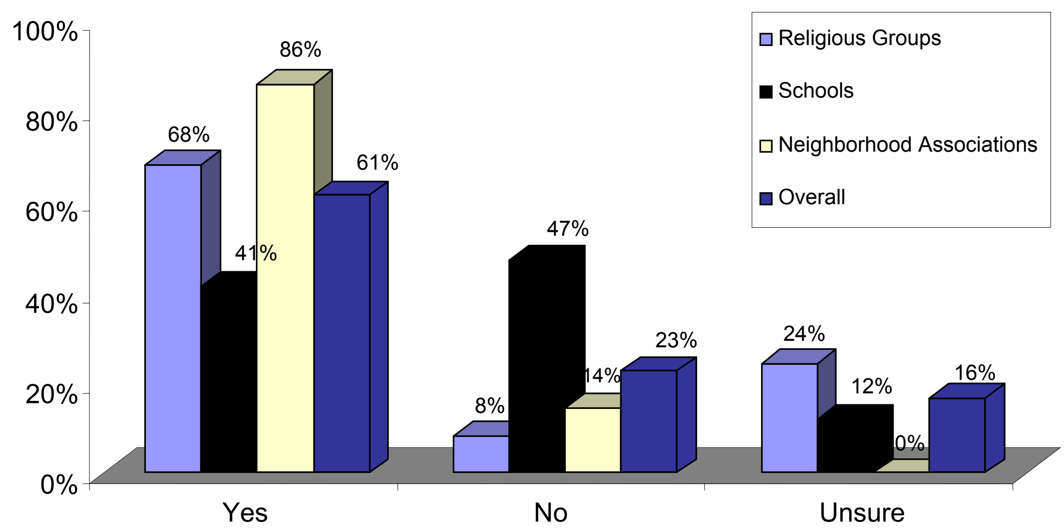


	Religious Groups		Schools		Neighborhood Associations		Overall	
	Responses	%	Responses	%	Responses	%	Responses	%
Yes	14	56	11	65	5	71	30	61
No	11	44	6	35	2	29	19	39
Total Valid Responses	25	100	17	100	7	100	49	100

Figure G.8. Impact of Toll Roads

G.4.5 Willingness to Participate in Community Outreach Activities

Figure G.9 shows the respondents' willingness to participate in community outreach activities to be informed about the proposed toll road system in Central Texas. Based on forty-nine valid responses, the most willing to participate are the neighborhood associations (86%) followed by the religious groups (68%) and the schools (41%). Overall, 60% of those surveyed expressed their willingness to participate in community outreach activities.

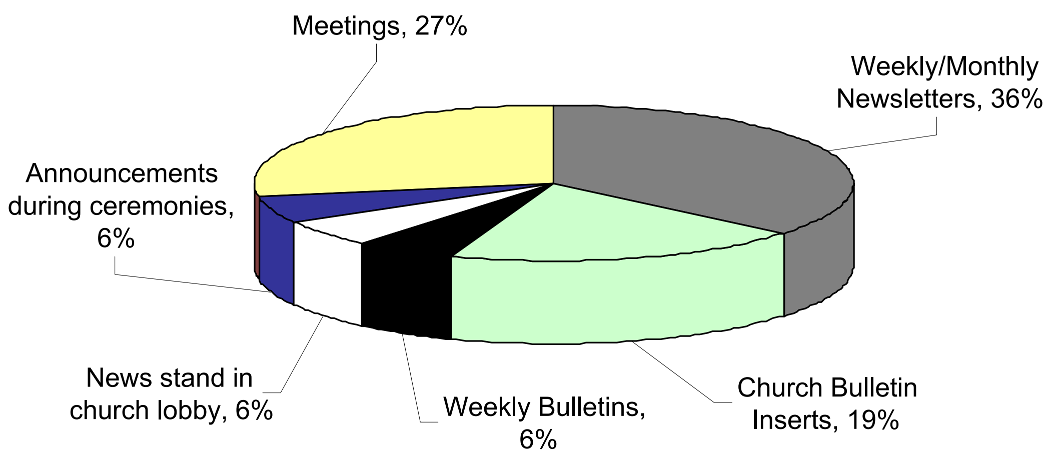


	Religious Groups		Schools		Neighborhood Associations		Overall	
	Responses	%	Responses	%	Responses	%	Responses	%
Yes	17	68	7	41	6	86	30	61
No	2	8	8	47	1	14	11	23
Unsure	6	24	2	12	1	0	8	16
Total Valid Responses	25	100	17	100	7	100	49	100

Figure G.9. Willingness to Participate in Community Outreach Activities

G.4.6 Avenues for Informing Communities about Proposed Toll Roads

Figure G.10 lists the best avenues or methods for informing communities about the proposed toll road system in Central Texas as indicated by respondents. Newsletters and meetings were indicated by the respondents to be the two preferred avenues for informing EJ communities about planned toll road facilities.



Avenues of Communication	Religious Groups	Schools	Neighborhood Association	Overall	
	Responses	Responses	Responses	Responses	%
Weekly/Monthly Newsletters	11	---	2	13	36
Church Bulletin Inserts	7	---	---	7	19
Weekly Bulletins	2	---	---	2	6
News Stand in Church Lobby	2	---	---	2	6
Announcements During Ceremonies	2	---	---	2	6
Meetings	---	7	3	10	27
Total Valid Responses				36	100

Figure G.10. Avenues for Informing Communities about Proposed Toll Roads

G.5 Concluding Observations

The response rate for the religious groups contacted was very high (54%). Of the thirty sampled units, twenty-five agreed to participate while only five declined to complete the survey. An important observation that has to be noted is the fact that a large number of the original sampled religious groups had inaccurate or disconnected telephone numbers. The interviewer thus had to discard sixteen churches that had automated message systems or simply did not answer the phone. A concern is that some smaller churches or churches in extremely poor neighborhoods may not have full or even part-time staff to answer the telephone. It is possible that survey methodology other than the telephone survey needs to be adopted to contact these churches. Finally, the church respondents were very knowledgeable about their congregations and appeared willing to serve as an avenue to both inform and involve their congregations about planned toll road projects in Central Texas. Most surveyed churches publish a monthly newsletter and offered this as a mean to distribute information to their congregation.

Of the thirty-nine sampled schools, seventeen officials completed the survey and the remaining eight were unwilling to participate, producing a response rate of 44%. It has to be noted that it was extremely hard to get in touch with school officials. They are often in meetings, off-campus, or out of their offices on school grounds, thus requiring repeated call backs. In spite of the modifications to the wording of question 1, school officials still struggled to identify the geographic boundaries of their schools. Some of the respondents indicated that school boundaries are constantly changing while others noted that the schools do not have set boundaries. On the other hand, school officials were in a position to give a good estimate of the minority families and poor families served by the schools by using the percentage enrollments in their free and reduced lunch program. Finally, although some school officials were willing to participate in community outreach activities by hosting information gathering events, others were concerned about political implications, did not have the space for meetings, were already overburdened with meetings, were worried about the paperwork needed to approve non–school-related meetings, or were simply not interested. Those that were willing to host meetings believed weekday evenings were the best time to conduct such meetings.

Of the thirteen sampled neighborhood associations, eight agreed to complete the survey while the remaining five were unwilling to participate, which resulted in a response rate of 62%. Neighborhood association respondents often struggled to provide the boundaries and population of their neighborhoods. Some, however, could provide the number of families in the neighborhood but not the exact population. Finally, the organization of neighborhood associations varied widely. Some of them rarely meet or keep in contact online, while others meet on a monthly basis and have a website. All respondents, however, were interested in this research and willing to help where and whenever possible.

Appendix H: Environmental Justice Door-to-Door Survey

One of the core principles of EJ analysis is the meaningful involvement of potentially impacted minority and low-income populations in the decision-making process surrounding transportation projects. This appendix presents the survey design, methodology, response rates, major findings, and conclusions from a door-to-door survey that was conducted between March 15 and April 2, 2006, in zones with high concentrations of minority and low-income populations in the potentially impacted areas of the SH 130 toll road and the toll road system planned for Central Texas.

H.1 Survey Design

H.1.1 Survey Objective

The three main objectives of the *Door-to-Door Survey* were to (a) assess how EJ communities foresee that the toll road(s) will impact their activity space (i.e., work trips, shopping trips, and trips to educational facilities and hospitals), (b) determine how EJ communities foresee that the toll road(s) will impact their communities, and (c) inform future community outreach efforts to ensure the meaningful involvement of EJ communities in the decision-making process surrounding toll road projects.

H.1.2 Target Population and Sampling Units

The target population was the EJ households living in the area impacted by the proposed toll road(s) in Central Texas. The impacted area was defined by a 6-mile wide buffer along the toll road alignment(s) (see Figure H.1). It was assumed that this buffer covered the footprints of all potential ecological, mobility, safety, social, economic, and cultural impacts (i.e., the potential EJ concerns) associated with the toll road(s).

The sampling units were the housing units in zones with high concentrations of minority and low-income populations within the impacted area (see Figure H.2). Based on the 2000 U.S. Census, there are 57,489 housing units in high EJ concentration zones, which is 17% of the total housing units in the impacted area. Table H.1 provides additional information about the minority and low-income populations within the impacted area and the zones with high concentrations of EJ populations. Given the scope of the analysis, available budget, and time frame to conduct the analysis, the target sampling unit was established at 1% of the housing units (i.e., 575 housing units) in zones with high concentrations of minority and low-income populations.

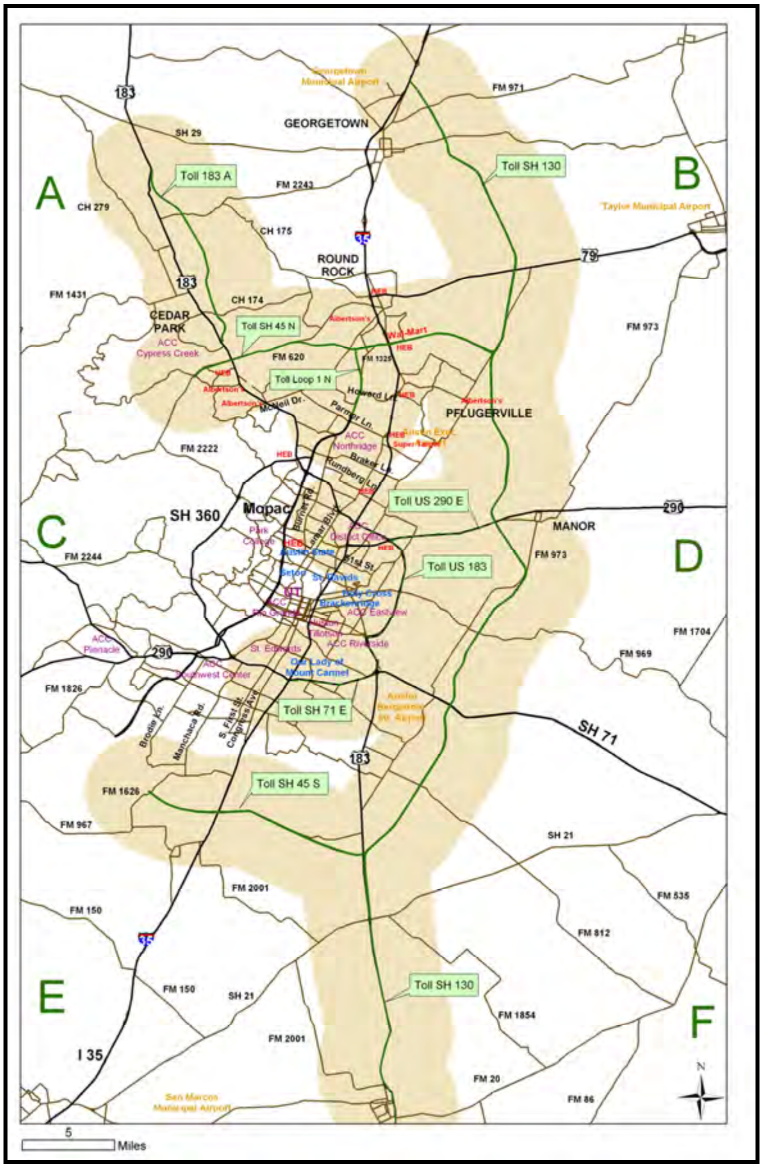


Figure H.1 Impacted Area

Table H.1 Target Population (based on the 2000 US Census)

	Total Population	Minority Population	% Minority Population
Impacted area	910,204	390,041	43%
Zones with high concentrations of minority populations	167,137	114,390	68%
	Total Population	**Low-Income Population**	**% Low-Income Population**
Impacted Area	895,959	97,339	11%
Zones with high concentrations of low-income populations	166,227	32,672	20%

Sampling Method

Five survey sites in zones with high concentrations of minority and low-income populations were selected (see Figure H.2). Two northern, one central, and two southern sites were identified. The housing units to be surveyed were randomly chosen from the selected survey sites.

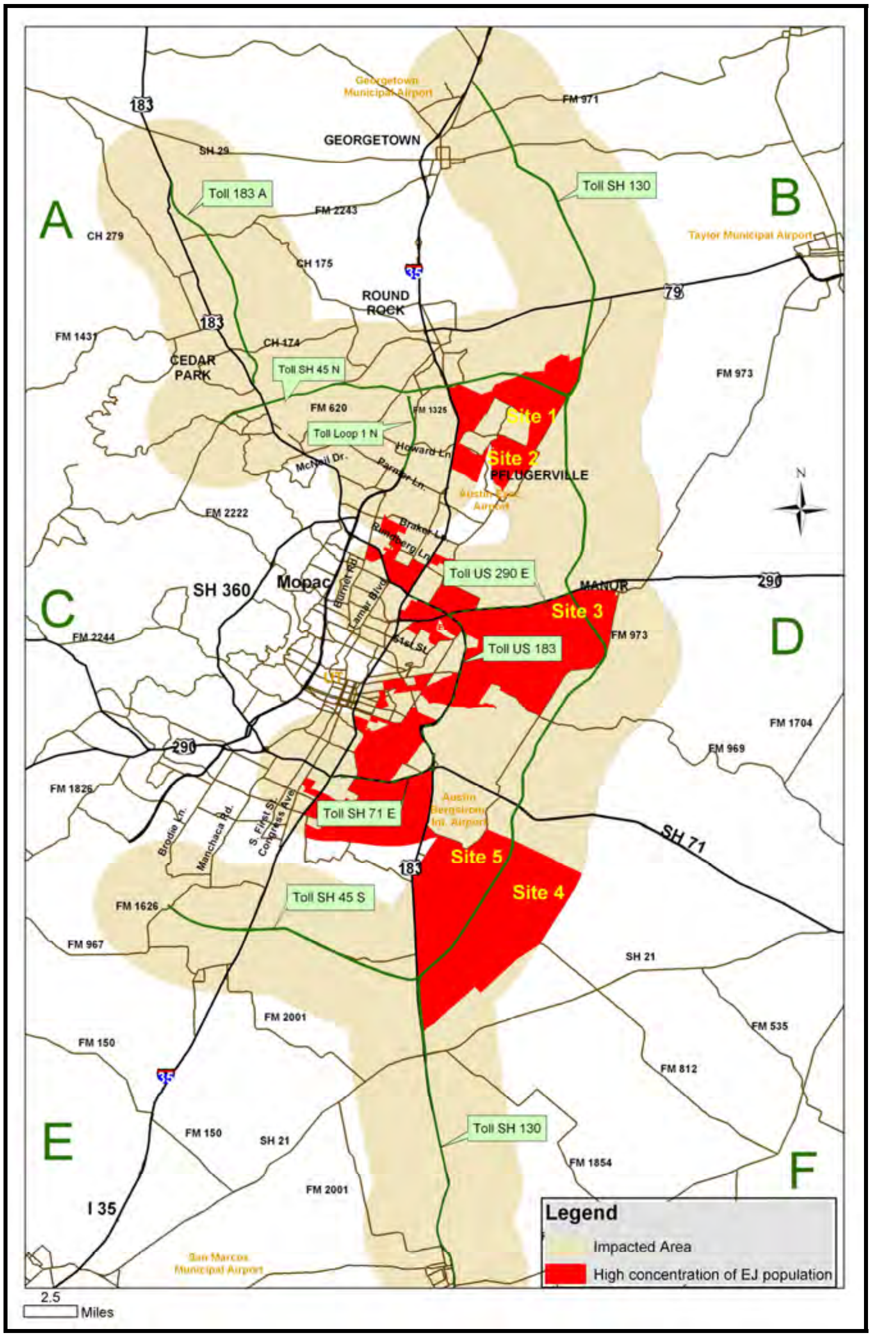


Figure H.2 Survey Sites

Survey Methodology

Door-to-door surveys were conducted in the five identified survey sites. This survey method, although comparatively more costly and time consuming per respondent than other survey techniques, was chosen because it overcomes many of the barriers[xx] preventing EJ communities from participating in other public outreach activities, minimizes respondent burden, and maximizes the response rate. The surveys were conducted between 10:00 a.m. and 6:00 pm on weekdays and weekends between March 15 and April 2, 2006. Ten survey administrators (paired in groups of two) conducted the interviews using two types of questionnaires: one pertaining to the SH 130 toll road and the other pertaining to the planned toll road system in Central Texas.

Survey Forms

The two survey forms and accompanying maps used to conduct the door-to-door surveys are provided in Figures H.3 and H.4. Both survey forms were prepared in English and Spanish. Questionnaire 1 pertains to SH 130 toll road. Questionnaire 2 pertains to the system of toll roads planned for Central Texas, which includes new toll roads (i.e., SH 130, SH 45 North, Loop 1 North, 183A, and SH 45 Southeast) and toll lanes in the median of existing highways (i.e., US 290 East, US 183 South, and SH 71 East). The first segment of SH 130 (between IH-35 in Georgetown and US 183 near Creedmoor), SH 45 North, Loop 1 North, and 183A are currently under construction and will open to traffic in 2007.[xxi] The construction of the US 290 E is scheduled to begin in 2007. Future projects include US 183 South (Ed Bluestein Blvd), SH 71 East (Ben White Blvd.), and SH 45 Southeast.[xxii]

[xx] Door-to-door surveys overcome the barriers of time, access, literacy, and language faced by EJ communities that other techniques might not. The method further provides opportunities to explain the purpose of the survey, how the information will be used, and the meaning of the questions.

[xxi] Central Texas Regional Mobility Authority. Project. Available at http://www.ctrma.org/?menu_id=6. Accessed: March 3, 2006.

[xxii] Central Texas Regional Mobility Authority. Project. Available at http://www.ctrma.org/?menu_id=6. Accessed: March 3, 2006.

QUESTIONNAIRE 1: Toll Road SH 130 and Their Impacts

Interviewer: _________________________ Date: ________ Time: _____ Site #: ____ Map #:_____

Will Toll Road SH 130 Impact YOU?

Interviewer: Mark on the map the area where the respondent live

1. Do you **WORK**? ____ Yes ____ No
   a. If yes, Where do you **WORK**? (please mark on the map)

      ____

   a. How do you usually **GET TO WORK**?

      ___ Car (drive alone) ___ Car (carpool) ___ Bus ___ Walk ___ Other

      i. If by car (drive alone or carpool), Which are the **MAJOR ROADS** you normally drive/take?

      ____

2. Do you go to **SCHOOL**? ____ Yes ____ No
   a. If yes, Where do you go to **SCHOOL**? (please mark on the map) ___________________________
   b. How do you usually **GET TO SCHOOL**?

      ___ Car (drive alone) ___ Car (carpool) ___ Bus ___ Walk ___ Other

      i. If by car (drive alone or carpool), Which are the **MAJOR ROADS** you normally drive/take?

      ____

3. Where do you usually **SHOP GROCERIES**? (please mark on the map) ___________________________
   a. How do you usually **GET TO THIS SHOP**?

      ___ Car (drive alone) ___ Car (carpool) ___ Bus ___ Walk ___ Other

      i. If by car (drive alone or carpool), Which are the **MAJOR ROADS** you normally drive/take?

      ____

4. If you need to go to the **HOSPITAL**,

   Which hospital would you go? (please mark on the map)_______________________________________
   a. How would you **GET TO THIS HOSPITAL**?

      ___ Car (drive alone) ___ Car (carpool) ___ Bus ___ Walk ___ Other

      i. If by car (drive alone or carpool), Which are the **MAJOR ROADS** you would drive/take to get there?____

5. Do you think that toll road **SH 130** will **AFFECT ANY OF THE TRIPS** you listed above?

   _____Yes _____ No

   a. If yes, Which **TRIPS** will be **AFFECTED**? ___Work ___School ___Grocery shopping ___Hospital
   b. **HOW** will this toll road **AFFECT YOUR TRIPS**? ____________________________________

   ____

Figure H.3 Questionnaire 1 and Accompanying Map

QUESTIONNAIRE 1: - Toll Road SH 130 and Their Impacts

Interviewer: ________________________ Date: ________ Time: _____ Site #: ____ Map #:____

Will Toll Road SH 130 Impact YOUR COMMUNITY?

6. Do you think that toll road **SH 130** (shown in the map) will **AFFECT YOUR COMMUNITY**?

   ___ Yes ___ No

   If yes, check all that apply

   a. Will it **BENEFIT** your community? ____ Yes ____ No

   b. Will it **BURDEN** your community? ____ Yes ____ No

   i. If the respondent said benefits, **WHAT** do you see as the **BENEFITS** of this toll road?

   ____

   ____

   ii. If the respondent said burdens, **WHAT** do you see as the **BURDENS** of this toll road?

   ____

   ____

   iii. If the respondent said burdens, **WHAT** can **TxDOT** do to **REDUCE** or **ELIMINATE** these **BURDENS**?

   ____

   ____

Do You Want to be INVOLVED?

7. Can we **CONTACT YOU IN THE FUTURE** to find out what you think about toll roads?

   ____ Yes ____ No

8. If yes, What is the **BEST WAY TO REACH YOU**? ___ Come to my home ____ Send a questionnaire

   ____ Phone me ___ Interview me at the shopping mall/grocery store ___ Come to my church

   ____ Come to one of the schools in the community

   ____ Other way. How? ____

9. Is there **ANYONE** in your community that **CAN SPEAK FOR THE COMMUNITY**?

   _____Yes _____ No

10. If yes, Could you please **SHARE HIS/HER NAME** with us? ______________________________

Personal Information (depending on answer to question 7)

Name:____Telephone: _______________

Address: ____

ADDITIONAL COMMENTS: ____

____

Figure H.3 Questionnaire 1 and Accompanying Map, continued

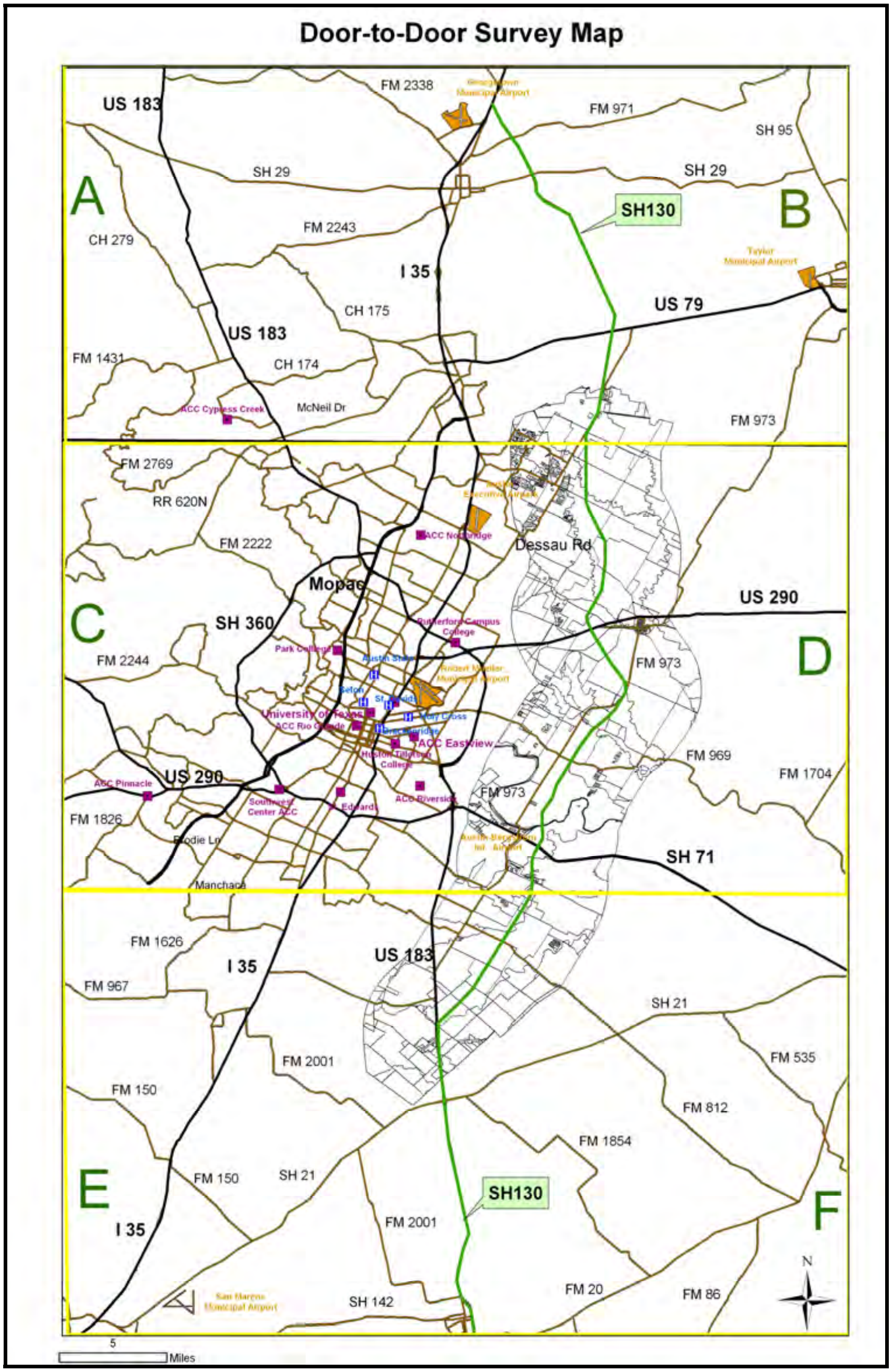


Figure H.3 Questionnaire 1 and Accompanying Map, continued

QUESTIONNAIRE 2: Toll Roads in Central Texas and Their Impacts

Interviewer: ___________________________ Date: ________ Time: ______ Site #: ____ Map #: ____

Will TOLL ROADS in CENTRAL TEXAS Impact YOU?

Interviewer: Mark on the map the area where the respondent live

2. Do you **WORK**? ____ Yes ____ No
   a. If yes, Where do you **WORK**? (please mark on the map) ____________________________________
   b. How do you usually **GET TO WORK**?
      ___ Car (drive alone) ___ Car (carpool) ___ Bus ___ Walk ___ Other
      ii. If by car (drive alone or carpool), Which are the **MAJOR ROADS** you normally drive/take?
      ____

3. Do you go to **SCHOOL**? ____ Yes ____ No
   a. If yes, Where do you go to **SCHOOL**? (please mark on the map) ______________________________
   b. How do you usually **GET TO SCHOOL**?
      ___ Car (drive alone) ___ Car (carpool) ___ Bus ___ Walk ___ Other
      i. If by car (drive alone or carpool), Which are the **MAJOR ROADS** you normally drive/take?
      ____

4. Where do you usually **SHOP GROCERIES**? (please mark on the map) ____________________________
   a. How do you usually **GET TO THIS SHOP**?
      ___ Car (drive alone) ___ Car (carpool) ___ Bus ___ Walk ___ Other
      i. If by car (drive alone or carpool), Which are the **MAJOR ROADS** you normally drive/take?
      ____

4. If you need to go to the **HOSPITAL**, Which hospital would you go? (please mark on the map) _________
   a. How would you **GET TO THIS HOSPITAL**?
      ___ Car (drive alone) ___ Car (carpool) ___ Bus ___ Walk ___ Other
      i. If by car (drive alone or carpool), Which are the **MAJOR ROADS** you would drive/take to get there? ____

5. Do you think that **TOLL ROADS** in **CENTRAL TEXAS** (shown in the map) will **AFFECT ANY OF THE TRIPS** you listed above? ___Yes __ No
   a. If yes, Which **TRIPS** will be **AFFECTED**? ___Work ___School ___Grocery shopping ___Hospital
   b. **HOW** will these toll roads **AFFECT YOUR TRIPS**? ______________________________________
   ____
   ____

Figure H.4 Questionnaire 2 and Accompanying Map

QUESTIONNAIRE 2: Toll Roads in Central Texas and Their Impacts

Interviewer: __________________________ Date: ________ Time: ______ Site #: ____ Map #: ____

Will TOLL ROADS in CENTRAL TEXAS Impact YOUR COMMUNITY?

6. Do you think that **TOLL ROADS** in **CENTRAL TEXAS** (shown in the map) will **AFFECT YOUR COMMUNITY**?_____ Yes _____ No

   If yes, check all that apply

   a. Will it **BENEFIT** your community? _____Yes _____ No

   b. Will it **BURDEN** your community? _____Yes _____ No

   i. If the respondent said benefits, **WHAT** do you see as the **BENEFITS** of these toll roads?

   ____

   ____

   ii. If the respondent said burdens, **WHAT** do you see as the **BURDENS** of these toll roads?

   ____

   ____

   iii. If the respondent said burdens, **WHAT** can **TxDOT** do to **REDUCE** or **ELIMINATE** these **BURDENS**?

   ____

   ____

Do YOU WANT to be INVOLVED?

7. Can we **CONTACT YOU IN THE FUTURE** to find out what you think about toll roads?

   _____ Yes _____ No

8. If yes, What is the **BEST WAY TO REACH YOU**? ___ Come to my home ___ Send a questionnaire

   ____ Phone me ___ Interview me at the shopping mall/grocery store ___ Come to my church

   ____ Come to one of the schools in the community

   ____ Other way. How? ____

9. Is there **ANYONE** in your community that **CAN SPEAK FOR THE COMMUNITY**?

   _____Yes _____No

10. If yes, Could you please **SHARE HIS/HER NAME** with us? ______________________________

Personal Information (depending on answer to questions 7 and 8)

Name: ____ Telephone: _______________

Address: ____

ADDITIONALCOMMENTS: ____

____

____

Figure H.4 Questionnaire 2 and Accompanying Map, continued

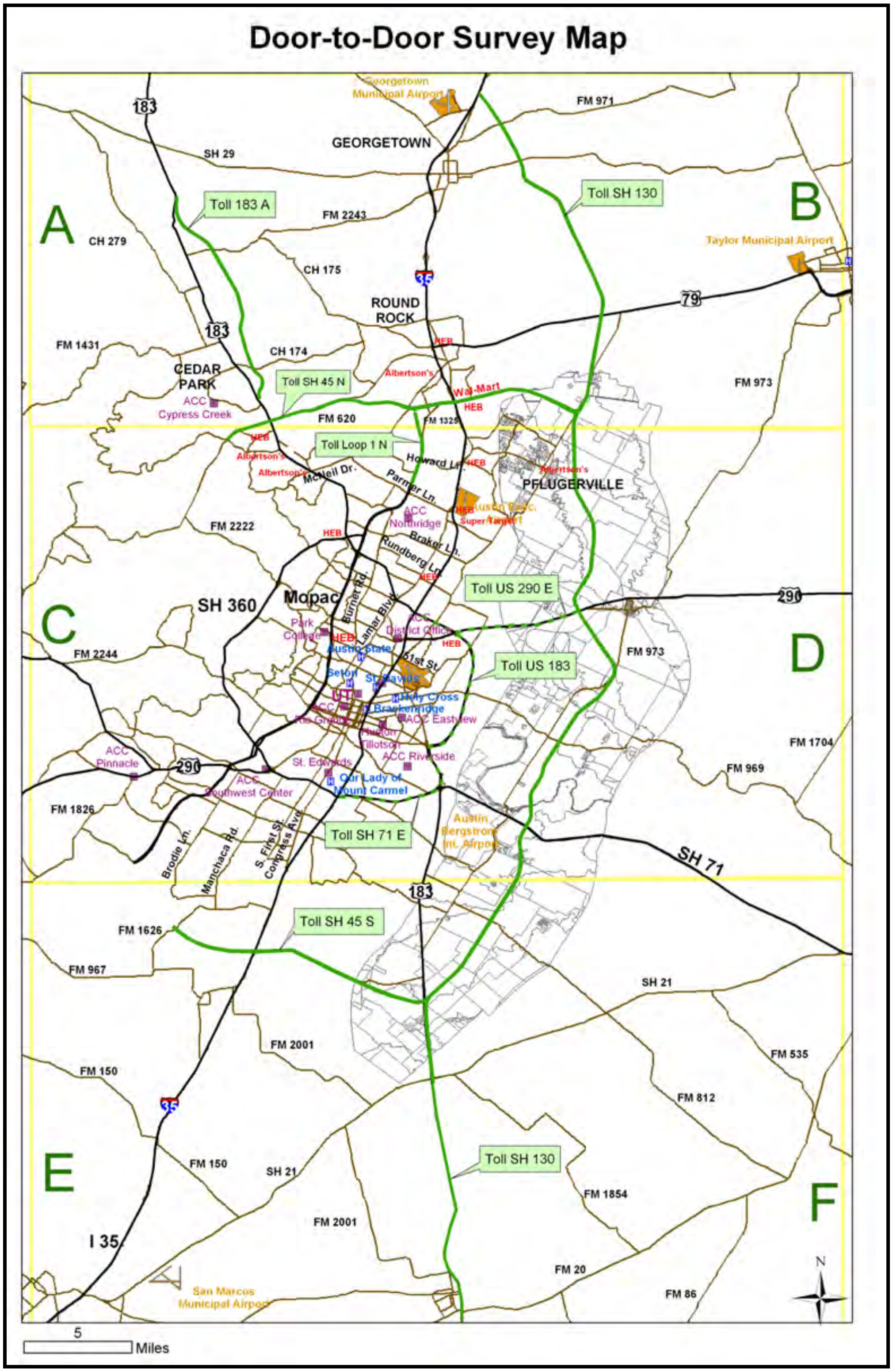


Figure H.4 Questionnaire 2 and Accompanying Map, continued

H.2 Survey Results and Interpretation

Effective Response Rate

Table H.2 summarizes the response rates by survey site and overall. In all cases, the response rates exceeded 25%. Sites 3 and 5 yielded the highest response rates at 44% and 43% respectively. An overall response rate of 34% was achieved.

Table H.2 Response Rate by Surveys Site and Overall

Site	Sampled Housing Units	Non-Reachable Housing Units*	Surveyed Housing Units	Response Rate (%)
1 (Pflugerville)	179	127	52	29
2 (Pflugerville)	200	148	52	26
3 (Manor)	127	71	56	44
4 (FM-973 & SH-812)	84	52	32	38
5 (FM-973 & SH-71)	112	64	48	43
TOTAL =	702	462	240	34

*Non-reachable housing units include residences that did not open the door or refused to participate in the survey.

Type of Survey

Table H.3 shows the number of completed surveys by questionnaire type. Based on the total number of completed surveys, 57% of the respondents (136 housing units) completed questionnaire 1 while 43% (104 housing units) completed questionnaire 2.

Table H.3 Completed Surveys by Questionnaire Type

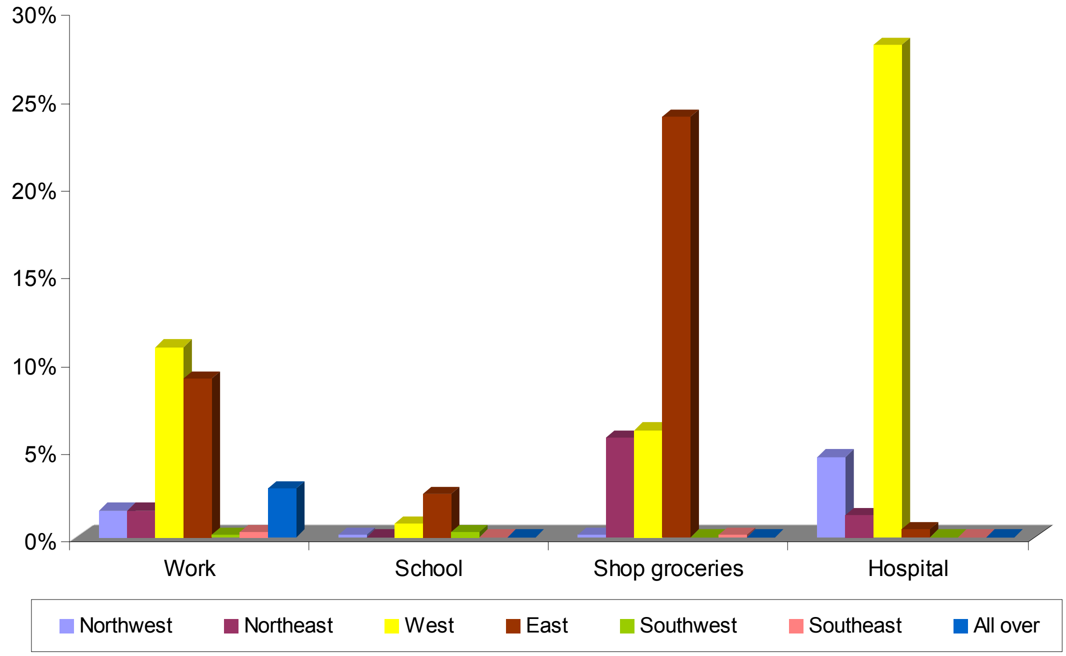
Site	Date	Questionnaire 1	Questionnaire 2
1 (Pflugerville)	03/25/06	50	2
2 (Pflugerville)	03/26/06	0	52
3 (Manor)	03/15/06	56	0
4 (FM-973 & SH-812)	04/01/06	1	31
5 (FM-973 & SH-71)	04/01/06-04/02/06	29	19
	TOTAL =	136	104

Trip Purpose

Analysis of the data reveals that 71% of the respondents work and that 24% of the respondents attend a school.

Trip Purpose by Region

Figure H.5 illustrates where the respondents indicated they work, go to school, shop for groceries, or go to the hospital.



Trip Purpose	Northwest (Area A)*		Northeast (Area B)		West (Area C)		East (Area D)	
Work	10	1.5%	10	1.5%	71	10.8%	59	9.0%
School	1	0.2%	0	0.0%	5	0.8%	16	2.4%
Shop Groceries	1	0.2%	37	5.6%	40	6.1%	157	23.9%
Hospital	30	4.6%	8	1.2%	184	28.0%	3	0.5%
TOTAL =	42	6.4%	55	8.4%	300	45.7%	235	35.8%
Trip Purpose	Southwest (Area E)		Southeast (Area F)		All over (Area G)		Total	
Work	1	0.2%	2	0.3%	18	2.7%	171	
School	2	0.3%	0	0.0%	0	0.0%	24	
Shop Groceries	0	0.0%	1	0.2%	0	0.0%	236	
Hospital	0	0.0%	0	0.0%	0	0.0%	225	
TOTAL =	3	0.5%	3	0.5%	18	2.7%	656	

*See Door-to-Door Survey Map

Figure H.5 Trip Purpose by Region

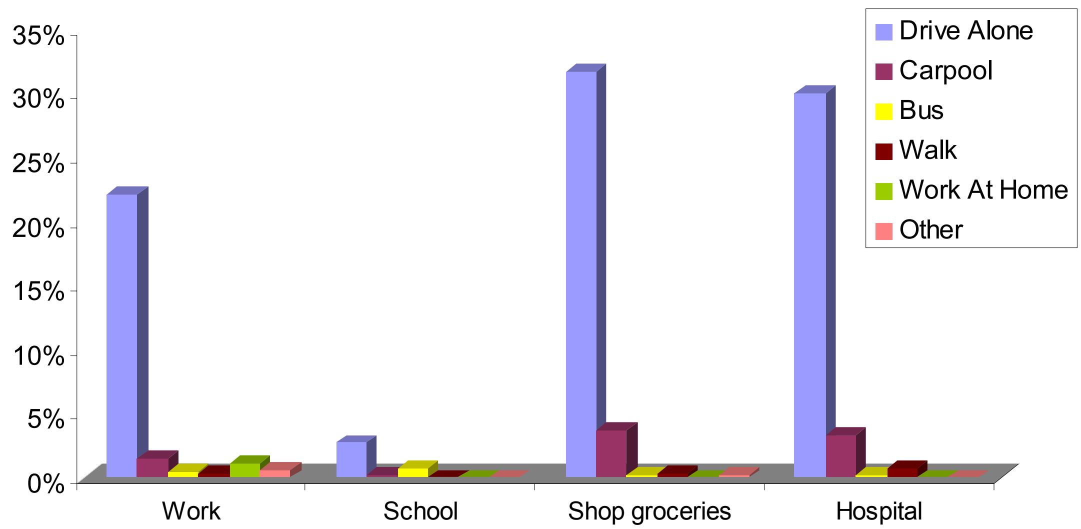
Based on Figure H.5, the following observations can be made:

- Most of the respondents indicated trip destinations (i.e., work, school, grocery shopping, and hospital) in the West (46%) and the East (36%) regions specified in the door-to-door survey map.
- Most respondents work in the West and East regions specified in the door-to-door survey map. Also, most of the respondents shop for groceries (approximately 67% of total shopping destinations) and go to school (approximately 67% of total school destination) in the East region.

- From Figure H.5 it is also evident that the Northwest, Northeast, Southwest, and Southeast regions are not major destinations for work, school, grocery shopping, or hospital trips.

Trip Purpose by Transportation Mode

Figure H.6 illustrates the transportation mode used by respondents for work, school, grocery shopping, and hospital trips.



Trip Purpose	Drive Alone		Carpool		Bus		Walk		Work At Home		Other		Total
Work	145	22.1%	10	1.5%	3	0.5%	2	0.3%	7	1.1%	4	0.6%	171
School	18	2.7%	1	0.2%	5	0.8%	0	0.0%	0	0.0%	0	0.0%	24
Shop Groceries	208	31.7%	24	3.7%	1	0.2%	2	0.3%	0	0.0%	1	0.2%	236
Hospital	197	30.0%	22	3.4%	1	0.2%	5	0.8%	0	0.0%	0	0.0%	225
TOTAL =	568	86.6%	57	8.7%	10	1.5%	9	1.4%	7	1.1%	5	0.8%	656

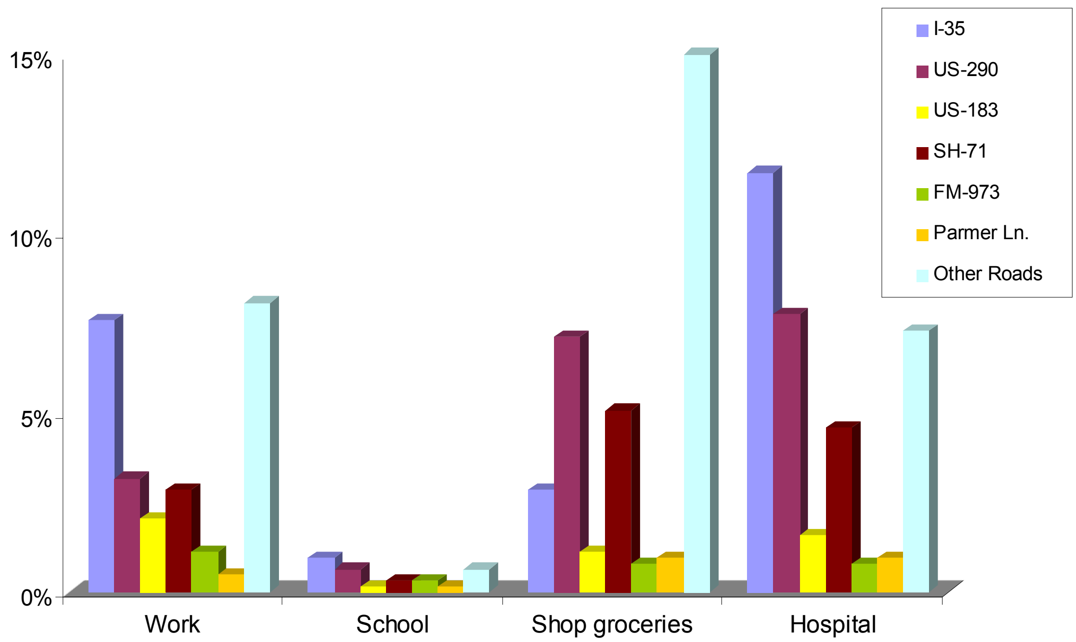
Figure H.6 Trip Purpose by Transportation Mode

Based on Figure H.6, the following observations can be made:

- *Drive alone* is the predominant mode of transportation (87%) used by respondents. About 9% of the respondents indicated they share driving responsibilities with others (i.e., carpool) and 2% indicated they ride the bus. Only 1% of the respondents indicated walking as their mode of transportation.

Major Roads by Trip Purpose

Figure H.7 shows the major roads used by respondents to get to work, school, grocery stores, and hospitals.



Trip Purpose	I-35		US-290		US-183		SH-71	
Work	48	7.6%	20	3.2%	13	2.1%	18	2.8%
School	6	0.9%	4	0.6%	1	0.2%	2	0.3%
Shop groceries	18	2.8%	45	7.1%	7	1.1%	32	5.1%
Hospital	74	11.7%	49	7.8%	10	1.6%	29	4.6%
TOTAL =	146	23.1%	118	18.7%	31	4.9%	81	12.8%

Trip Purpose	FM-973		Parmer Ln.		Other Roads		**OVERALL**
Work	7	1.1%	3	0.5%	51	8.1%	160
School	2	0.3%	1	0.2%	4	0.6%	20
Shop groceries	5	0.8%	6	0.9%	120	19.0%	233
Hospital	5	0.8%	6	0.9%	46	7.3%	219
TOTAL =	19	3.0%	16	2.5%	221	35.0%	632

Figure H.7 Major Roads Used by Respondents by Trip Purpose

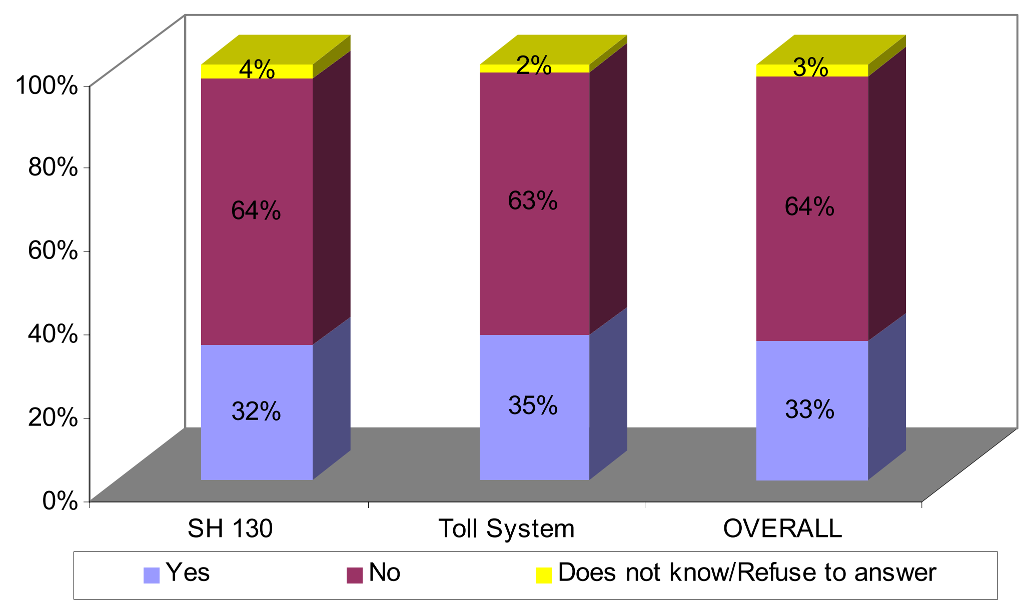
From Figure H.7, the following observations can be made:

- Respondents mainly use I-35, US-290, and SH-71 to travel to work, school, grocery stores, and hospitals.
- From the survey responses it appears that the respondents will not travel on the SH 130 toll road. Although the toll road does not seem to provide an alternative road given the respondents' origin-destination patterns, residents benefit if a substantial volume of through traffic currently using I-35 is diverted to SH 130. On the other

hand, the proposed toll lanes in the median of US 290, US 183 and SH 71 have the potential to impact the respondents' trips.

Foreseen Impacts on Trips Imposed by Toll Road(s) (Question 5)

Figure H.8 summarizes the gathered responses regarding whether the respondent's trips will be impacted by the proposed toll road(s).



Will toll road affect your trips?	SH 130		Toll System		**OVERALL**	
	Responses	Percent	Responses	Percent	Responses	Percent
Yes	44	32%	36	35%	80	33%
No	87	64%	66	63%	153	64%
Does not know/Refuse to answer	5	4%	2	2%	7	3%
TOTAL =	136	100%	104	100%	240	100%

Figure H.8 Results about whether Respondent's Trips Will Be Impacted by the Proposed Toll Road(s)

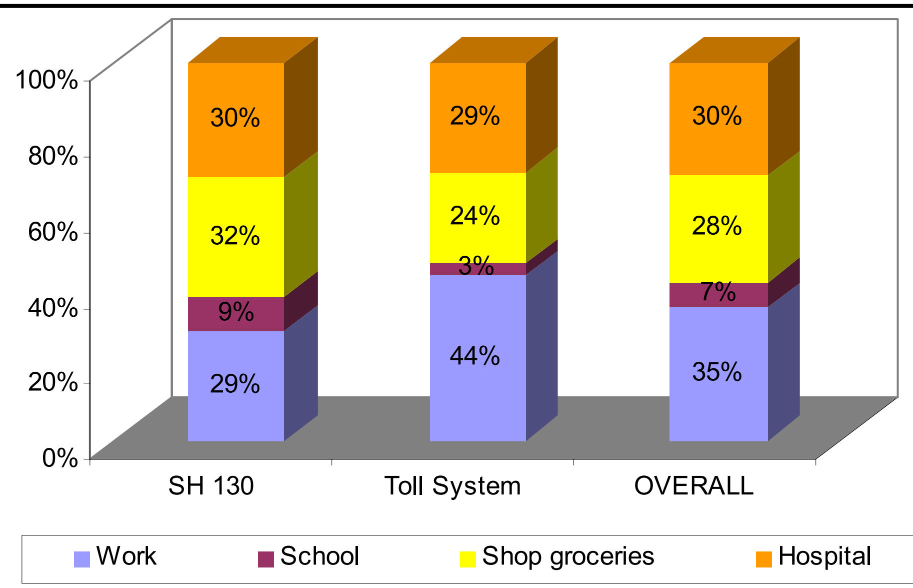
From Figure H.8, the following is evident:

- Overall, about one-third of the respondents (33%) indicated that the toll road(s) will impact one or more of the types of trips listed (i.e., work, school, grocery shopping, or hospital), 64% indicated no impact on their trips, and 3% refused to answer the question or did not know if or how the toll road(s) will impact their trips.

- As expected, a higher percentage of the surveyed respondents (35% compared to 32%) indicated that their trips will be impacted by the system of toll roads compared to the single toll road (i.e., SH 130). To determine if the latter was statistically significant at the 99% confidence level, the differences between population proportions were tested assuming the test statistic has a standard normal distribution. The outcome revealed that the population proportion perceived to be impacted by the SH 130 is statistically significantly less than the toll road system at a 0.01 significance level ($observed\ Z = -0.368 > -Z_{0.01} = -2.326$, p-value>0.01).

Trips Purposes Potentially Impacted by the Proposed Toll Road(s) (Question 5a)

Figure H.9 illustrates the trip purposes that will be impacted by the proposed toll road(s), as perceived by the respondents.



Trips to:	SH 130		Toll System		**OVERALL**	
	Responses	Percent	Responses	Percent	Responses	Percent
Work	22	29%	27	44%	49	35%
School	7	9%	2	3%	9	7%
Shop groceries	24	32%	15	24%	39	28%
Hospital	23	30%	18	29%	41	30%
TOTAL =	76	100%	62	100%	138	100%

Figure H.9 Respondents' Trips Affected by the Proposed Toll Roads

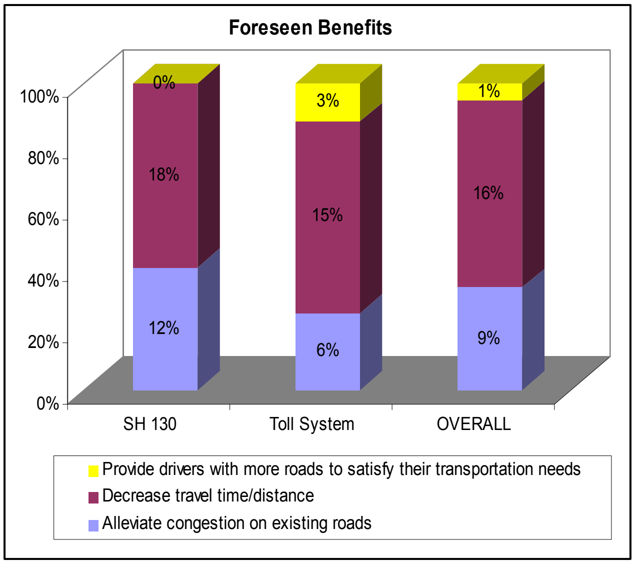
From Figure H.9, the following observations can be made:

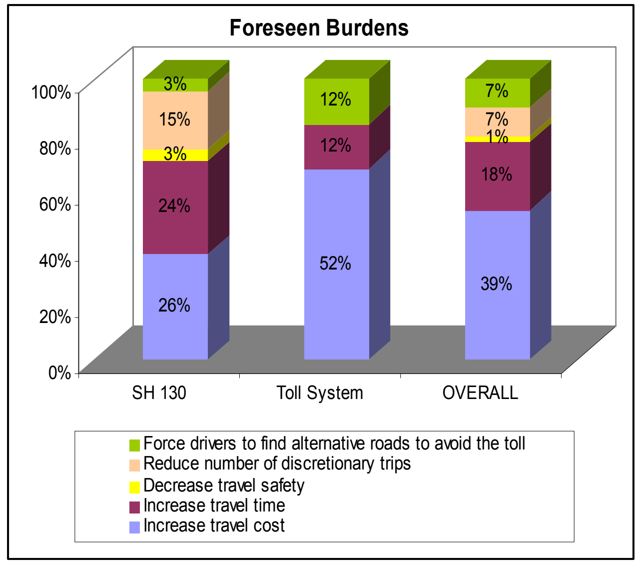
- Overall, most respondents indicated that their work trips will be impacted (35%), followed by their trips to the hospital (30%) and to grocery stores (28%). Trips to school seem to be less impacted by the toll road(s) (7%).

- As expected, a higher percentage of the respondents indicated that the toll system (consisting of 183A, SH 45N, Loop 1N, US 290E, US 183, SH 71E, SH 45S, and SH 130) will impact their trips to work compared to the SH 130 toll road (44% compared to 29%). This finding was statistically significant at the 99% confidence level ($\textit{observed } Z = -1.783 > -Z_{0.01} = -2.326$, p-value > 0.01) but not at the 95% confidence level ($\textit{observed } Z = -1.783 < -Z_{0.05} = -1.645$, p-value < 0.05).
- A higher percentage of respondents indicated that the SH 130 toll road will impact their trips to grocery stores (32%) compared to the toll system (24%). This finding was statistically significant at the 99% confidence level ($\textit{observed } Z = 0.958 < Z_{0.01} = 2.326$, p-value > 0.01). This was also true in the case of trips to hospital. A higher percentage of the respondents indicated that the SH 130 toll road will impact their trips to the hospital (30%) compared to the toll system (29%). This finding was statistically significant at the 99% confidence level ($\textit{observed } Z = 0.157 < Z_{0.01} = 2.326$, p-value > 0.01).

Foreseen Impacts Imposed by the Toll Roads (Question 5b)

Figure H.10 summarizes the foreseen impacts imposed by toll road(s) on their trips as listed by respondents.





FORESEEN BENEFITS	SH 130		Toll System		OVERALL	
	Responses	Percent	Responses	Percent	Responses	Percent
Alleviate congestion on existing roads	4	12%	2	6%	6	9%
Decrease travel time/distance	6	18%	5	15%	11	16%
Provide drivers with more roads to satisfy their transportation needs	0	0%	1	3%	1	1%
SUB-TOTAL=	**10**	**29%**	**8**	**24%**	**18**	**27%**
FORESEEN BURDENS	**SH 130**		**Toll System**		**OVERALL**	
	Responses	Percent	Responses	Percent	Responses	Percent
Increase travel cost	9	26%	17	52%	26	39%
Increase travel time	8	24%	4	12%	12	18%
Decrease travel safety	1	3%	0	0%	1	1%
Reduce number of discretionary trips	5	15%	0	0%	5	7%
Force drivers to find alternative roads to avoid the toll	1	3%	4	12%	5	7%
SUB-TOTAL =	**24**	**71%**	**25**	**76%**	**49**	**73%**
TOTAL =	34	100%	33	100%	67	100%

Figure H.10 Foreseen Impacts Imposed by Toll Road(s) on Respondents' Trips

Based on Figure H.10, the following observations can be made:

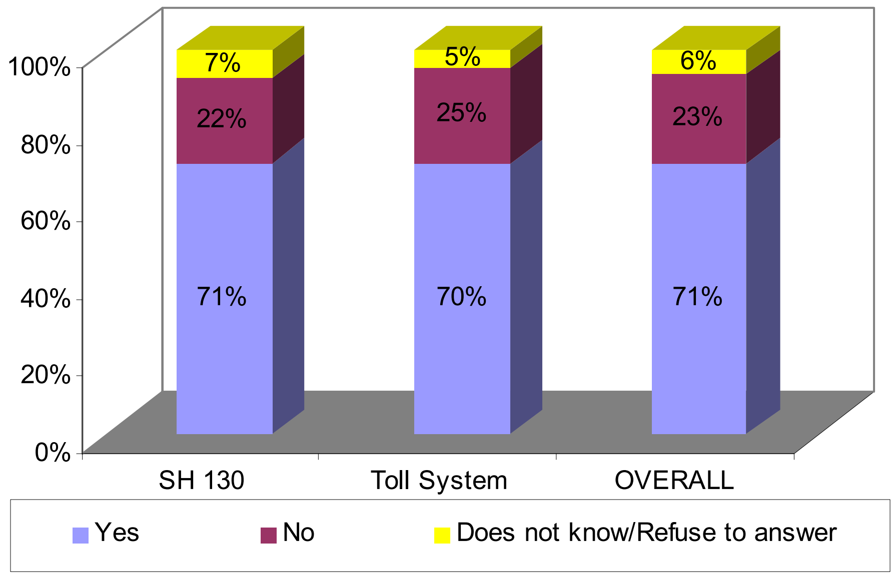
- Overall, 73% of the responses pertained to foreseen burdens while the remaining 27% of the responses pertained to foreseen benefits.
- The respondents associated more burdens on their activity space (e.g., work, school, grocery shopping, and hospital trips) with the toll road system in Central Texas (e.g., 183A, SH 45N, Loop 1N, US 290E, US 183, SH 71E, SH 45S, and SH 130) as compared to the SH 130 toll road (76% of the responses compared to 71% of the responses). This finding was statistically significant at the 99% confidence level ($observed\ Z = -0.477 > -Z_{0.01} = -2.326$, p-value > 0.01). Also, the respondents

associated fewer benefits with the toll road system as compared to the SH 130 toll road (24% of the responses compared to 29% of the responses). This finding was also statistically significant at the 99% confidence level ($observed\ Z = 0.477 < Z_{0.01} = 2.326$, p-value > 0.01).

- Overall, the respondents foresee that the added capacity provided by the toll roads will help to reduce travel time and distance (16% of the responses) and alleviate congestion on existing roads (9% of the responses). A few of the respondents mentioned that the toll road(s) will reduce traffic on I-35 and FM 973.
- Overall, the respondents foresee that the toll road(s) will increase their travel cost (39% of the responses) and travel time (18% of the responses). In terms of travel cost, the respondents foresee the following burdens: (a) in the future drivers have to pay for using the SH 290, which is “free” at present, (b) on Sundays, the cost of trips to church will increase if the toll road(s) is used, and (c) the toll road(s) will increase the travel cost of local business customers. In terms of travel times, the respondents mentioned the following burdens: (a) the toll road(s) will attract more vehicles to the area, (b) drivers will have to stop to pay for the toll, and (c) drivers avoiding the toll road(s) will increase traffic on local streets.
- Overall, 14% of the responses concerned the fact that toll road(s) would force the respondents to limit their discretionary trips and seek alternative roads to avoid the toll(s). Some respondents feel that they may have to change the places where they shop.
- None of the respondents remarked that the SH 130 toll road would provide them with an additional road to satisfy their transportation needs while only one respondent noted that the toll road system in Central Texas will provide more options to satisfy his transportation needs.
- Respondents seem to be more concerned about the travel cost imposed by the Central Texas toll road system (e.g., 183A, SH 45N, Loop 1N, US 290E, US 183, SH 71E, SH 45S, and SH 130) as opposed to the travel cost imposed by the SH 130 toll road (52% of the responses compared to 26% of the responses). On the other hand, the responses seem to suggest that respondents are more concerned about the increased travel time impacts imposed by the SH 130 (24% of the responses) compared to the toll road system in Central Texas (12% of the responses).
- Respondents are more concerned about the impacts on discretionary trips imposed by the SH 130 toll road than by the toll road system. On the other hand, the results suggest that respondents recognize that the toll road system will force drivers to find alternate roads (12% of the respondents) more so than in the case of a single toll road (3% of the respondents).

Potential Community Impacts Imposed by Toll Roads (Question 6)

Figure H.11 summarizes the gathered responses regarding whether the respondents' communities will be impacted by the proposed toll road(s).



Will toll roads affect your community?	SH 130		Toll System		**OVERALL**	
	Responses	Percent	Responses	Percent	Responses	Percent
Yes	96	71%	73	70%	169	71%
No	30	22%	26	25%	56	23%
Does not know/Refuses to answer	10	7%	5	5%	15	6%
TOTAL =	136	100%	104	100%	240	100%

Figure H.11 Results about whether Respondents' Community Will Be Impacted by the Proposed Toll Road(s)

Based on Figure H.11, the following observations can be made:

- Overall, 71% of the respondents indicated that the proposed toll road(s) will impact their communities while 23% indicated the toll road(s) will not impact their communities. Only 6% of the respondents refused to answer the question or did not know how the proposed toll road(s) will impact their communities.
- Although a similar percentage of respondents foresee that the SH 130 toll road and the toll system in Central Texas will impact their communities (71% and 70% of the respondents respectively), the statistical test at the 99% confidence level revealed that a statistically significantly higher number of respondents indicated that the SH 130 toll road will impact their communities compared to the system of toll roads in Central Texas ($observed\ Z = 0.067 < Z_{0.01} = 2.326$, p-value > 0.01).
- A higher percentage of respondents (25%) indicated that the system of toll roads in Central Texas will not impact their communities compared to the SH 130 toll road

(22%). This finding was statistically significant at the 99% confidence level ($observed\ Z = -0.477 > -Z_{0.01} = -2.326$, p-value > 0.01).

Table H.4 summarizes the gathered responses regarding whether the proposed toll road(s) will impact respondents' trips (Question 5a) and communities (Question 6). The following observations can be made:

- Overall, 71% of the respondents indicated that the proposed toll road(s) will impact their communities—more than twice the number of respondents who indicated that the toll road(s) will impact their trips (33% of the respondents).
- Fewer respondents did not know or refused to answer when asked about the impacts of the toll road system in Central Texas upon their trips than when asked about the SH 130 toll road (2% and 4%, respectively). This finding was statistically significant at the 99% confidence level ($observed\ Z = 0.800 < Z_{0.01} = 2.326$, p-value>0.01). Also, fewer respondents did not know or refused to answer when asked about the impacts of the toll road system in Central Texas upon their communities than when asked about the SH 130 toll road (5% and 7%, respectively). This finding was statistically significant at the 99% confidence level ($observed\ Z = 0.807 < Z_{0.01} = 2.326$, p-value>0.01). This finding could suggest that it was easier for the respondents to visualize the impacts of the system of toll roads on their trips and communities than the impacts imposed by a single toll road.

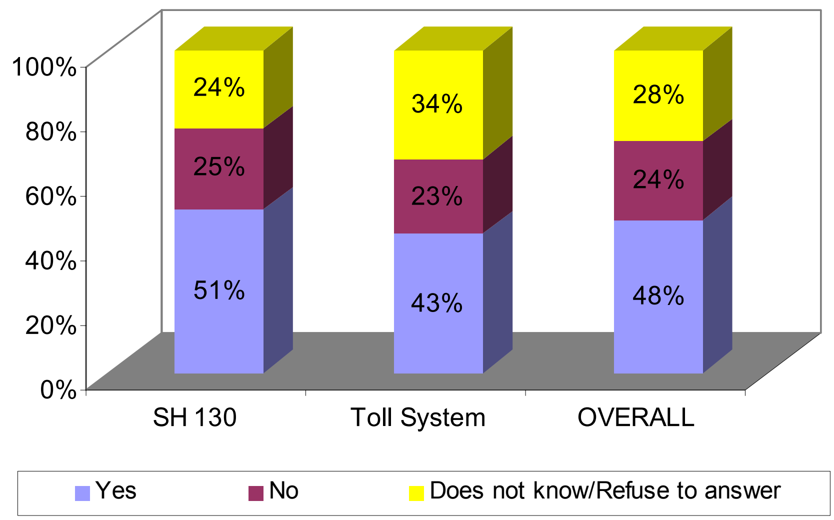
Table H.4 Results about whether Toll Road(s) Will Impact Respondents' Trips/Community

Will toll road(s) affect your trips?								
YES			**NO**			**Does not know/Refuses to answer**		
SH 130	Toll System	Overall	SH 130	Toll System	Overall	SH 130	Toll System	Overall
32%	35%	33%	64%	63%	64%	4%	2%	3%
Will toll road(s) affect your community?								
YES			**NO**			**Does not know/Refuses to answer**		
SH 130	Toll System	Overall	SH 130	Toll System	Overall	SH 130	Toll System	Overall
71%	70%	71%	22%	25%	23%	7%	5%	6%

Note: Based on 240 responses

Will Proposed Toll Roads Benefit Respondents' Community? (Question 6a)

Figure H.12 summarizes the gathered responses regarding whether the respondents' community will benefit from the proposed toll road(s).



Will the toll road(s) benefit your community?	SH 130		Toll System		**OVERALL**	
	Responses	Percent	Responses	Percent	Responses	Percent
Yes	69	51%	45	43%	114	48%
No	34	25%	24	23%	58	24%
Does not know/Refuses to answer	33	24%	35	34%	68	28%
TOTAL =	136	100%	104	100%	240	100%

Figure H.12 Results abut whether Respondents' Community Will Benefit from Proposed Toll Road(s)

Based on Figure H.12, the following observations can be made:

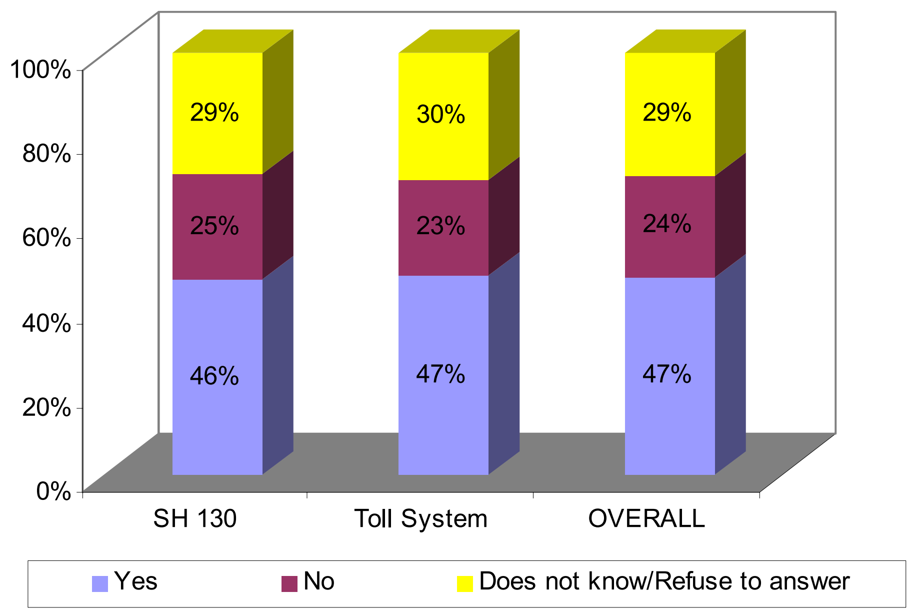
- Overall, 48% of the respondents indicated that the toll road(s) will benefit their communities while 24% did not foresee any benefits from the toll road(s). About 28% of the respondents refused to answer or did not know. This was especially the case for those surveyed about the toll road system in Central Texas (i.e., 34% of the respondents did not know whether the proposed toll road(s) will benefit their communities or refused to answer this question). This could point to the need for increased public information to inform and educate communities about the proposed toll road system in Central Texas.
- A higher percentage of the respondents indicated that the SH 130 toll road will benefit their communities (51%) compared to the toll road system in Central Texas

(43%). This finding was statistically significant at the 99% confidence level ($observed\ Z = 1.148 < Z_{0.01} = 2.326$, p-value>0.01).

- At the same time, a higher percent of respondents indicated that the SH 130 toll road will not benefit their communities (25%) compared to the toll road system in Central Texas (23%). This finding was statistically significant at the 99% confidence level ($observed\ Z = 0.345 < Z_{0.01} = 2.326$, p-value>0.01).

Will Proposed Toll Roads Burden Respondents' Communities? (Question 6b)

Figure H.13 summarizes gathered responses regarding whether the respondents' communities will burden by the proposed toll road(s).



Will toll road(s) burden your community?	SH 130		Toll System		**OVERALL**	
	Responses	Percent	Responses	Percent	Responses	Percent
Yes	63	46%	49	47%	112	47%
No	34	25%	24	23%	58	24%
Does not know/Refuse to answer	39	29%	31	30%	70	29%
TOTAL =	136	100.0%	104	100%	240	100%

Figure H.13 Results about whether Respondents' Community Will Be Burdened by the Proposed Toll Road(s)

Based on Figure H.13, the following observations can be made:

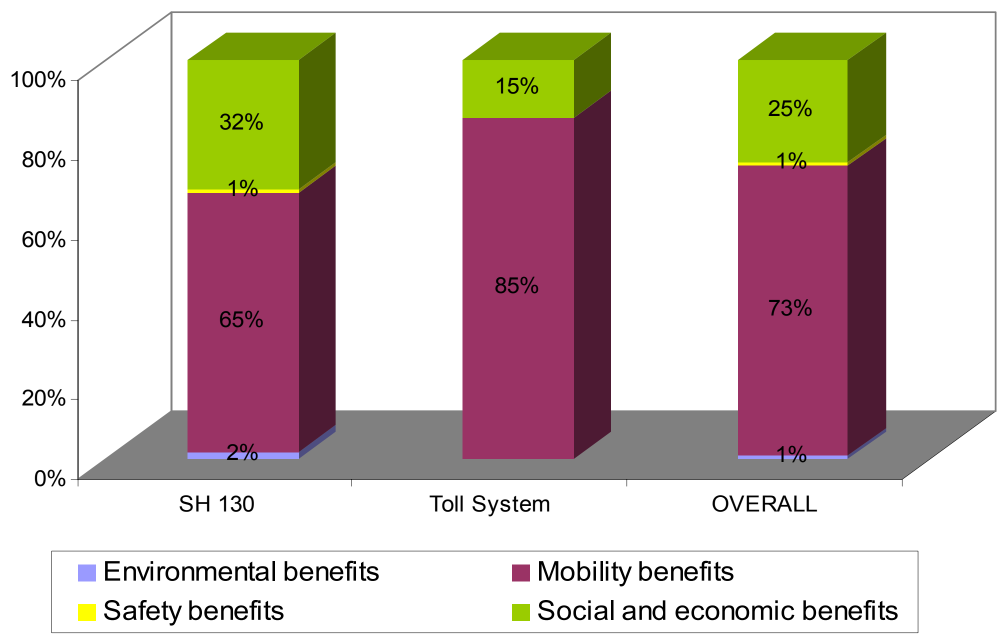
- Overall, 47% of the respondents indicated that the toll road(s) will burden their communities while 24% did not foresee any burdens imposed by the toll road(s).

About 29% of respondents did not know whether the proposed toll road(s) will burden their communities or refused to answer this question.

- The results were similar when respondents were asked about the burdens imposed by the toll road system in Central Texas and the SH 130 toll road. Around 46% of the respondents indicated that the toll road(s) will burden their communities and around 24% indicated that the toll road(s) will not burden their communities.

Foreseen Community Benefits Imposed by Toll Road(s) (Question 6bi)

Figure H.14 summarizes the gathered responses regarding foreseen benefits the proposed toll road(s) may have on the surveyed community.



BENEFITS	SH 130		Toll System		OVERALL	
	Responses	Percent	Responses	Percent	Responses	Percent
Environmental benefits	1	2%	0	0%	1	1%
Mobility benefits	42	65%	35	85%	77	73%
Safety benefits	1	1%	0	0%	1	1%
Social and economic benefits	21	32%	6	15%	27	25%
TOTAL =	65	100%	41	100%	106	100%

Note: Environmental benefits relate to less pollution. Mobility benefits comprise reduced traffic on congested roads, faster roads, and more options for drivers. Safety benefits include fewer traffic accidents. Finally, social and economic benefits include attracting new businesses and increasing property values.

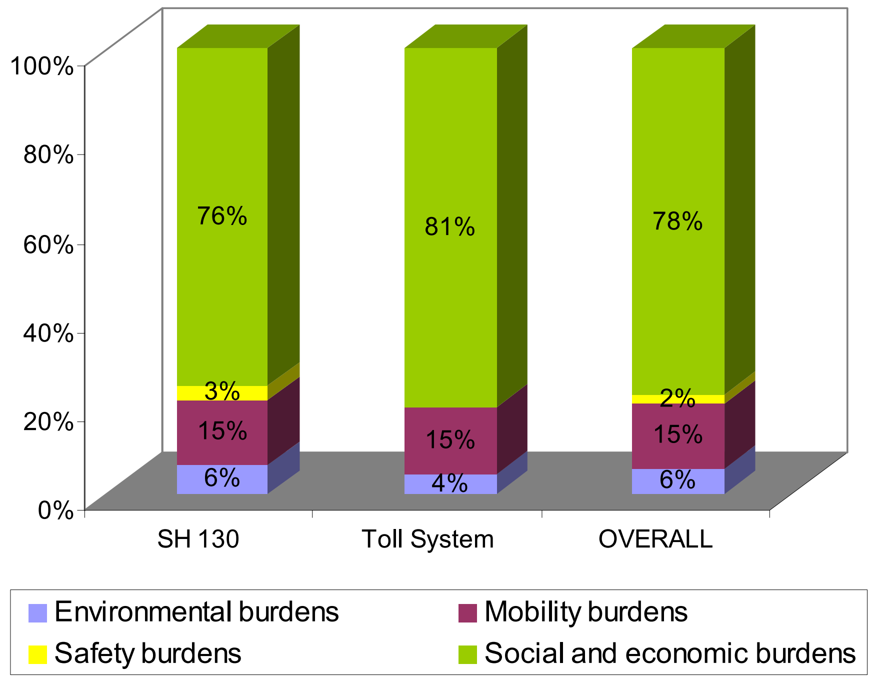
Figure H.14 Foreseen Community Benefits from Proposed Toll Road(s)

The respondents provided 106 responses when asked about the foreseen benefits from toll road(s) on their communities. The following observations can be made:

- Overall, the respondents indicated that the toll road(s) will provide improved surface mobility (73% of the responses), an increase in social and economic benefits (25% of the responses), an improved environment (1% of the responses), and enhanced highway safety (1% of the responses).
- The results suggest the toll road system in Central Texas is perceived to provide more mobility benefits compared to the SH 130 toll road (85% of the responses compared to the 65% of the responses). This finding, however, was not statistically significant at the 99% confidence level ($\textit{observed}\ Z = -2.334 < -Z_{0.01} = -2.326$, p-value < 0.01).
- The SH 130 toll road is perceived to provide more social and economic benefits than would the toll road system in Central Texas (32% of the responses compared to 15% of the responses). This finding was statistically significant at the 95% confidence level (p-value > 0.05) but not at the 99% confidence level (p-value < 0.01). Overall, 22% of the responses indicated that the toll road(s) will attract new businesses to the region and 4% of the responses indicated that the toll road(s) will increase property values.
- Overall, 43% of the responses referred to a reduction in traffic on congested roads such as I-35, SH 290 and Loop 1 (Mopac). Some respondents mentioned that the SH 130 toll road will reduce truck traffic on I-35. In addition, 21% of the responses indicated that the toll road(s) will provide faster routes compared with the existing roads.

Foreseen Community Burdens Imposed by Toll Road(s) (Question 6bii)

Figure H.15 summarizes the gathered responses regarding foreseen burdens the proposed toll road(s) may have on the surveyed community.



BURDENS	SH 130		Toll System		OVERALL	
	Responses	Percent	Responses	Percent	Responses	Percent
Environmental burdens	4	6%	2	4%	6	6%
Mobility burdens	9	15%	7	15%	16	15%
Safety burdens	2	3%	0	0%	2	2%
Social and economic burdens	47	76%	38	81%	85	78%
TOTAL =	62	100%	47	100%	109	100%

Note: The environmental burdens listed relate to increased air pollution/traffic noise, and increase of flooding areas. Mobility burdens mentioned by respondents include increased traffic jams in areas close to construction zones, worsened traffic conditions on entry/exit ramps, increased trip length, slower traffic due to toll booths, and increased traffic ticketing. The safety burdens listed relate to an increase in traffic accidents. Finally, the social and economic burdens listed include the following: affect driver's transportation budget, increase traffic through neighborhoods, affect quality of life in the community, increase driver's stress, hamper community cohesion, encourage community segregation by income level, decrease property values of homes near toll roads, necessitate relocation of homes and businesses, and increase property taxes.

Figure H.15 Foreseen Community Burdens Imposed by Proposed Toll Road(s)

The respondents provided 109 responses when asked to list the potential burdens imposed by the toll road(s) on their communities. The following observations can be made:

- The respondents indicated that the toll road(s) will have a negative impact on the social and economic aspects of their communities (78% of the responses), their mobility (15% of the responses), the physical environment (6% of the responses), and highway safety (2% of the responses).

- The results suggest that more respondents were concerned about the social and economic burdens imposed by the toll system in Central Texas than the social and economic burdens imposed by the SH 130 toll road (81% and 76% of the responses respectively). This finding was statistically significant at the 99% confidence level ($observed\ Z = -0.629 > -Z_{0.01} = -2.326$, p-value>0.01).
- The most often cited social and economic burden was the impact that the toll road(s) will have on the driver's budget (43% of the responses) because drivers have to pay for using the toll road(s). Also a number of respondents feel that the toll road(s) will negatively impact the quality of life in their communities by attracting more people to the area (18% of the responses).

Mitigation Options Proposed to Minimize or Eliminate the Identified Burdens (Question 6biii)

Table H.5 lists the mitigation options provided by the respondents to avoid or lessen the burdens imposed by the proposed toll road(s) on their communities.

Table H.5 Proposed Mitigation Options

MITIGATION OPTIONS	SH 130		Toll System		OVERALL	
	Responses	Percent	Responses	Percent	Responses	Percent
Do not build toll roads/Continue to pay for roads with tax dollars	12	40%	12	48%	24	44%
Put the toll road decision up to a vote	3	10%	3	12%	6	11%
Improve community outreach to inform and involve the community in the planning, design, and construction of toll roads	3	10%	2	8%	5	9%
Upgrade and improve existing non-toll roads for those who cannot afford the tolls (e.g., improve connectivity and safety of existing roads, improve traffic light management)	4	13%	1	4%	5	9%
Provide better public transportation for those who cannot afford the toll	2	7%	1	4%	3	5%
Provide "free passes" to those living near toll roads and low-income people who cannot afford the toll	1	3%	2	8%	3	5%
Only build toll road through commercial areas	1	3%	1	4%	2	4%
Do not allow truck traffic on toll roads	1	3%	1	4%	2	4%
Charge reasonable toll fees	1	3%	0	0%	1	2%
Build noise walls	0	0%	1	4%	1	2%
Provide tags so drivers do not have to stop to pay the toll	0	0%	1	4%	1	2%
Limit toll road construction to off-peak travel hours	1	3%	0	0%	1	2%
Relocate affected properties	1	3%	0	0%	1	2%
TOTAL =	30	100%	25	100%	55	100%

Based on Table H.5, the following observations can be made:

- Overall, the most frequently proposed mitigation option was to not build toll roads and/or continue to pay for roads with tax dollars (44% of the responses). Also, a number of respondents said that the toll road decision should be put up to a vote (11% of the responses).

- A higher percentage of the responses favored not building toll roads/continuing to pay for roads with tax dollars in the case of the Central Texas toll road system (48% of the responses) than for the SH 130 toll road (40% of the responses). This finding was statistically significant at the 99% confidence level ($observed\ Z = -0.596 > -Z_{0.01} = -2.326$, p-value>0.01).

- Overall, the respondents listed better community outreach to inform and involve the community in the planning, design, and construction of toll road(s) (9% of the responses). This mitigation option comprised 10% of the responses when respondents were asked about SH 130 and 8% of the responses when respondents were asked about the toll road system in Central Texas.

- Overall, the respondents proposed improvements to the connectivity and safety of the non-toll existing roads so those who cannot afford the toll may have a comparable alternative to satisfy their transportation needs (9% of the responses). This option was listed by respondents who were asked about the SH 130 toll road (13% of the responses) and respondents who were asked about the toll road system in Central Texas (4% of the responses).

- Overall, the respondents also listed the provision of better public transportation in low-income areas so drivers who cannot afford the toll would have an alternative transportation mode (5% of the responses) and the provision of "free passes" to those living near toll roads and low-income drivers who cannot afford the toll (5% of the responses). Regarding the latter, fewer respondents listed "free passes" as a potential mitigation option when asked about the SH 130 toll road (3% of the responses) than when asked about the toll road system in Central Texas (8% of the responses). This finding was statistically significant at the 99% confidence level ($observed\ Z = -0.759 > -Z_{0.01} = -2.326$, p-value>0.01).

Table H.6 relates the respondents' answers to whether the toll road(s) will impact their trips (i.e., work, school, grocery shopping, and hospital) with the number of the identified impacts (i.e., benefits and burdens), and the listed possible mitigation options to reduce or eliminate the identified burdens. From Table H.6 the following observations can be made:

- The 80 respondents that indicated that the toll road(s) will impact their trips identify 49 burdens (responses) and list 36 mitigation options (responses) to avoid or mitigate the negative impacts imposed by the toll roads on their trips. Only 17 benefits associated with the proposed toll roads were provided by these respondents.

- The 114 respondents who said toll road(s) will benefit their communities were able to provide 105 benefits (responses).

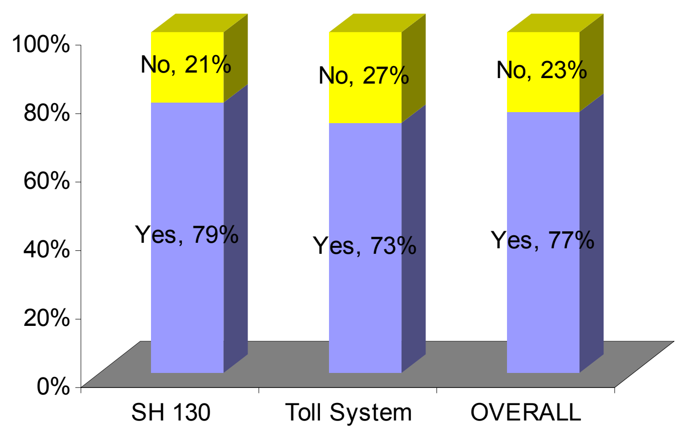
- The 112 respondents who indicated that toll road(s) will burden their community could provide 65 measures (responses) to mitigate or avoid the negative impacts. This question had a relative low response rate, which might suggest the need for additional outreach activities to inform and involve the EJ communities in the decision-making process surrounding toll road(s) in Central Texas.

Table H.6 Relationship Between Trip and Community Impacts and Ability to Identify Mitigation Options

Respondents who said toll road(s) will:	Total number of responses	Identified burdens (number of responses)	Identified mitigation options (number of responses)	Identified benefits (number of responses)
Affect any of their trips	80	49	36	17
Benefit the community	114	NA	NA	105
Burden the community	112	107	65	NA

Willingness to Be Involved (Question 7)

Figure H.16 summarizes the gathered responses regarding the respondents' willingness to be contacted in the future to obtain their input in the decision-making process surrounding toll road(s).



Can we contact you in the future?	SH 130		Toll System		OVERALL	
	Responses	Percent	Responses	Percent	Responses	Percent
Yes	108	79%	76	73%	184	77%
No	28	21%	28	27%	56	23%
TOTAL =	136	100%	104	100%	240	100%

Figure H.16 Respondents' Willingness to Be Contacted in the Future

From Figure H.16, the following observations can be made:

- Overall, 77% of the respondents indicated that they were amenable to being contacted in the future to provide input in the decision-making process surrounding toll road(s). The remaining 23% did not want to be contacted in the future.
- A higher percentage of respondents that were asked about the SH 130 toll road indicated that they can be contacted in future compared to the respondents that were

asked about the toll road system in Central Texas (79% and 73%, respectively). This finding was statistically significant at the 99% confidence level ($observed\ Z = 1.150 < Z_{0.01} = 2.326$, p-value>0.01).

Table H.7 related the respondents' answers to whether the proposed toll road(s) will impact their trips and community with their willingness to be contacted in future to provide input in the decision-making process surrounding the toll road(s).

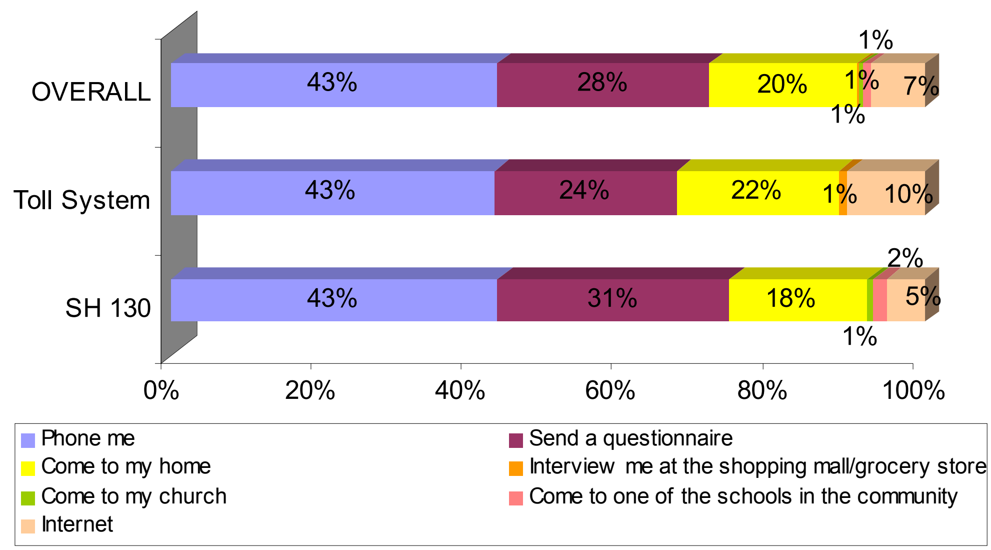
Table H.7 Relationship Between Trips and Community Impacts and Willingness to be Contacted in Future

Respondents who said toll road(s) will:	Willingness to be Contacted in Future				Valid Number of respondents
	Yes		No		
	Number of respondents	Percentage	Number of respondents	Percentage	
Affect any of their trips	66	83%	14	18%	80
Benefit the community	83	73%	31	27%	114
Burden the community	87	78%	25	22%	112

From Table H.7 is evident that more than 80% of the respondents who indicated that the proposed toll road(s) will impact their trips and 78% of the respondents who indicated that the proposed toll road(s) will burden their communities indicated a willingness to provide input in the decision-making process surrounding toll road(s) in Central Texas in the future.

Preferred Participation Techniques (Question 8)

Figure H.17 summarizes the preferred community participation techniques listed by respondents to provide input regarding proposed toll road(s).



Community Outreach Efforts	SH 130		Toll System		OVERALL	
	Responses	Percent	Responses	Percent	Responses	Percent
Phone me	52	43%	34	43%	86	43%
Send a questionnaire	37	31%	19	24%	56	28%
Come to my home	22	18%	17	22%	39	20%
Interview me at the shopping mall/grocery store	0	0%	1	1%	1	1%
Come to my church	1	1%	0	0%	1	1%
Come to one of the schools in the community	2	2%	0	0%	2	1%
Internet (e-mail)	6	5%	8	10%	14	7%
TOTAL =	120	100%	79	100%	199	100%

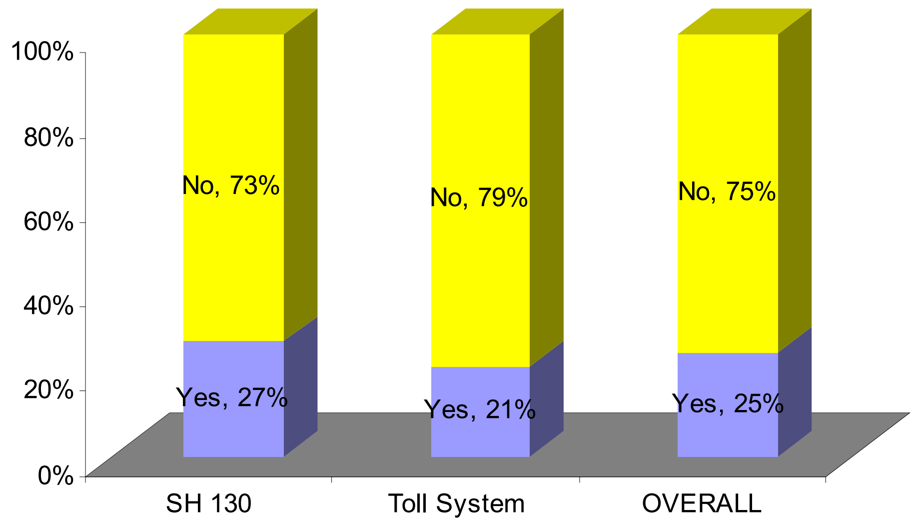
Figure H.17 Preferred Community Outreach Efforts

From Figure H.17, the following observations can be made:

- Overall, the community participation techniques preferred by the respondents were ‘phone me’ (43% of the responses), ‘send a questionnaire’ (28% of the responses), and ‘come to my home’ (20% of the responses). On the other hand, the less preferred participation techniques were ‘interview me at the shopping mall/grocery store’ (1% of the responses), ‘come to my church’ (1% of the responses), and ‘come to one of the schools in the community’ (1% of the responses). Only 1% of the surveyed people choose these options. Also, 7% of the respondents indicated that the best way to contact them was through electronic mail (i.e., Internet).

Leaders in the Community (Question 9)

Figure H.18 summarizes the gathered responses regarding whether the respondents could identify a community leaders that could speak on behalf of the impacted community.



Anyone can speak for the community	SH 130		Toll System		OVERALL	
	Responses	Percent	Responses	Percent	Responses	Percent
Yes	37	27%	22	21%	59	25%
No	99	73%	82	79%	181	75%
TOTAL =	136	100%	104	100%	240	100%

Survey Site	Yes		No	
	Responses	Percent	Responses	Percent
Site 1 (Pflugerville)	9	15%	43	24%
Site 2 (Pflugerville)	13	22%	39	21%
Site 3 (Manor)	22	37%	34	19%
Site 4 (FM-973 & FM-812)	6	11%	26	15%
Site 5 (FM-973 & SH-71)	9	15%	39	21%
TOTAL =	59	100%	181	100%

Figure H.18 Leaders in the Community

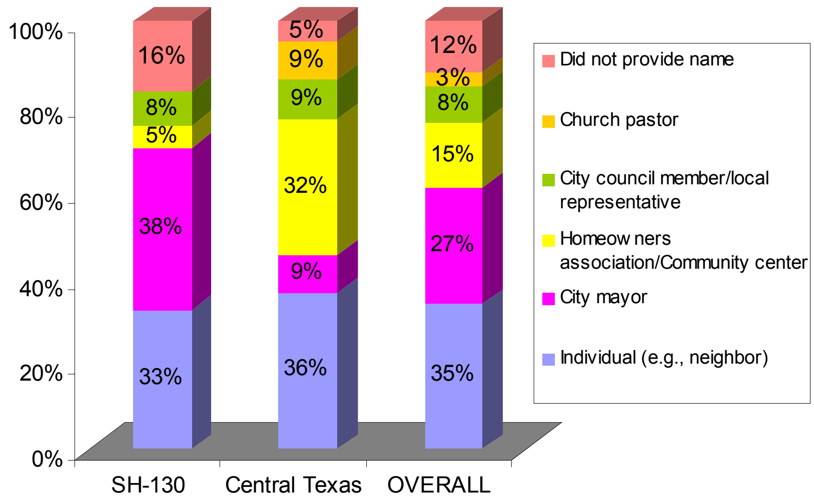
From Figure H.18, the following observations can be made:

- Overall, 25% of the respondents indicated that there was someone in the community that could speak for the community, while 75% said that there was no one that could speak for the community.
- It is evident that 37% of the respondents in Manor said that there was someone that could speak for the community. Also, at Site 2 (Pflugerville), 22% of the respondents indicated that there was someone that could speak for the community. At the three

remaining sites, however, 60% of the respondents said that there was no one that could speak for the community.

Identified Community Leaders (Question 10)

Figure H.19 summarizes the community leaders identified by respondents.



Community leaders identified by respondents	SH 130		Toll System		OVERALL	
	Responses	Percent	Responses	Percent	Responses	Percent
Individual (e.g., neighbor)	12	33%	8	36%	20	35%
City mayor	14	38%	2	9%	16	27%
Homeowners association/Community center	2	5%	7	32%	9	15%
City council member/Local representative	3	8%	2	9%	5	8%
Church pastor	0	0%	2	9%	2	3%
Did not provide name	6	16%	1	5%	7	12%
TOTAL =	37	100%	22	100%	59	100%

Survey Site	City mayor		City council member/Local representative		Individual (e.g., neighbor)		Homeowners association/Community center	
	Responses	Percent	Responses	Percent	Responses	Percent	Responses	Percent
Site 1	4	44%	1	11%	2	22%	2	22%
Site 2	2	15%	1	8%	3	23%	6	46%
Site 3	10	45%	2	9%	6	27%	0	0%
Site 4	0	0%	1	17%	4	67%	1	17%
Site 5	0	0%	0	0%	5	56%	0	0%

Survey Site	Church pastor		Did not provide name		**OVERALL**	
	Responses	Percent	Responses	Percent	Responses	Percent
Site 1	0	0%	0	0%	9	100%
Site 2	0	0%	1	8%	13	100%
Site 3	0	0%	4	18%	22	100%
Site 4	0	0%	0	0%	6	100%
Site 5	2	22%	2	22%	9	100%

Figure H.19 Community Leaders

From Figure H.19, the following observations can be made:

- Overall, 35% of the respondents identified an individual (e.g., a neighbor) as the person who can speak for the community, followed by 27% of the respondents who identified the city mayor, a representative from the homeowner association/community center (15% of the respondents), a city council member/local representative (8% of the respondents), and a church pastor (3% of the respondents).
- The gathered responses also revealed that 44% of the respondents surveyed at Site 1 (Pflugerville) and 45% of the respondents surveyed at Site 3 (Manor) identified the city major as the person who could speak for the community. Also of interest is the fact that 67% and 56% of the respondents surveyed at Site 4 (FM-973 & FM-812) and Site 5 (FM-973 & SH-71), respectively, identified a specific individual that could speak on behalf of the community. Sites 4 and 5 are smaller EJ communities.

H3. Concluding Remarks

The transportation mode used by those surveyed to get to work, school, grocery stores, and the hospital is the car, either driving alone (87% of the respondents) or carpooling (9% of the respondents). This suggests that minority and low-income communities also mainly rely on private cars to satisfy their transportation needs.

From the reported origin-destination travel patterns and the roads used by the respondents, it appears that the toll lanes being added to the median of the existing roads (i.e., US 290, US 183, and SH 71) will potentially have the most significant impacts on those surveyed. Besides I-35, the US 290, US 183, and SH 71 are the three major roads used by minority and low-income drivers to get to work, school, grocery stores, or the hospital.

About one-third of the respondents thus indicated that the proposed toll road(s) will affect (i.e., benefit or burden) the trips they make to work, school, grocery stores, or the hospital. The remaining 64% indicated that the toll road(s) will not affect their trips. Of those that indicated an impact on the trips they make, 35% of the responses reported an impact on trips to work, followed by travel to hospitals (30% of the responses) and grocery stores (28% of the responses). The less affected trips are to school (7% of the responses). Also, of those that indicated that the toll road(s) will impact their trips, 73% foresaw that the impact would be negative (i.e., burden) and 27% foresaw that the impact would be positive (i.e., benefit).

The respondents foresaw that the proposed toll road(s) will increase their travel cost (39% of the responses), travel time (18% of the responses), limit the number of their discretionary trips (7% of the responses), and force drivers to find alternative roads to avoid the toll (7% of the responses). On the other hand, some respondents recognized that the added toll capacity will reduce travel time and distance (16% of the responses) and alleviate congestion on existing roads (9% of the responses), especially on I-35 and FM 973. Finally, respondents did not foresee that SH 130 would provide them with an alternative road to satisfy their transportation needs and only 3% of those surveyed about the toll road system in Central Texas foresaw that the toll system would provide them with alternative roads(s) to satisfy their transportation needs.

Compare to the 33% of the respondents (80) that indicated that the proposed toll road(s) will affect their trips, more than 70% (169) indicated that the proposed toll road will impact their community. Similar results were obtained irrespective of whether the questionnaire pertained to SH 130 toll road or to the system of toll roads in Central Texas.

Of the 240 respondents overall, 114 respondents (48%) indicated that the proposed toll road(s) will benefit their communities, while 58 respondents (24%) did not foresee that the toll road(s) will benefit their communities. About 68 respondents (28%) refused to answer or did not know whether the proposed toll road(s) will benefit their communities. A higher percentage refused to answer or did not know whether the toll road system in Central Texas will benefit their communities compared to the SH 130 toll road. This is especially true for people surveyed regarding the proposed Central Texas toll road system (i.e., 34% of respondents did not know or refused to answer whether the proposed toll road system will benefit their communities).

The data analysis further revealed that 112 of the respondents (47%) indicated that the toll road(s) will impose a burden on their communities, while 58 of the respondents (24%) did not foresee any burden imposed by the toll road(s) on their communities. Seventy of the respondents (29%) refused to answer the question or did not know when asked if the toll road(s) will burden their communities.

The respondents provided 106 responses when asked to list the foreseen benefit associated with the toll road(s) on their communities. The respondents indicated that the toll road(s) will improve mobility (73% of the responses), provide social and economic benefits to the region (25% of the responses), enhance the environment (1% of the responses), and improve highway safety (1% of the responses). Of the 106 responses, 43% of the responses concerned the reduction of traffic on congested roads, specifically on I-35, SH 290 and Loop 1; 21% referred to the new toll road(s) providing a faster road to drivers; and 26% of the responses stated that the new toll road(s) will attract new businesses to the region (22%) and increase property values (4%).

The respondents provided 109 responses when asked to list the foreseen burdens imposed by the toll road(s) on their communities. The most often cited burdens were negative social and economic impacts on the community (78% of the responses), worsened mobility conditions in the area (15% of the responses), harm to the physical environment (6% of the responses), and reduced highway safety (2% of the response). The most often cited social and economic burden was the impact that toll road(s) will have on the families' budget because drivers have to pay for using the toll road(s). Also, a number of respondents were concerned that the toll road(s) will negatively impact the quality of life in their communities by attracting more people to the area.

Overall, the respondents provided 55 responses when asked about potential mitigation options to avoid or lessen any negative impact toll road(s) may have on their communities. The most often cited mitigation option was to not build toll roads or continue to pay for roads with tax dollars (44% of the responses). Also, a number of respondents said that the toll road decision should be put up to a vote (11% of the responses). The respondents also mentioned the need for better community outreach to inform and involve the community in the planning, design, and construction of toll road(s) (9% of the responses). Respondents further listed as mitigation options improvement of the connectivity and safety of the existing non-toll roads (9% of the responses) and the provision of better public transportation in low-income areas (5% of the responses) so that those who cannot afford the toll may have comparable alternatives to satisfy their transportation needs. Other mitigation options provided by respondents included providing "free passes" to those living near toll road and low-income people who cannot afford the toll, charging reasonable toll fees, building noise walls, and relocating affected properties.

The 112 respondents who indicated that toll road(s) will burden their community provided 65 measures (responses) to mitigate or avoid the negative impacts. This question had a relatively low response rate, which might suggest the need for additional outreach activities to inform and involve EJ communities in the decision-making process surrounding toll road(s) in Central Texas.

Overall, 77% of the respondents (184) indicated that they were amenable to being contacted in the future to provide input in the decision-making process surrounding toll road(s). The remaining 23% of the respondents did not want to be contacted in the future.

One of the core principles of the Environmental Justice Evaluation Methodology (EJEM) is the meaningful involvement of minority and low-income communities impacted by proposed toll road(s) in the decision-making process surrounding such projects. In this regard, the door-to-door survey revealed that community participation techniques preferred by most respondents were 'phone me' (43% of the responses), 'send a questionnaire' (28% of the responses), and 'come to my home' (20% of the responses). A few respondents (3% of the responses) preferred 'interview me at the shopping mall/grocery store', 'come to my church', or 'come to one of the schools in the community'. Also, 7% of the respondents indicated that the best way to contact them was through electronic mail (i.e., Internet). Furthermore, only 25% of the respondents (59) indicated that there was someone in the community that could speak for the community. The answers to this question were, however, site specific. In Manor, for example, 37% of the respondents said that there was someone that could speak for the community. On the other hand, 60% of the respondents of Site 1 (Pflugerville), Site 4 (FM-973 & FM-812), and Site 5 (FM-973 & SH-71) said that there was no one that could speak for the community. Overall, 35% of the respondents identified a neighbor who can speak for the community followed by 27% of the respondents who identified the city mayor, a representative from the homeowner associations/community center (15% of the respondents), a city council member/local representative (8% of the respondents), or a church pastor (3% of the respondents).

Over 80% of the respondents who indicated that the proposed toll road(s) will impact their trips and 78% of the respondents who indicated that the proposed toll road(s) will burden their communities indicated a willingness to provide input in the decision-making process surrounding toll road(s) in Central Texas in the future.

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