QUALITATIVE EVALUATION OF TRANSPORTATION CONSTRUCTION RELATED SOCIAL COSTS AND THEIR IMPACTS ON THE LOCAL COMMUNITY

by

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ABSTRACT

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Although construction is valuable after completion, it can cause many disturbances throughout the duration of the project. These negative impacts, such as economic losses and annoyances which face the community surrounding a construction project, are referred to as social costs. They are the inconveniences that confront the general public and take many forms, such as traffic delays and congestion, decreased revenue, increased accidents, and air and noise pollution. Social costs negatively affect the surrounding environment and everyday quality of life.

Social costs are often not incorporated into construction design, planning or budgets. This can be attributed to the complexity of quantifying the above inconveniences and the fact that most social costs do not affect the contractual parties, i.e., the project owner and the contractor. Instead, the community endures the negative impacts of construction. To change the mindset of both owners and contractors and to provide a safe construction zone with minimal inconveniences, it is imperative to understand the public's opinion of these costs. By use of surveys designed specifically for this thesis, this research evaluates the impacts of road

construction on the neighboring community, for both residents and local businesses. With a better knowledge and understanding of social cost impacts, it is possible to reduce inconveniences and nuisances due to construction operations. This thesis concludes that the construction-related social costs which businesses incur include customer decline and financial loss, whereas residents find traffic delays and traffic congestion problems to be more of an intrusive inconvenience.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter presents the introduction and background on the topic of social costs in relation to construction projects. It also develops an understanding of the problem and provides objectives and scope of this research.

1.2 Social Costs

Although construction is beneficial in the long run, it can cause many disturbances in the phases before completion. Different aspects of life are affected by construction activities including but not limited to environment, population, atmosphere, and/or economic activities. These negative effects impacting the surrounding community are known as social costs and "include inconvenience to the general public and damage to the environment and existing structures" (Najafi and Gokhale 2005). These costs involve such aspects as the monetary value of resources expended i.e., gas and time, economic losses of surrounding businesses, pollution in the air and surrounding environments, damage caused to arteriole roads due to rerouting, or damage done to vehicles driving on roads with pavement issues surrounding the construction area.

Social costs are also referred to as *user costs* since the "users" in the community are those most disturbed by the inconveniences of construction. These costs are due to inconveniences surrounding a construction site and are predominantly not included in a monetary cost analysis of the project. This can be attributed to the fact that it is difficult to measure and quantify these costs. Regardless of the complexity of quantifying social costs, it is imperative to analyze the impacts a construction endeavor will have on the community.

1.2.1 Traffic

Traffic disruption is one of the major social costs that impact the community near and around a construction project, especially road construction. People commute everywhere; whether it is to work or the grocery store, the public is always on the road and, naturally, construction will disturb this daily practice of driving. Construction detours and lane closures cause congestion and delays that can lead to accidents, extra time in the car and frustration. Extra time in the car causes additional wear and tear on a vehicle, increased fuel consumption, and a feeling of wasted time that can transfer to the workplace, affecting productivity. Detours which direct traffic to secondary roads can cause accelerated deterioration of these roads due to increased volume and load.

1.2.2 Economic Impacts

The economy plays a major role in society and should be taken into consideration during the construction phases of a project. Although its importance is pressing, economic losses are rarely deliberated because of the positive impacts construction can have on surrounding businesses. Once construction is complete, land prices may rise, development begins or continues, and access and mobility is improved; all of these advantages are economic stimuli that make it difficult for a contractor to evaluate the negative impacts a construction project may have on the area bordering a construction project. Yet in some cases, the damages such as loss of income or customers, decreased productivity, or property destruction are irrevocable and businesses are forced to close or relocate.

1.2.3 Environmental and Social Impacts

The environment surrounding us affects many aspects of our lives. Construction can be the cause of effluence detrimental to the environment and social aspects of life. Pollution encompasses air, water, land, dust, and vibration disturbances. Today, laws, policies and regulations governed by the Environmental Protection Agency (EPA) have been made to ensure the environment remains safe during any construction project; but regardless of the

many tactics available to alleviate the negative impacts they still reach the environment, even in the slightest manner. This is confirmed in a thesis by Kamat (2011) which studies the affect of dust generation on a traditional open-cut utility project. Dust, being a form of air pollution, can contribute to asthma, allergies and other respiratory problems (Kamat 2011). These problems are harmful to all those near a construction project.

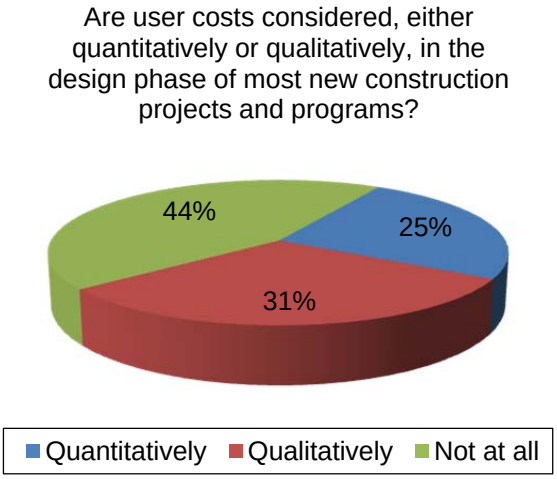
1.3 Research Statement

> "Social costs, while widely acknowledged, are rarely considered in the design, planning, or bid evaluation phases of construction projects in North America" (Allouche et al., 2004).

Social costs can cause a multitude of problems to the community near a construction site, yet are hardly ever addressed. This could be attributed to several reasons. One problem could be the lack of estimating procedures for these indirect costs. For example, it is hard to determine the amount of time that will be lost to traffic delays and consequent productivity loss due to this extra time. Also, there is no formal document listing the different social costs and how to mitigate each one; instead, these nuisances are informally noted and only if it is cost effective to do so will they be attended to.

In addition, the two parties involved, i.e., the owner and contracting firm, are minimally affected by the construction inconveniences and, therefore, do little investigation into the impacts of their construction project on the community. The owner wants the project completed on time and on budget, and the contractor's main objectives are to ensure this happens in accordance to project drawings, documents, and specifications. Because of this, "the contractor is unlikely to implement low-impact practices unless they are required contractually or are economically favorable to him" (Allouche et al., 2004). Mitigating social costs can cost extra time and money, both of which are valuable commodities to the owner and contractor, specifically when operating under limited budgets.

A survey issued by the National Cooperative Highway Research Program (NCHRP) in 1999 shows the amount of decision making that goes into examining user costs and mitigation techniques. This survey was sent to 50 state departments of transportation and 13 Canadian agencies to establish the current practice of user cost consideration and mitigation techniques. Out of the 65 recipients of the survey, 36 responded. Figure 1.1 illustrates the results of two of the questions asked.



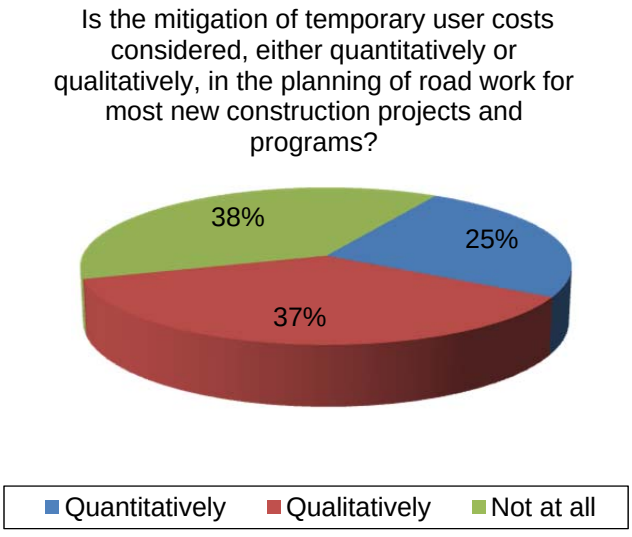


Figure 1.1 Results to NCHRP Survey Questions (Lewis, 1999)

As seen in Figure 1.1, user costs and mitigation techniques are not a top priority, and yet they do hold some regard in transportation construction projects. The results might be different for commercial, industrial, heavy/highway, and pipeline and utility projects. This can prove that social costs are not only a nuisance to the surrounding community, but detrimental to the economy, local businesses, and the environment. A local resident in Hurst, Texas, near the expansion of State Highway 121 comments on the construction in the "Cheers and Jeers" section of the Star Telegram and states: "Cheers to the highway workers widening and improving our highways. Jeers to the workers in charge of lane changes, lights and stripes. Every day someone almost runs into another car on the freeway because the 'snakelike' lines are confusing, hard to see and narrow" (Star Telegram 2011). This is a prime example of community hostility concerning construction. To alleviate the negative impacts of social costs, it is imperative to evaluate the effects these annoyances have on the community.

This research evaluates several social costs that arise due to construction and presents opinions gathered from the public near a construction site, those most affected by the activities. It will cover factors such as traffic congestion and delays, noise and air pollution, and economic impacts faced by businesses. These parameters are important issues, considering that they are commonly overlooked by the contractual parties.

1.4 Motivation

The motivation behind choosing this topic is the fact that social costs are widely ignored in the construction field yet can cause so much distress to the community. Construction will never end so the inconveniences faced by people in the area surrounding a project should be taken seriously. Understandably, the project must go on and some nuisances are unavoidable but, at the same time, contractors should be aware of the social costs of their activities just as they scrutinize over the monetary costs. From a safety standpoint, it is important to pay attention to these costs because they can inevitably cause harm if not properly assessed. Therefore, these firms should take more of an interest in mitigating the negative effects of social

costs, not only for the sake of communities but for company public relations and their professional reputation as well.

Another reason for studying social costs is to further define this crucial issue in the field of construction management. Identifying problems that concern this area can ultimately help firms be more competent when evaluating how to prevent the burdens of construction to the bordering communities.

1.5 Objectives and Scope

The main objective of this thesis is to itemize and evaluate social costs caused by a transportation construction project and the effects of these inconveniences on surrounding businesses and local residents.

Several underlying objectives will also be considered such as:

- the different types of social costs,
- negative effects of social costs,
- mitigation techniques of the negative effects of construction, and
- economic effects of social costs on businesses.

The scope of this thesis extends from identifying and assessing the different types of social costs to evaluating these costs and their effects on the community through a survey presented to local businesses and residents near a major transportation project. Quantifying social costs and estimating associated costs are not included in this research.

1.6 Methodology

The following steps will be taken to achieve the objectives of this thesis:

- Review literature and evaluate construction-related social costs affecting the community.
- Conduct surveys to obtain an accurate opinion of the businesses and residents surrounding the construction project.
- Analyze survey results to understand how construction affects the community.

- Study mitigation techniques that can be used by project owners and contractors to reduce the impacts of social costs.

1.7 Expected Outcome

A thorough understanding of social costs and their impacts on the surrounding community is the main outcome of this thesis. Through the use of surveys, this research will be able to gauge the impact of construction on the general public. With better knowledge on the subject, it will be more feasible to prevent some of the inconveniences and damages construction social costs can cause.

1.8 Organization of the Thesis

This research paper consists of seven chapters. The first chapter introduces the topic of study and the needs for this study. The second chapter presents the existing literature in the problem area and evaluates different social costs of construction. The third chapter introduces the methodology to achieve objectives. The fourth chapter organizes, evaluates and analyzes the data and results of the research. Conclusions and recommendations for future research are presented in chapter five.

1.9 Chapter Summary

This chapter introduced the inconvenience of construction operations, also known as social costs, and developed a platform for this thesis. It also reviewed the objectives, scope, methodology and expected outcome of the research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Chapter 1 presented an introduction, background, objectives and brief methodology for this research. The objective of this chapter is to examine and review the literature found on construction-related social costs, and will look at the methods of estimating the economic impacts of construction inconveniences unless mentioned in literature.

2.2 Social Costs of Utility Construction

According to the book, "Trenchless Technology" by Mohammad Najafi and Sanjiv Gokhale (2005), total budget costs consist of preconstruction, construction, and post-construction costs. Direct, indirect and social costs are included in construction costs. Social costs are those costs that are not apparent to the contractual parties but are obvious to the community near a construction project. Awareness of these costs is becoming more evident due to the need to conserve the environment and protect our quality of life. In the case of a pipeline or utility project, authors present that if social costs are evaluated in the life cycle costs of a project, trenchless technologies[1] can be more cost effective. Social costs for trenchless projects can amount to three to ten percent of the total costs of the project, whereas for traditional open-cut, social costs can be up to 70% of the total construction costs (Najafi and Gokhale 2005). Table 2.1 presents factors for social costs and the impacts for both open-cut and trenchless technology.

[1] Trenchless technology is an advancement in the field of utility and pipeline construction and renewal compared with the traditional method which is trenching or open-cut. Using new equipment and improved technology, these techniques, such as microtunneling, pipe jacking or horizontal directional drilling allow for minimal surface disruptions, decreased social costs, less footprint, enhanced safety, increased productivity, and in some cases less costs (Najafi and Gokhale 2005).

Table 2.1 Cost Factors for Social Costs (Najafi and Gokhale 2005)

Cost Factor	Open Cut	Trenchless
Vehicular traffic disruption	Major	Minor
Road damage	Major	Minor
Damage to adjacent utilities	Major	Minor
Damage to adjacent structures	Major	Minor
Noise and vibration	Major	Minor
Heavy construction and air pollution	Major	Minor
Pedestrian safety	Major	Minor
Business and trade loss	Major	Minor
Damage to detour roads	Major	Minor
Site and public safety	Major	Minor
Citizen complaints	Major	Minor
Environmental impact	Major	Minor

Calculating these social cost factors is important to understanding their impacts on the community. Although specified methods for estimating social costs are presented in the text, Najafi and Gokhale reiterate the fact that project conditions differ and to get an accurate quantification, project specific aspects must be taken into consideration, one of the most important being project duration. For example, the loss of revenue for a business is equal to the average dollar loss per day multiplied by the duration of the project in days (Najafi and Gokhale 2005). To reduce social costs, proper planning, scheduling, choice of construction method, and timing of construction activities should be considered.

In a similar article, Glenn Boyce and Eleanor Bried (1994) analyze indirect costs by studying the advantages of trenchless technologies over traditional trenching techniques concerning social and environmental costs. They are concerned with comparing total costs of both methods and state that traffic disruptions consist of two elements: vehicular wear and gas consumption, and time costs for individuals in the vehicles and on the roads. Vehicular wear accelerates when the road pavement is damaged by trenches and heavy machinery that causes potholes and cracks. Detours to avoid the construction which force individuals to drive further and the traffic congestion from construction can both be a source of excess gas consumption. As stated previously, traffic congestion and detours can cause wasted valuable time for those

on the road. Obviously, with trenchless expertise these traffic disruptions can be minimized and the negative impacts of trenching operations on the community are mitigated.

In the same article by Boyce and Bried, they attest that trenchless technologies are “far less disruptive to businesses than trenching” (Boyce and Bried 1994). Economic loss is obviously a concern with all construction projects and can eventually lead to business closures. The authors state that there are three parts associated with businesses shutting down:

- Decreased sales– To some individuals, the nuisance of construction outweighs the need for a particular service or good and therefore this customer will find another location to shop or not go out at all which in turn leads to decreased revenue for the business.
- Decreased rent for building owners – Due to construction noise, dust, and aesthetics, the value of land and buildings will decrease temporarily.

The inconveniences construction has on the community can cause consumers to go elsewhere to get the goods or services they need. Not only is this a nuisance to the individual, it causes sales to decrease and can lead to debt or closure. Also, “business closures have a greater or lesser social impact depending on the substitutability of goods or services offered and the ease with which customers can go elsewhere to purchase the same items” (Boyce and Bried 1994). Therefore it can be difficult to measure these social costs because they are dependent on the specific nature of an individual and project location. Nonetheless, economic losses can cause many problems during the construction phase of a project and should always be taken into account when analyzing the total cost of an endeavor.

Noise pollution and dust and dirt control are referred to as environmental impacts in the journal article by Boyce and Bried (1994). These impacts affect productivity and quality of life, and should be considered when analyzing the costs and benefits of a construction project.

2.3 Social Costs at Highway Work Zones

Yi Jiang (1999) specifically develops a model for estimating user costs at highway work zones. He uses two Indiana Highway work zones as case studies in his research and states that traffic disruptions at work zones "result in excess costs to motorists in time, consumption of fuel and oil, and wear and tear of vehicle parts" (Jiang 1999). Traffic disruptions include reduced speed at work zones, congestion, and traffic capacity through work zones. In his research, Jiang estimated social costs on the basis of equations developed to measure travel delay costs. To conclude the research, it is stated that "user costs were mainly affected by traffic flow rates, vehicle speeds, and work zone lengths" (Jiang 1999). Models similar to this one should be used to estimate user costs at construction sites in order to be proactive regarding the inconveniences faced by the public.

In a comparable study performed by Lee et al (2005), traffic analysis was initiated to develop the most economical reconstruction closure scenario of an Interstate 15 (I-15) segment in California. The authors state that "construction activities negatively influence the traffic flow of roadways that are already above or near flow capacity" and should be carefully considered in the total cost, which includes road user costs (Lee et al. 2005). In this research, an innovative approach was developed to design construction operations and traffic management plans that will minimize road user costs for the rehabilitation project on I-15.

To develop efficient construction and traffic management plans in regards to construction schedule, traffic inconvenience and total cost, the authors studied four different closure scenarios: 72-hour weekday, 55-hour weekend, one-time continuous, and 20 hour nighttime. The Construction Analysis for Pavement Rehabilitation Strategies (CA4PRS) was used to come to a final conclusion. After a thorough analysis it was decided to use eight 72-hour weekday closures to accelerate construction and reduce total cost, including road user costs, by millions of dollars. It was estimated that there will be 34% less road user costs due to traffic delay using this method (Lee et al. 2005). Although this case study reflects a California

highway, it can be used for any similar roadway construction project to increase productivity while maintaining nominal traffic delay and minimizing total cost.

2.4 Quantification of Social Costs

Social costs as defined previously are “costs incurred due to the execution of a construction project that cannot be classified as either direct or indirect costs incurred by the parties engaged in the contractual agreement” (Allouche and Gilchrist 2004). In order to quantify social costs, it must be understood what social costs are. In the article “Quantification of Social Costs Associated with Construction Projects,” Allouche and Gilchrist look at several social cost indicators including traffic, economic activities, and environmental and social health.

Traffic delays and interruptions can be caused by a number of factors. According to Allouche and Gilchrist the following are the causes of traffic delays:

- Prolonged lane or road closures – Construction activities require excess space for equipment, staging, entry/exit corridors and more, and unfortunately the area used to produce this space are the existing roads and land adjacent to the site. These designated areas can cause the roads to be partially or fully closed.
- Modification to routes or detours – Since road closures are typical of a construction project, detours are necessary. These detours lead traffic to alternate routes to navigate around the construction.
- Reduced speed through construction zones – When construction is located in a fast paced urban setting, the workers at the site must be protected. To provide a safe work environment the speed limit must be lowered. This not only protects the construction worker but can also protect pedestrians who may be walking nearby or the driver travelling through the construction zone.

The above article also states that the previous causes of traffic delays result in the subsequent social costs:

- Traffic congestion – When roads are closed, lanes are reduced, or the speed limit is lowered, traffic congestion can occur and roads can be clogged for miles.
- Travel delay – Traffic congestion and detours can cause increased travel, whether in minutes, miles, or both.
- Additional fuel consumption – With the frequent stop and go actions that traffic can cause, excess fuel will be consumed by vehicles. This not only causes increased pollution but can be a financial burden.
- Increased traffic accidents – Traffic backups, lane closures and speed changes cause an increase in traffic accidents due to the congestion that occurs.
- Accelerated deterioration of detour roads – When construction activities force roads to close, alternative routes must be provided to redirect traffic to its intended destination. These detour roads are most likely not made for the traffic flow and load they are now carrying, and as a result will shorten the designed life of the pavement.
- Loss of parking space – Area surrounding the construction site might be commandeered by the contractor for equipment, staging and more, causing the loss of parking spaces which can be an expense over time.
- Road rage – Road rage is a defiant behavior evoked by anger and frustration that occurs between vehicle drivers. Construction can heighten road rage because of the congestion and confusion it can cause. A study completed in 2003 claims “that over 1,200 road rage-related deaths occur each year in the United States” (Allouche and Gilchrist 2004).

Large, prolonged construction projects “can have a measureable fiscal impact on the municipal and local government tax base, business sales and personal income within the project’s influence zone” (Allouche and Gilchrist 2004). The authors go on to recognize several negative economic impacts including:

- Loss of income – Businesses within the influence zone of a construction site may often face decreased income or revenue due to reduced accessibility and detours that lead customers away from their location and construction nuisances. Noise and dust can also deter customers. This loss of income can ultimately force companies to go bankrupt and close.
- Productivity reduction – The ability to perform work at intended levels may be lessened from the impacts of construction. Construction annoyances, including traffic delays, dust and noise, can cause employee's productivity rate to decrease. Traffic congestion can also negatively affect people's mood which in turn can transfer directly to work, inhibiting productivity.
- Reduction in tax revenue – With diminishing sales caused by decreased customer traffic, businesses naturally will pay less income tax. This is detrimental to city and state tax revenues.
- Property damage – Construction activities can bring about damage to surrounding properties resulting in a number of costs to property owners. Settlement is the most damaging cost and can result in structural failure of buildings. Dust and noise not only affect customer retention and productivity but can lower property value.

Although construction projects can produce long-term positive impacts, the disadvantages should still be weighed and considered to protect the city or surrounding businesses.

Lastly, the research by Allouche and Gilchrist (2004), discusses noise, dust, vibration and air as types of pollution affecting the environment and community. Noise is measured in decibels and has the ability "to annoy or disturb humans, or cause adverse psychological or physiological effects on humans" (Allouche and Gilchrist 2004). Prolonged exposure to noise can be more than a mere distress; it can lead to high blood pressure and cardiovascular disease (Allouche and Gilchrist 2004). Noise disturbance can impact the quality of life when it affects sleeping patterns and reduces productivity due to fatigue and frustration.

Disturbance of the dirt and soil during construction can also significantly agitate residents near jobsites and can damage electrical and mechanical utility systems. Not only is agitation a cost of surface disruption, a major impact can be seen on the water surrounding the construction site, surface or groundwater. Projects that interrupt water flow can affect “volume, velocity and sedimentation rate, and can result in bank erosion, flooding, alterations of the normal course of rivers and streams, and damage to the aquaculture” (Allouche and Gilchrist 2004). Dewatering can also harm the surrounding environment by lowering the groundwater table which can impact nearby vegetation or settlement of structures. Vibration from activities such as pile driving, compaction, blasting or operation of heavy equipment can range from frustration to structural damages. A major issue caused by vibration is settlement, the moving of soil, which can cause structures to become unsound and ultimately cost large amounts of money to fix. Vibrations can also cause feelings of a lack of safety when they are high enough to shake buildings or cars.

Air pollution from a number of things operated at construction sites, including heavy machinery, tailpipes, and engines, can cause harm to humans and other living organisms. This equipment tends to emit harmful emissions into the air, such as carbon and nitrogen oxides, which not only affect the nearby breathing air but can impact our ozone layer. Along with toxic emissions, dust is another air pollutant originating from construction sites that can “increase cleaning and maintenance costs, reduce agricultural production and lower aesthetic quality of the environment” (Allouche and Gilchrist 2004). These different types of waste can cause destruction to the environment, reduced quality of life, and consumption of resources (Allouche and Gilchrist 2004).

To conclude, the authors present different techniques for the valuation of social costs. The ability to estimate social costs is crucial to lessen the impacts they have on the community.

2.5 Environmental Impacts

In a report by Bein (1997), he proposes that environmental impacts include: air, noise, vibration and water pollution, land disturbance, resource consumption, waste problems, and ecosystem disruption. These environmental impacts have become an increasingly growing concern for the government and public agencies. He goes on to say that “traditional evaluation approaches have been criticized for their failure to account for the intrinsic values of the environment,” which is indicative to the eminence placed on sustainability in today’s world (Bein 1997).

The above report goes into detail about the monetization of environmental costs that must be considered when evaluating the costs and benefits of road construction. If environmental impacts can be quantified, then their incorporation into a budget is straight forward. In addition to quantifying construction impacts on the surrounding land, laws and policies are set forth to protect the natural environment.

2.5.1 National Environmental Policy Act

The National Environmental Policy Act (NEPA) was founded in 1969 and became effective January, 1 1970. This national policy studies the costs a construction project will have both environmentally and socially and must be adhered to if the project is to receive federal funding. NEPA “establishes national environmental policy and goals for the protection, maintenance, and enhancement of the environment and provides a process for implementing these goals within the federal agencies” (USEPA 2011).

There are three major NEPA documents for analysis of a proposed construction project: Categorical Exclusion (CE), Environmental Assessment (EA) and Environmental Impact Statement (EIS). If an undertaking is considered to have minimal environmental impacts it will be categorically excluded. If a project cannot be excluded an EA must be drafted to determine the significance of the endeavor’s environmental impact. After substantial analysis if the project is found to have a minimum affect on the environment A Finding of No Significant Impact

(FONSI) will be issued. On the other hand, if the project is determined to significantly affect the environment an EIS is prepared. An EIS is the highest level of analysis and is a detailed evaluation of the environmental impacts of the intended project and any alternatives. Once an EA or EIS is reviewed and approved by the Environmental Protection Agency a project can move forward. (USEPA 2011).

A recent State Environmental Assessment by the Texas Department of Transportation, prepared in 2011, studies the environmental impacts of a proposed road expansion. The road in question is FM 720 between Eldorado Parkway and U.S. Highway 380 in Denton County, Texas, and "is needed because the current transportation network in the project area is insufficient to accommodate future traffic demands projected by the TxDOT Transportation Planning and Programming Division" (TxDOT 2011). This EA consists of a description of the project and existing conditions, alternatives, potential social, economic and environment effects and a conclusion. Some topics analyzed for potential environmental impacts include 4(f) properties, nearby lakes, rivers and streams, vegetation habitat, endangered species, and more. For example, in the Environmental Assessment drafted for the proposed road in Denton County, a study is performed on the threatened or endangered species in or near the proposed action. Out of the federal/state listed threatened/endangered species in Denton County, only two were of concern for this anticipated project, the Plains Spotted Skunk and the Texas Garter Snake (TxDOT 2011). To evaluate potential social impacts on the surrounding area, TxDOT analyzes cultural resources, noise, visual impacts and more.

2.6 Community Impact Assessment

In order to mitigate social costs, a contractor must examine the community surrounding the construction site. For example, traffic disruption is a critical social cost in the city, yet where traffic is nominal it is of slight concern. In a rural area there is obviously little or no business activity so there will be minimal economic loss near the construction site. If anything, new construction will lead to growth and development. This is the advantage to community impact

assessments; they allow the contractor to be aware of both the negative and positive impacts their construction project will have on the bordering area. There are many articles, handbooks, and guidebooks regarding community impact assessment but, for the sake of simplicity, two pieces will be reviewed.

First, the Community Impact Assessment by Brock et al (1996) is a guidebook to help professionals and analysts to assess the impacts of transportation projects on the community. It summarizes a community impact assessment process, examines critical areas that must be evaluated, identifies tools and information sources to complete an assessment, and stimulates the thought process related to individual projects. It goes on to define what a community is and the importance of a community impact assessment. Analysts should take into consideration negative and positive impacts, long-term and short-term effects, public thoughts on impacts, and then focus on the magnitude of an issue to adopt an appropriate level of specificity (Clower et al. 2006). The following types of impacts might be identified and analyzed:

- Social and psychological aspects
- Physical aspects
- Visual environment
- Land use
- Economic conditions
- Mobility and access
- Provision of public services
- Safety
- Displacement

A significant quality of a community impact assessment is the fact it “ensures that human values and concerns receive proper attention during project development” (Brock et al1996). The community is of high importance since they are directly affected and should take precedence when evaluating a project’s impact.

Next, is the Caltrans Community Impact Assessment which is volume four in the Environmental Handbook from 1997. The intention of the handbook "is to set forth study procedures for gathering information and assessing impacts related to proposed transportation improvements on communities and neighborhoods…and to provide guidance on how to reduce or avoid project effects on the human environment" (Caltrans 1997). Laws, regulations and policies are set forth in the book to help with the process of evaluating the impacts of a construction project, and mitigation techniques are presented to lessen the negative effects. The handbook lists the following impacts included in a community impact assessment (Caltrans 1997):

- Social Impacts
    - Relocation of Housing
    - Population Characteristics
    - Community Institutions
    - Community Stability and Cohesion
- Economic Impacts
    - Change in Employment
    - Income Gains or Loss
    - Tax Base Changes
- Land Use and Growth
    - Consistency of Projects with Local Plans
    - Shift in Location Where Growth Will Occur
    - Development Opportunities Enhanced
- Public Services Impacts
    - Schools and Health Systems
    - Police and Fire Protection
    - Accessibility and Parking

- Utilities

In addition to the previous two reviews, there is more research on analyzing the impact of construction on the community; therefore it is an important necessity. The community is the most affected entity and their well-being should be taken into consideration. Contractors should not only perform these assessments to determine possible impacts but must do their best to mitigate any negative effects from the construction project.

2.7 Mitigation of Social Costs

Although some construction nuisances cannot be avoided, there are ways to lessen the social costs of construction on the surrounding community. One of the easiest ways to evade the annoyances of construction is to choose the “no-build” alternative. Though this is always a possible option, it is not always the right one. Therefore, contractors should take into consideration the surrounding community.

Typically, accepted contracts between an owner and contractor do not take into account costs, whether social or monetary, resulting from construction-related activities that affect outside parties. This is because owners and contractors do not have to answer directly to the public since they are not contractually bound. Presently there are overpowering policies that govern mitigation techniques but, nonetheless, all social costs cannot be covered and the main goal of the contractor is to finish the project on time and on budget, even at the expense of the community. Thus, “the contractor is unlikely to implement low impact practices unless they are required to contractually or are economically favorable to him” (Allouche and Gilchrist 2004). According to Allouche and Gilchrist (2004), Figure 2.1 should be adopted as a new paradigm.

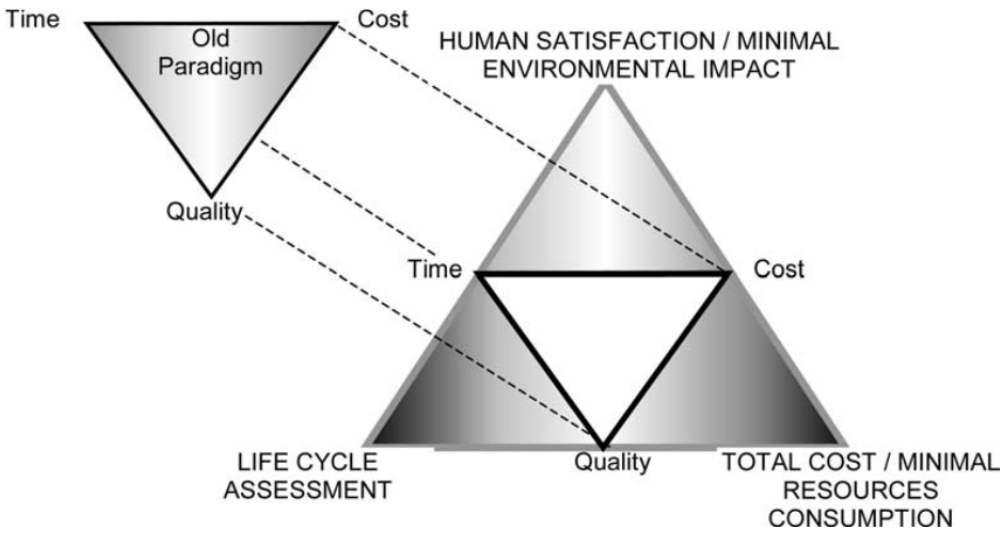


Figure 2.1 The New Paradigm for Sustainable Construction (Allouche and Gilchrist 2004)

In comparison to the traditional standard attainment of time, cost and quality, Allouche and Gilchrist suggest that the new paradigm encompass an extensive view of these three requirements: "time (life cycle assessment), cost (construction and social costs; minimal resource consumption) and quality (human satisfaction; minimal environmental impact)" (Allouche and Gilchrist 2004). Incorporating this into the contractors system begins with the bidding process, namely the cost estimate. If costs are set aside in the beginning for mitigation techniques, funding will not be an issue when the need arises.

The Wisconsin Department of Transportation's (WisDOT) Economic Guideline Analysis has an entire section on "Mitigating Work Zone Traffic Impacts" (2010). Almost all transportation projects have an impact on the road users. *Mitigation* is the term for reducing these construction-related impacts or costs to the user; it is the measures taken to lessen the temporary impacts of construction seen by the general public. WisDOT's policy is to design the most cost-effective and efficient Mitigation Strategy that lessens the negative impacts of construction while still maintaining a feasible cost to the agency. Several examples of mitigation methods include:

- public campaigns or meetings to give updates on construction, detours, and closings,

- electronic message signs to notify the public of closures or alternate routes,
- clearing accidents quickly to reduce additional congestion,
- contracting with temporary alternate modes of public transportation to allow for more traveling options and to alleviate congestion,
- enhanced detour route signs for better flow and less public frustration,
- constructing temporary roads or lanes to avoid full or partial closures,
- modifying the hours or days when work is performed. Night and weekend work will cut down construction impact on road users, and
- using designated accelerated construction techniques to complete work earlier.

The department states that mitigation costs should not exceed 10% of the total Road User Costs (WisDOT 2010). This keeps agency costs minimized but allows finances to be apportioned to the reduction of social costs. A combination of mitigation techniques is compiled to form the most cost-efficient mitigation strategy. The selection of mitigation methods is also substantially site-specific. The department illustrates this point with an example showing that using a “Smart Work Zone” system of traffic deflectors and electronic signs is more effective and cost efficient for a shorter detour but may be more cost prohibitive on a long and confusing detour. Overall, a mitigation strategy is developed for all transportation construction projects in Wisconsin, which helps reduce the social costs of the endeavor.

2.8 Chapter Summary

This chapter reviewed the existing literature on construction related social costs. It is imperative to understand the impacts of construction on the general public in order to select effective methods to reduce these impacts.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The previous chapter reviewed the literature on the subject of social costs. This chapter presents the methodology implemented to achieve the objectives stated in Chapter 1.

3.2 Methods

The main objective of this research is to evaluate the social costs caused by construction and the effects these inconveniences have on the surrounding community, namely businesses and local residents bordering the corridor of a transportation project. Several underlying objectives include the study of mitigation techniques and investigating the economic effects of construction on businesses.

To achieve the proposed research goals, several tasks were completed. These tasks consisted of:

- collecting information on known social costs and mitigation techniques,
- surveying a community, both residents and businesses, surrounding a construction site, and
- analyzing and evaluating survey results to better understand how construction affects the community.

This above methodology was used as a guideline by which this thesis and its objectives were completed.

3.3 Research

To begin, a literature search was completed with the intention of gathering information regarding social costs and their impacts on the community as well as methods of lessening their effects. There is ample research on the broad aspect of the effects of social costs

on the community. The literature focuses on what social costs are and the negative outcomes they have on the area surrounding a construction project. Mitigation plans are the main approach taken by construction companies to draft a strategy to minimize the negative effects of construction. In addition to researching mitigation means, an interview with a contractor was conducted.

3.4 Data Collection

Following selection of a research methodology, a survey was dispersed to local businesses and residents near the State Highway 121 expansion through the cities of Bedford and Hurst, Texas.

3.4.1 Project Description

The State Highway 121 expansion is part of a massive construction project, the North Tarrant Express (NTE), to improve mobility of 13 miles along Interstate 820, Interstate 35-W, and State Highway 121/183 through a regionally supported toll road. Figure 3.1 displays a map of this expansion.

Figure 3.1 Map of the NTE (NTE 2010)

North Tarrant Express Mobility Partners (NTEMP) is designing and rebuilding the infrastructure. NTEMP, working closely with the Texas Department of Transportation, has contracted with Bluebonnet Contractors to construct this 2.02 billion dollar project.

With a fast-track project delivery method, construction began in October of 2010 and should be completed by 2015. The completed project will consist of eight to ten lanes with a combination of continuous frontage roads, reconstructed general purpose lanes, and additional managed toll lanes that will use dynamic pricing. Initially, during peak hours it will cost 53 cents per mile to travel in the managed lanes and out of peak hours it will cost 15 cents per mile (TxDOT 2012). The endeavor will improve mobility throughout North Texas by almost doubling the existing road capacity. Figure 3.2 shows an aerial view of the construction at the SH121/183 split in February of 2012.

Figure 3.2 SH 121/183 Split Facing East (NTE 2010)

3.4.2 Surveys

The purpose of the surveys conducted for this thesis was to focus on the effects social costs have on the community. Research on designing a survey was completed to have an efficient survey. A simple process, as described below, was followed in the compilation of each survey:

- set goals and objectives of the survey,
- address and avoid biases of the survey author,
- explore resources,
- define and set the parameters for participants,
- determine response format, and
- decide on survey length (Morrison and Seibert 2002).

To facilitate unbiased responses, proper questions were asked to accurately assess the opinions of the community. Although each survey contained optional open-ended responses, all other questions were close-ended to measure knowledge and attitudes. Several advantages to close-ended questions include less researcher bias, enhanced reliability and quick turnaround. Concise questions were created with simple, clear language to diminish any uncertainty or difficulty for any participant.

In both surveys, multiple choice questions were used as well as scaled questions. The focus of the business survey is on the economic losses, such as loss of income, productivity loss, or employment problems. Multiple choice questions begin with respondent's information, and move on to concentrate on business operations, including sales and employees. The scaled question is aimed at capturing the business's attitude towards several construction nuisances faced by businesses such as property protection and noise disruption. This 16-question survey was taken to businesses along the corridor of the construction project between Murphy Road and Bedford-Euless Road in Bedford, Texas. It was conducted in person so a proper introduction was given verbally. Owners or managers were asked to fill out the survey since their position affords them more knowledge of the business.

Surveys to local residents focus on the daily nuisances of a major construction project near their home. Multiple choice questions examine daily commutes to work and local driving through and around construction. The scaled question concerns the participant's personal opinion regarding construction nuisances the public faces on a daily basis. In order to relate the

two surveys, this residential survey highlights residents' responses concerning travel to local businesses. Residents living within three miles of the construction were sent an email with a link to the online survey of eight questions for completion. Since this survey was produced online an appropriate written introduction appeared at the beginning and all residents in the household who drive were asked to participate. Appendix A includes blank survey forms.

3.5 Analysis

Data collected was analyzed to reveal the opinions of those most affected by the construction project, and conclusions were based on the findings. This analysis, along with research results, will take place in the next chapter. Analyzing techniques will include bar graphs, pie graphs and tables. Statistical analysis of the data consists of frequency distribution, mean and mode.

3.6 Chapter Summary

In this chapter the research methodology was introduced. Through the study of social costs and the execution of surveys to local businesses and residents the objectives of this thesis will be reached. The methods presented and the survey results will lead to a better understanding of construction and its impact on the community.

CHAPTER 4

RESEARCH RESULTS

4.1 Introduction

This chapter presents the results and analysis of the research methods discussed in Chapter 3. Results are separated into two groups: 1) outcome from business surveys and 2) outcome from residential surveys.

4.2 Business Survey

The sixteen-question business survey was taken to businesses along the North and South corridors of the State Highway 121 expansion project between Murphy Road and Bedford-Euless Rd in Bedford, Texas. Figure 4.1 shows an aerial map of the passage where business surveys were taken.

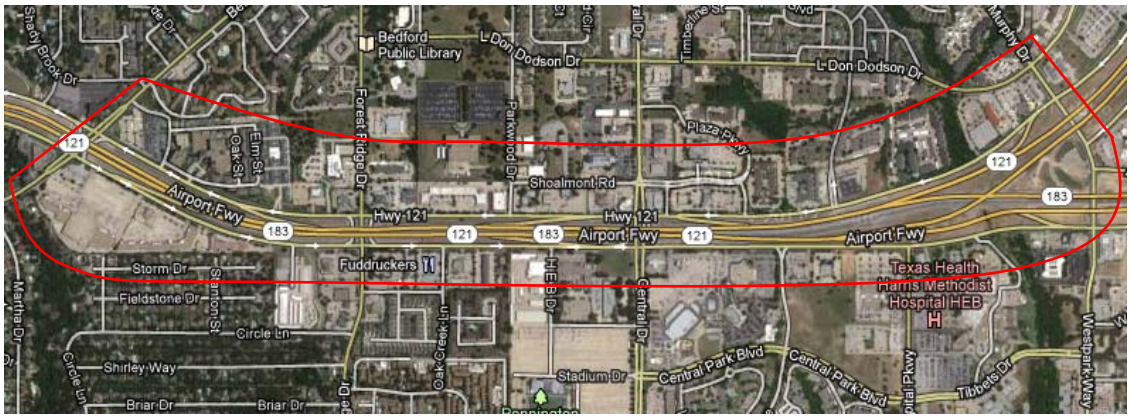


Figure 4.1 Aerial Map of SH 121 Corridor (Google Maps)

The survey examines social costs endured by businesses due to construction. For a list of businesses that completed the survey, refer to Appendix D. Out of the forty-six (46) businesses that were asked to participate, twenty-six (26) filled out a complete survey. This is a fifty-six percent (56%) response rate. The analysis presented in the next section evaluates the

results from the business survey. It is divided into two sections according to whom or to what the question pertains.

4.2.1 Personal

The first three survey questions directly relate to the individual completing the survey. Questions one and two concern driving times before and after construction commencement; the results are seen in Tables 4.1 and 4.2 and Figures 4.2 and 4.3.

Table 4.1 Results of Question 1

1. Before construction began, how many minutes did you travel to work?		
Response	**No. of Respondents**	**Percentage of Respondents**
0-10 minutes	14	53.8%
11-20 minutes	6	23.1%
21-30 minutes	2	7.7%
31-40 minutes	4	15.4%

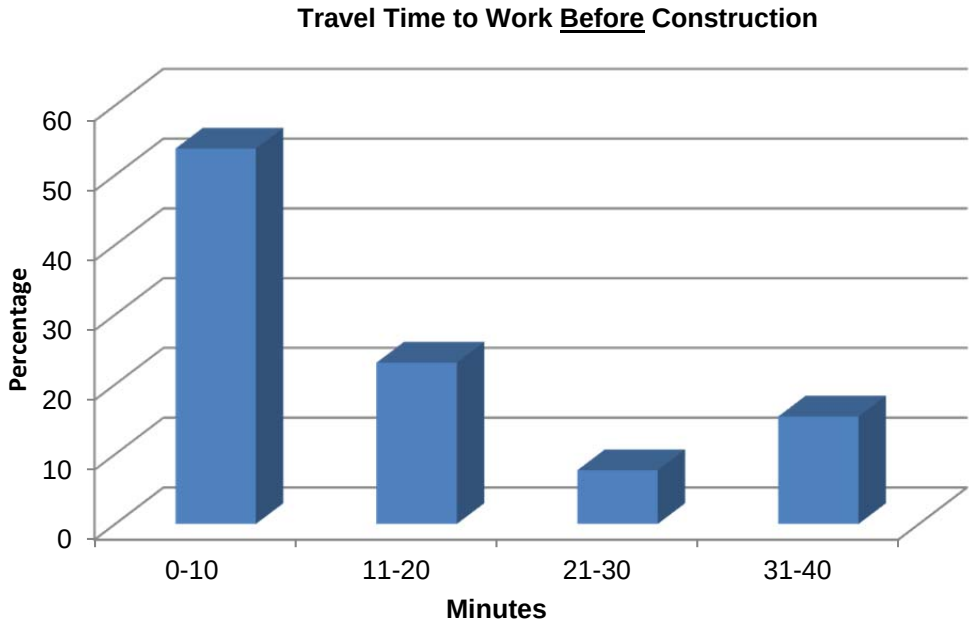


Figure 4.2 Results of Question 1

Table 4.2 Results of Question 2

2. If your travel time to work has increased because of construction, how many extra minutes do you spend in the car?		
Response	**No. of Respondents**	**Percentage of Respondents**
0-5 minutes	10	38.5%
6-10 minutes	8	30.8%
11-15 minutes	5	19.2%
16-20 minutes	3	11.5%

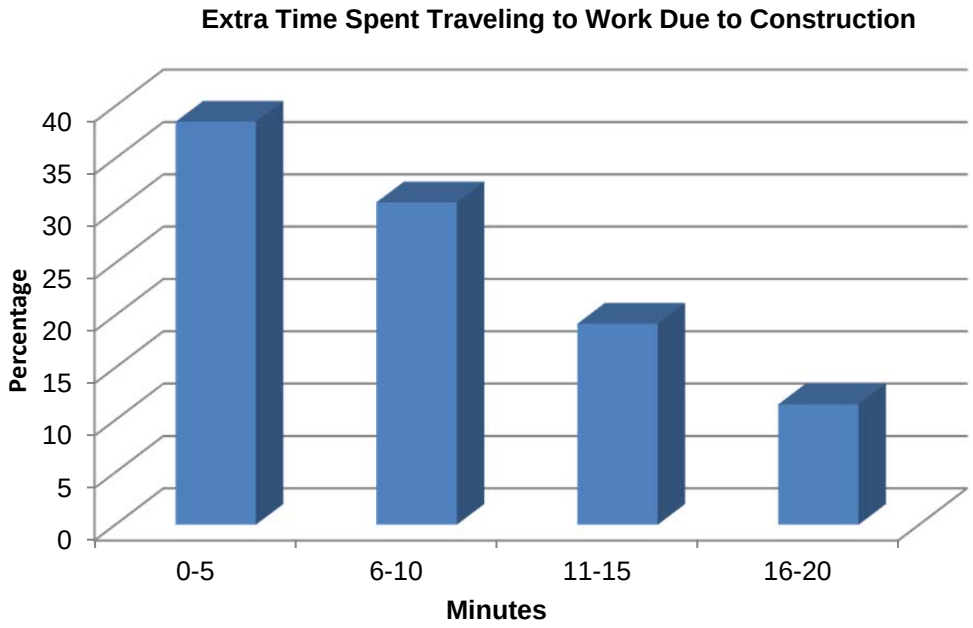


Figure 4.3 Results of Question 2

The results from Question 1 and 2 from the business survey are indicative to the individual who filled out the survey, either a manager or owner of the business. They show that on average it took the participant between zero and twenty minutes, leaning towards the latter part of the interval at 11 to 20 minutes, to drive to work before construction began. Following the commencement of construction and the inconvenience of detours and congestion, the average travel time to work increased by 6 to 10 minutes. The outcomes from these two questions are evidence that construction causes inconveniences to the driver. The extended travel time leads

to additional fuel consumption, added vehicle wear and tear, and agitation. These social costs are rarely investigated by a contractor.

Table 4.3 and Figure 4.4 illustrate the results from Question three reflecting how construction can affect mood.

Table 4.3 Results of Question 5

3. How is your work productivity affected when you get to work?		
Response	**No. of Respondents**	**Percentage of Respondents**
Negatively	11	42.3%
Not Affected	14	53.9%
Positively	1	3.8%

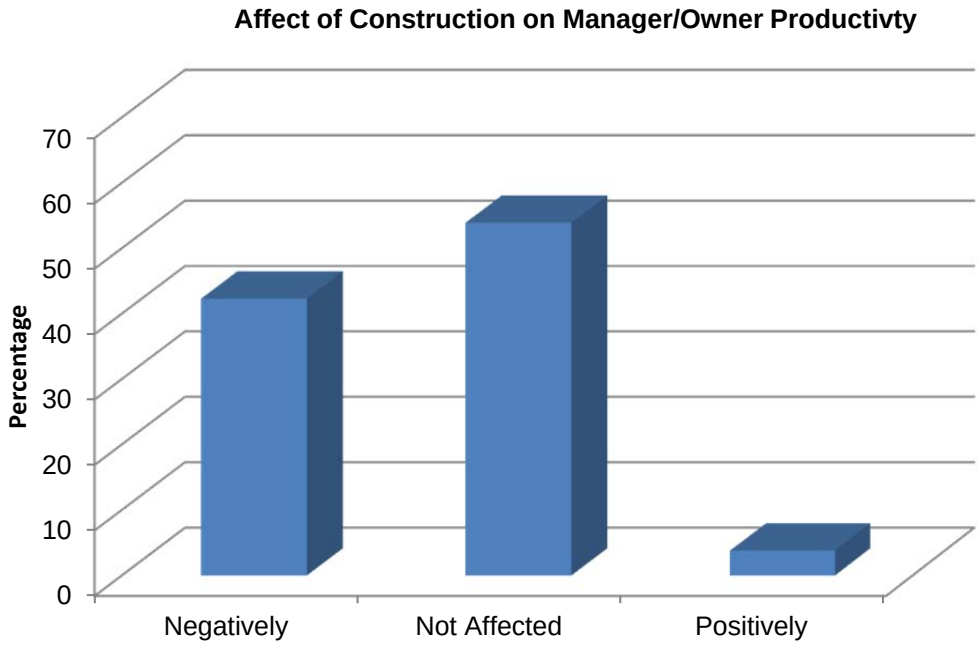


Figure 4.4 Results of Question 3

From the results of Question three, 11 of 26 participants stated that their productivity is negatively affected when they arrive at work and 14 of 26 stated that productivity is unaffected. Only one participant indicated that his/her productivity was positively affected, implying that construction does not increase work place productivity but may not necessarily decrease productivity. Longer travel times to work, traffic congestions, or detours can influence a person's

mood or attitude which can, in turn, impact productivity. According to this survey, out of the 11 respondents who said their productivity was negatively affected, 7 spent an extra 10 or more minutes driving due to construction. Every participant who spent an additional 16-20 minutes in the car stated their productivity was negatively affected. This shows that the more time spent in a car due to traffic congestions and detours can negatively affect mood and productivity.

4.2.2 Business Operations

This section contains the survey results that directly concern the business such as pre-construction forewarning, economic impacts, and employees. Tables 4.4 and 4.5 and Figures 4.5 and 4.6, show the results of the first two questions in this section.

Table 4.4 Results of Question 4

4. Were you forewarned about this extensive construction project in order to plan ahead?		
Response	**No. of Respondents**	**Percentage of Respondents**
Yes, via written communication	16	61.5%
Yes, via verbal communication	8	30.8%
No , the business was not forewarned	2	7.7%

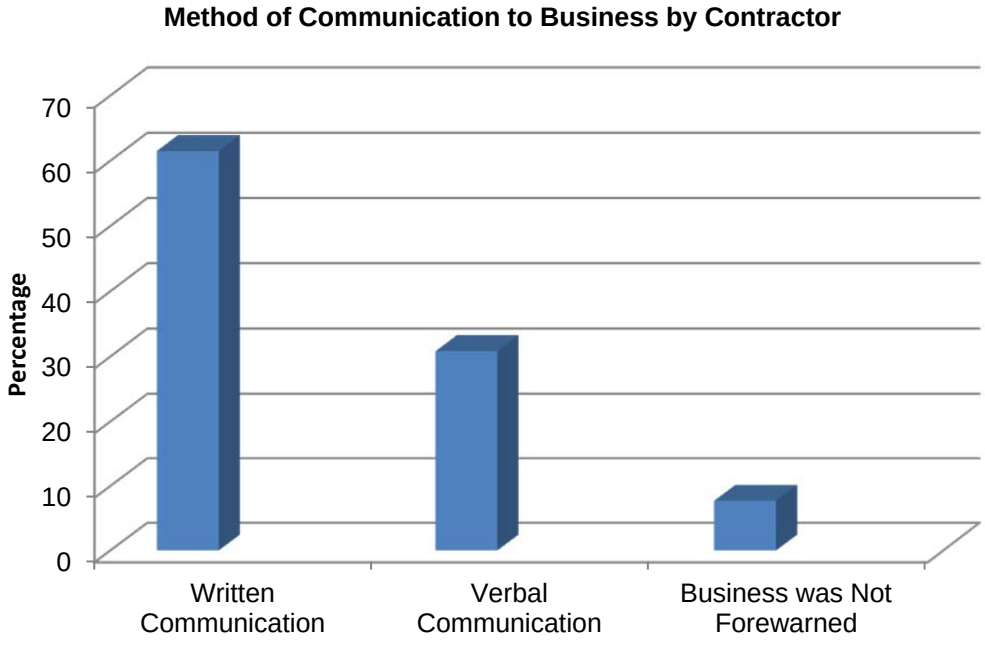


Figure 4.5 Results of Question 4

Table 4.5 Results of Question 5

5. Did the contractor express any methods to reduce the inconveniences of construction for your business?		
Response	**No. of Respondents**	**Percentage of Respondents**
Yes	3	11.5%
No	23	88.5%

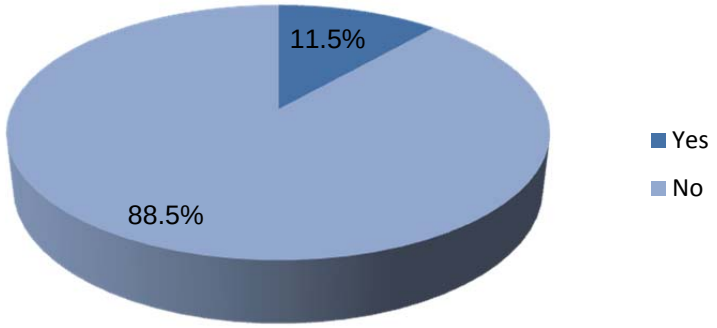


Figure 4.6 Results of Question 5

The results indicate that 24 out of the 26 businesses responding were forewarned by the contractor, either written or verbally, about the State Highway 121 expansion. As expected, the contractor only offered three of the 26 businesses methods to reduce the inconveniences of traffic. For one business, a restaurant, the contractor created a gravel road to a vacant parking lot to accommodate the lack of parking space that was confiscated for construction. A second business was given moving expenses in order to relocate because their existing building was in the acquired right of way. The manager at the third business, another restaurant, responded to this question by saying “the contractor gave us his personal business card so we can give him feedback or if we need anything to help our business.” Businesses face many social costs that can ultimately lead to closure. Although construction can be unavoidable, additional remedies by the contractor to surrounding business would lessen business closure. Contractors should draft a thorough mitigation plan that includes methods to reduce the impacts of construction on businesses.

The next seven questions in the survey pertain to economic impacts businesses face due to construction. Figure 4.7 presents the results to Question 6.

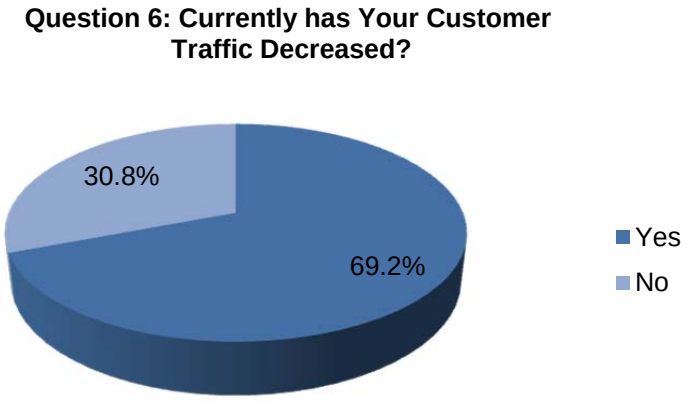


Figure 4.7 Results to Question 6

From the 26 respondents, 18 said their customer traffic has decreased. Table 4.6 and Figure 4.8 summarize the results of the 18 participants that said yes to Question 6.

Table 4.6 Results of Question 7

7. By what percentage do you think your customer traffic has decreased?			
Response	**No. of Respondents**	**Percentage of Respondents**	**Percentage of Total**
Less than 10%	1	5.6%	3.8%
Between 10% to 20%	6	33.3%	23.1%
Between 20% to 30 %	9	50%	34.6%
More than 30%	2	11.1%	7.7%

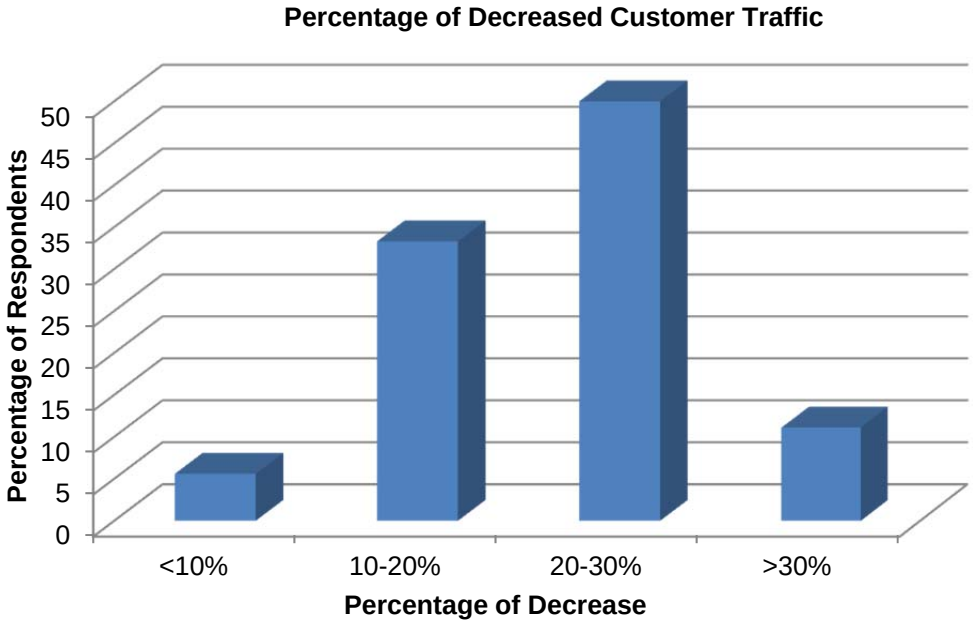


Figure 4.8 Results of Question 7

On average, customer traffic has decreased by 20 percent for these 18 businesses. As expected, the same number of respondents who said their customer traffic has decreased also said their sales had lessened. Figure 4.9 shows the results of Question 8 concerning business sales.

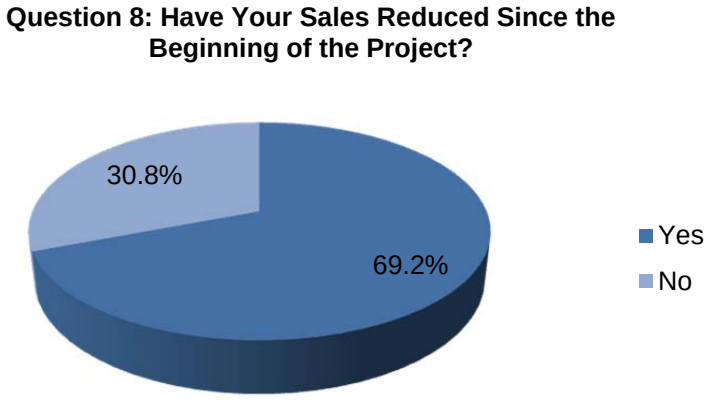


Figure 4.9 Results of Question 8

Table 4.7 and Figure 4.10 present the results of the 18 respondents who stated that their sales have decreased since the beginning of the project.

Table 4.7 Results of Question 9

9. By what percentage do you think your sales have decreased?			
Response	**No. of Respondents**	**Percentage of Respondents**	**Percentage of Total**
Less than 10%	2	11.1%	7.7%
Between 10% to 20%	5	27.8%	19.2%
Between 20% to 30 %	8	44.4%	30.8%
More than 30%	3	16.7%	11.5%

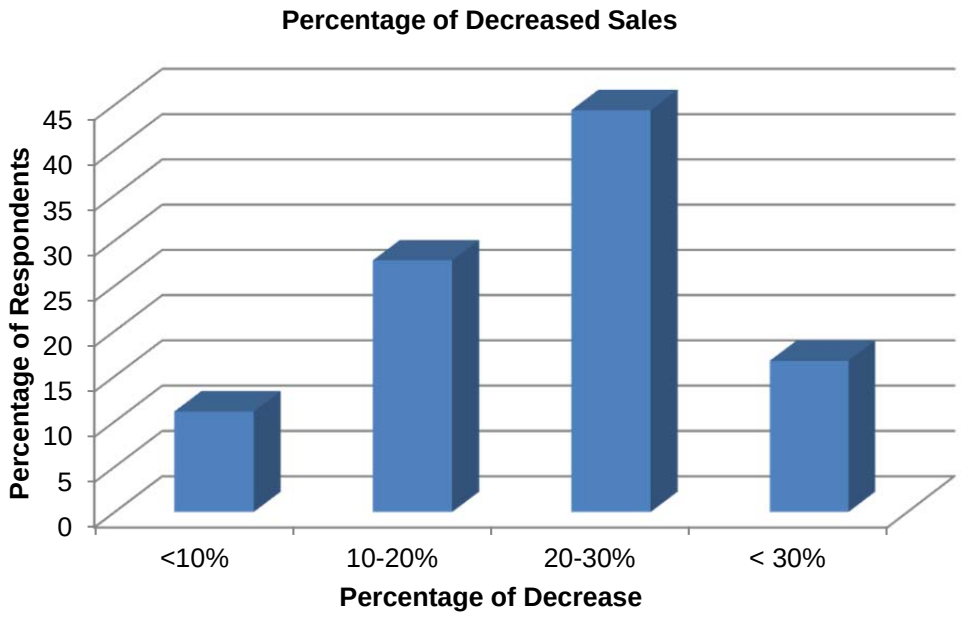


Figure 4.10 Results to Question 9

The average sales decrease of the 18 respondents was approximately 20% as well. This can be attributed to fewer customers as seen in Question 7 where customer traffic had decreased by twenty percent. As customers begin to go elsewhere for a particular good or service, revenue will decrease. This can ultimately cause a business to shut down. Furthermore, the city may suffer from decreased tax revenue. There may be many reasons the public does not go to a particular business but the main reason in this case is construction.

Individuals avoid construction and the traffic congestion it causes. Businesses are often hard to get to and access is limited which is a deterrent for many.

Even though businesses lose income during construction, there is no reimbursement from the project contractor or owner. This is noted to be true by the results of the next question. Question 10 asks the business respondent if there is any type of compensation for business loss. All 26 participants answered no to this question showing that businesses are not monetarily compensated for loss of sales. Although businesses may feel differently, it can be difficult to quantify the economic loss they had during construction compared to the increase in sales following construction due to increased mobility and access. Because of this, contractors cannot reimburse a company for its deficit.

Tables 4.8 and 4.9 and Figures 4.11 and 4.12 present the results of Questions 11 and 12, which reflect customer retention.

Table 4.8 Results of Question 11

11. Do you think you may permanently lose customers who will go elsewhere because of construction		
Response	**No. of Respondents**	**Percentage of Respondents**
Yes	6	23.1%
No	6	23.1%
Maybe	14	53.8%

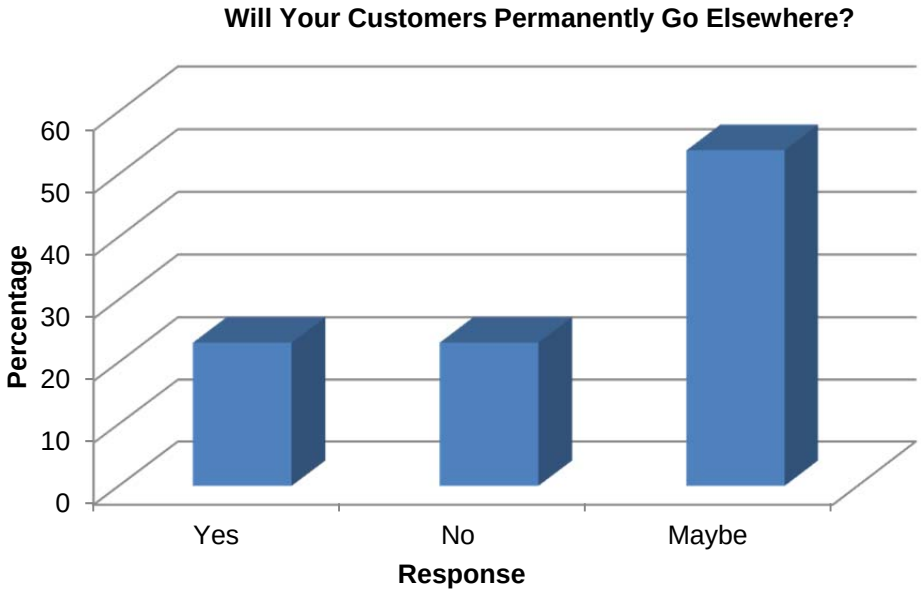


Figure 4.11 Results of Question 11

Table 4.9 Results of Question 12

12. By what percentage do you think your customers will permanently go elsewhere?		
Response	**No. of Respondents**	**Percentage of Respondents**
My Customers Will Not Go Elsewhere	6	23.1%
Less than 25%	16	61.5%
25-50%	3	11.5%
50-75%	1	3.9%
More than 75%	0	0.0%

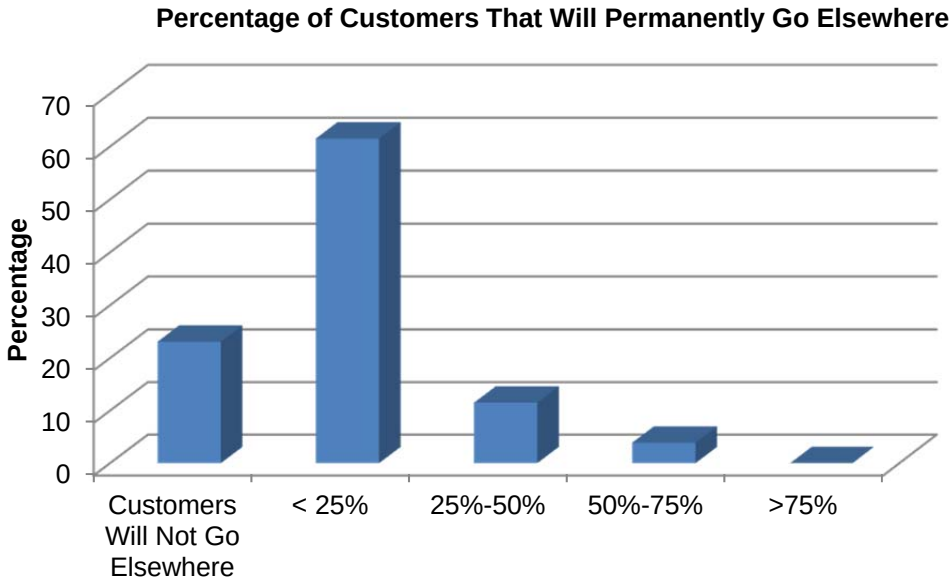


Figure 4.12 Results of Question 12

The results of the previous two questions provide evidence that businesses think construction will cause their customers to permanently go elsewhere. It has already been shown that customer traffic has decreased for 18 of the 26 respondents. The respondents to this question feel that the customers who are choosing different locations may permanently continue to shop or eat at another site, including all 18 who have seen a decrease in customer traffic. 16 of the 26 participants felt that they would permanently lose 25% or less of customers. People who avoid construction will go to a different business for the same good or service. If individuals are more impressed with the alternate business it may become a permanent solution for their needs and wants causing the original business to suffer.

The subsequent two questions relate to employee retention and productivity. Table 4.10 and Figure 4.13 display the results of Question 13.

Table 4.10 Results of Question 13

13. Throughout the construction process has it been difficult to maintain employees? If so, approximately how many do you lose per month?		
Response	**No. of Respondents**	**Percentage of Respondents**
I have maintained all of my employees	21	84.0%
1-3 Employees	3	12.0%
4-6 Employees	1	4.0%
7-9 Employees	0	0.0%

Figure 4.13 Results of Question 13

Of the 26 businesses surveyed 21 have not lost any employees. This could be indicative of a number of things besides construction, one of which could be the job market during an economic crisis. Also, employees who are satisfied with their jobs are less likely to leave regardless of driving conditions affected by construction. The one business that lost 4-6 workers is a bar and employee turnover rates are high in that industry, according to the manager who completed the survey. Fortunately, from the results, businesses can count on employees to remain working even during construction.

Although employees may continue working it does not mean that construction will not affect their work ethic, ultimately impacting productivity. Figure 4.14 shows the results of Question 14 which concerns employee productivity.

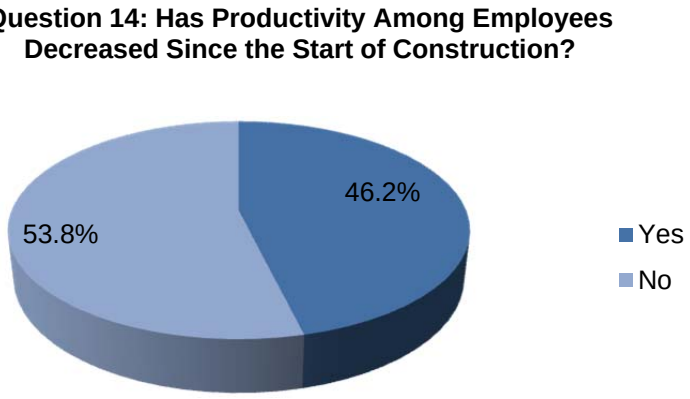


Figure 4.14 Results of Question 14

The response to this question provides a picture of how construction can affect employee productivity. Overall it is split nearly evenly between respondents who feel that construction has affected productivity and those who do not. 12 of the 26 participants feel that their employees' productivity has decreased. This could be credited to the fact that workers must drive through the congestion and headache caused by construction to get to work. This can cause agitation and irritation which can overflow to the workplace.

Construction may be inevitable in some circumstances due to the design life of existing infrastructure as is the case in this study. And although business loss may be heightened during construction, once it is complete, business will flourish due to increased mobility. Figure 4.15 shows the results of the final question of the business survey.

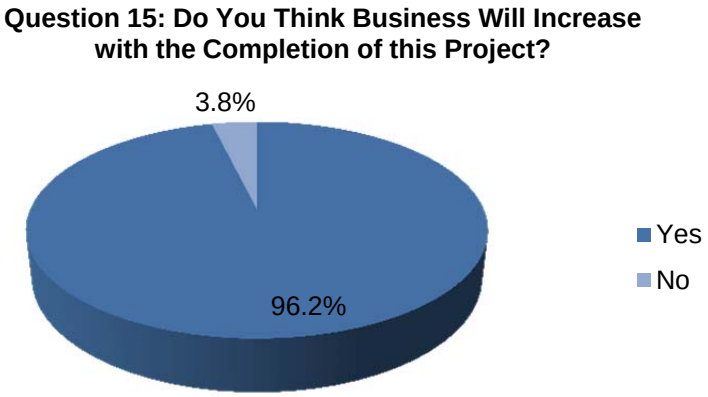


Figure 4.15 Results of Question 15

The results presented indicate that 25 of the 26 businesses surveyed think business will increase following the conclusion of construction. There was an additional optional question that asked the respondent to comment on why they felt business would improve in which Table 4.11 shows the remarks.

Table 4.11 Participant Comments on the Increase of Business Following Construction

	COMMENT by BUSINESS OWNER/MANAGER
1	Because it will be less of a hassle to get here
2	People will be able to get here
3	Reduced traffic congestion
4	Better traffic flow and better visibility for our store
5	We are getting a new building
6	Other restaurants have closed due to construction, less congestion
7	Access to the shop will be easier
8	It will look nicer

Most businesses would agree that the completion of construction will provide better access to their stores, reduced traffic congestion, and aesthetics. These are the intentions of construction and can ultimately increase business. Businesses may have to endure the distressing social costs during construction but the benefits can outweigh the damages if the business can survive through its entirety.

The final question of the business survey was a scaled question reflecting the respondent's position, whether satisfied or dissatisfied, on different factors regarding the business. Table 4.12 shows the results of question 16.

Table 4.12 Results of Question 16

Factor	**Percentage of Respondents**									
	Dissatisfied 1	2	3	4	5	6	7	8	9	Satisfied 10
Property Protection by Contractor	0%	0%	11%	7%	11%	3%	7%	7%	3%	46%
Customer/Employee Parking	3%	0%	0%	3%	15%	7%	7%	7%	15%	38%
Noise Disruption	7%	7%	3%	11%	7%	0%	7%	11%	23%	19%
Detours	19%	3%	11%	11%	11%	3%	11%	19%	3%	3%
Traffic Disruption	28%	8%	16%	8%	8%	16%	0%	16%	0%	0%
Dirt/Dust Pollution	26%	11%	23%	11%	3%	7%	0%	11%	0%	3%

4.3 Residential Survey

The residential survey consists of eight questions concerning the public's opinion of construction impacts. This online survey was emailed to residents in a Homeowner's Association approximately two miles from the construction activities of the SH 121 expansion as well as arbitrarily placed homes near the project. Figure 4.16 shows the location of these residents.

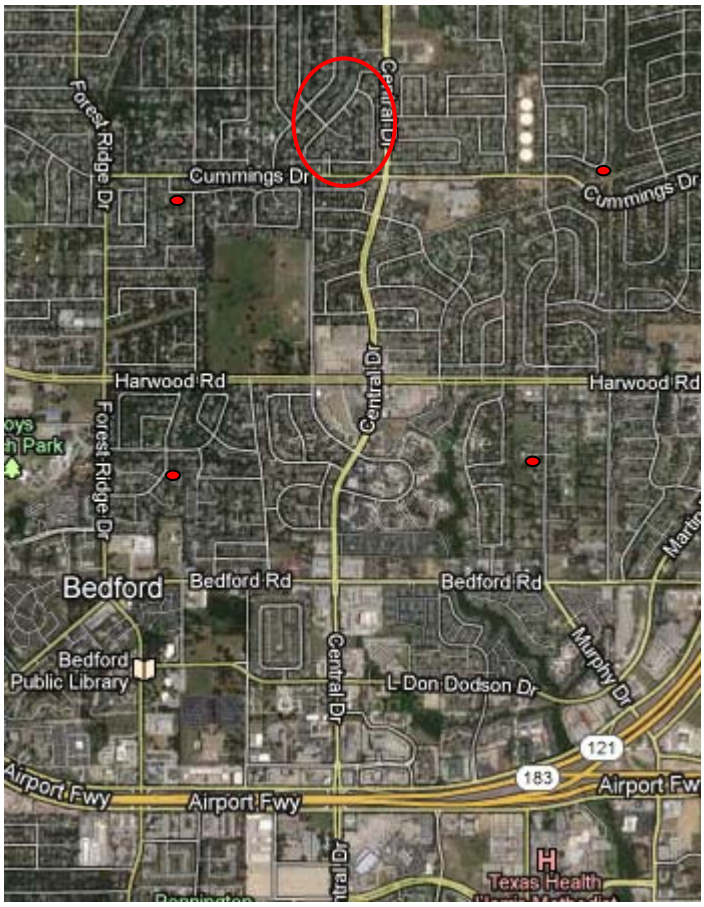


Figure 4.16 Locations of Residential Surveys (Google Maps)

This survey measures local resident's thoughts and attitudes towards construction. It was sent to 85 homes in the area and anyone in the home who drives was encouraged to fill out the survey. Without knowing the exact number of people living in the home who drive, a response rate is hard to determine. The assumption is made that two individuals at each home could have completed the survey, making a total of 170 applicable residents. The sample size was larger because of the nature of an online survey and its expected completion rate. Of this 170, 46 people filled out the survey. This is a 27% response rate. The following analysis compiles the results from the residential survey.

The first four questions are simple factual inquiries regarding a resident's distance from SH 121 and the distance they drive to work and the time it takes to arrive at work before and

after construction. The following tables and figures present this information. Figure 4.17 shows the results to Question 1.

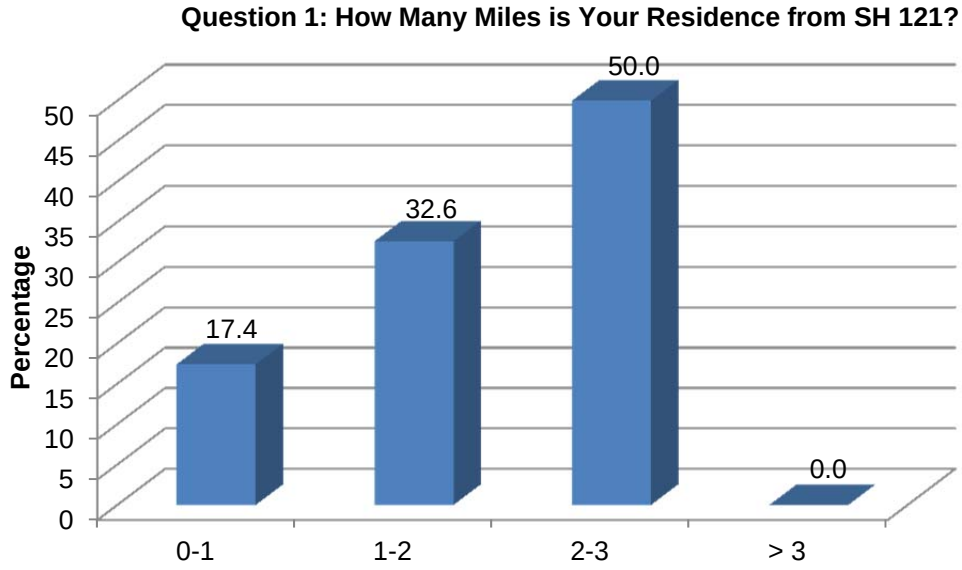


Figure 4.17 Results of Question 1

The average distance between the homes and SH 121 is approximately two miles. This is as expected since a majority of the surveys went out to the Homeowner's Association two miles from the construction. Tables 4.12 and 4.13 and Figures 4.18 and 4.19 present the results of Question 2 and 3.

Table 4.13 Results of Question 2

2. How many miles do you travel to work?		
Response	**No. of Respondents**	**Percentage of Respondents**
0-10 miles	26	56.6%
11-20 miles	10	21.7%
21-30 miles	6	13.1%
31-40 miles	2	4.3%
More than 40 miles	2	4.3%

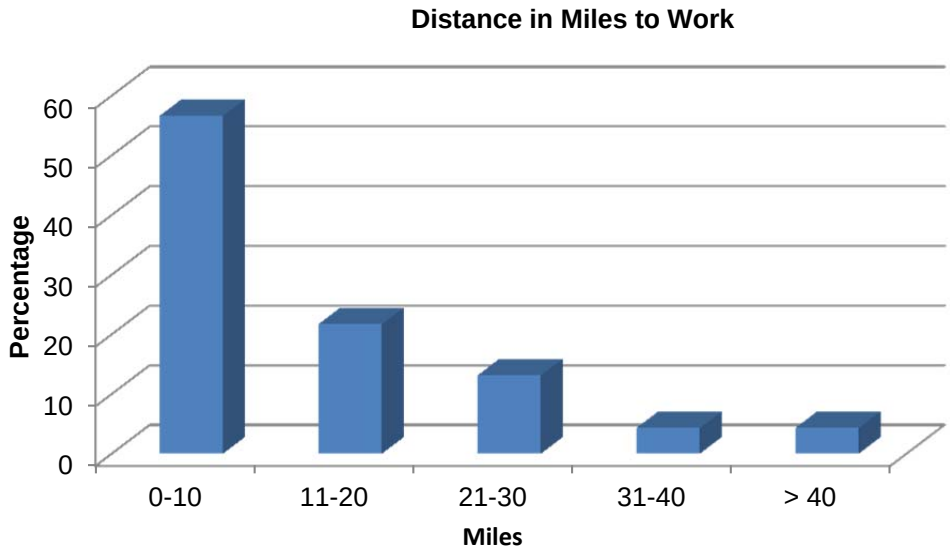


Figure 4.18 Results of Question 2

Table 4.14 Results of Question 3

3. Before construction began, how many minutes did you travel to work?		
Response	**No. of Respondents**	**Percentage of Respondents**
0-10 minutes	18	39.1%
11-20 minutes	12	26.1%
21-30 minutes	11	23.9%
31-40 minutes	5	10.9%

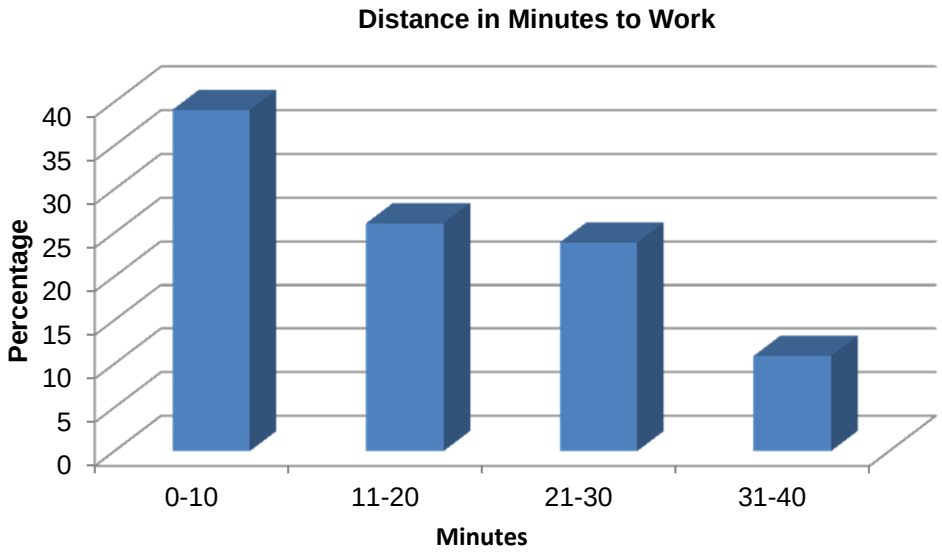


Figure 4.19 Results of Question 3

The results of the previous questions show that a majority of residents drive zero to ten minutes to work with the average drive being 11 to 20 miles. The common drive time in minutes is zero to ten minutes as well with the average time being 11 to 20 minutes. Question 4 is split into two parts concerning the addition of miles and minutes to the resident's drive time to work. Tables 4.14 and 4.15 and Figures 4.20 and 4.21 show the results to this Question.

Table 4.15 Results of Question 4a

4a. If your travel time to work has increased because of construction, how many extra minutes do you spend in the car		
Response	**No. of Respondents**	**Percentage of Respondents**
0-5 minutes	20	43.5%
6-10 minutes	14	30.4%
11-15 minutes	8	17.4%
16-20 minutes	4	8.7%

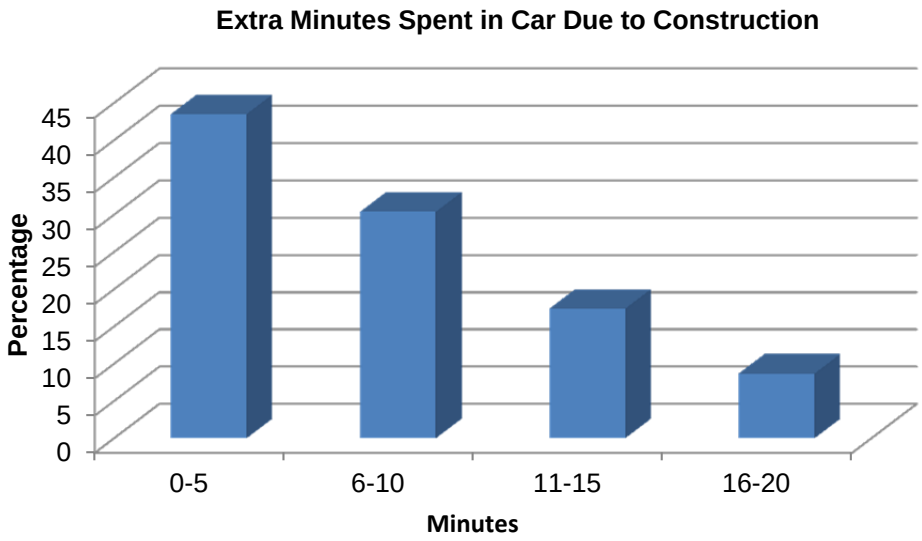


Figure 4.20 Results of Questions 4a

Table 4.16 Results of Question 4b

4b. If your travel time to work has increased because of construction, how many extra miles do you spend in the car		
Response	**No. of Respondents**	**Percentage of Respondents**
0-1 miles	25	54.4%
1-2 miles	15	32.6%
2-3 miles	4	8.7%
More than 3 miles	2	4.3%

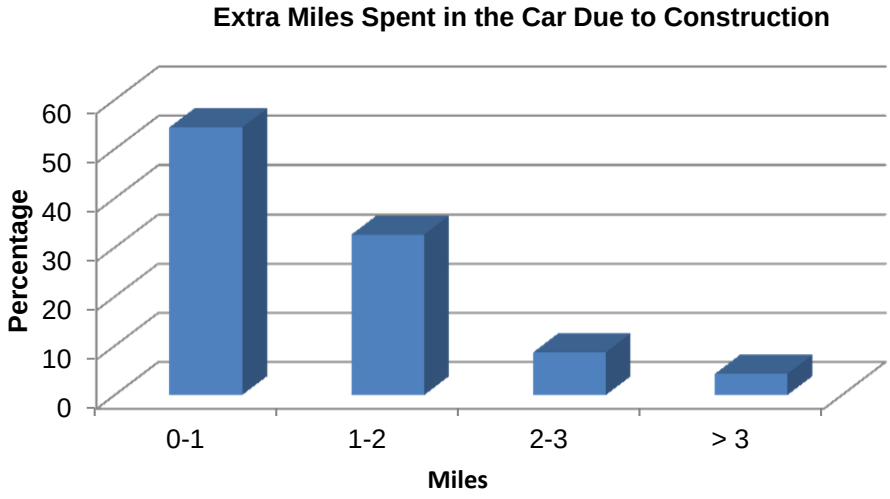


Figure 4.21 Results of Question 4b

The results presented indicate that 34 of 46 respondents spend an extra zero to ten minutes in the car and 40 of 46 respondents spend an extra zero to two miles in the car. On average, a resident will spend six to ten more minutes in their car due to construction and an additional one mile is added to their commute. Extra time spent in the car can lead to frustration and agitation to the driver and can also increase fuel consumption hurting the driver's finances as well as the environment. The extra miles added to drive time can be attributed to traffic detours or construction avoidance. Detours reroute traffic to side roads which can lead to deteriorated road due to increase volume of travel. Residents may also take alternate paths which lengthen travel in order to avoid construction. Both added time and miles can depreciate a car more quickly due to the increased wear and tear on the vehicle. These social costs are the price local residents pay and are hardly investigated by the Contractor.

Questions five through seven reflect residents' behavior in avoiding construction. Figure 4.22, Table 4.16 and Figure 4.23 present the results of Question 5 and 6.

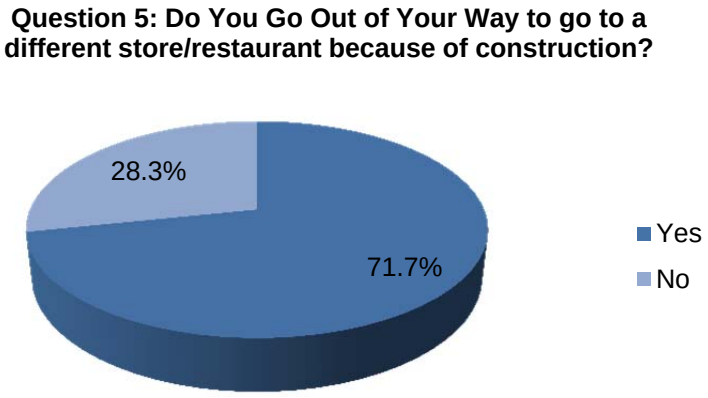


Figure 4.22 Results of Question 5

Table 4.17 Results of Question 6

6. What percent do you go out of your way to go to a different store because of construction			
Response	**No. of Respondents**	**Percentage of Respondents**	**Percentage of Total**
Less than 25%	7	21.2%	15.2%
25-50%	11	33.3%	23.9%
50-75%	12	36.4%	26.1%
More than 75%	3	9.1%	6.5%

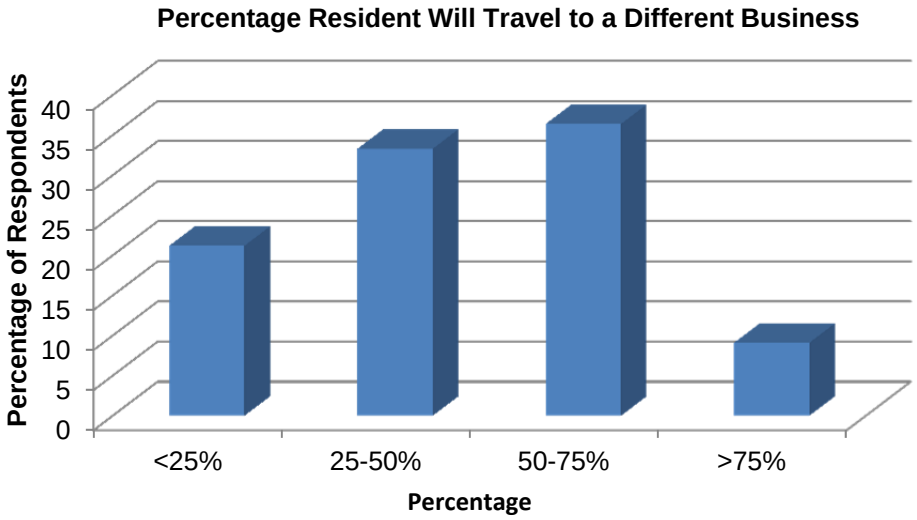


Figure 4.23 Results of Questions 6

Of the 46 participants responding to question 5, 33 said they would go out of their way to purchase the same goods or service instead of navigating through construction. This indicates that the public has a negative view of construction due to the inconveniences that accompany it. The 33 residents who answered yes to question 5 also answered question 6 pertaining to the percentage of instances they will drive to a different location. The majority of local residents will travel to a different location to avoid construction 25 to 75 percent of the time. Most people do this at least half of the time; once again proving that construction is not worth dealing with if there is an alternate store that offers similar goods and services.

Not only do these statistics affect local residents, this is the cause of sales loss and potential closure of businesses near construction. The results of the previous questions provide

evidence that local residents will go to a different store in order to avoid the nuisances of construction. Without the sales from local residents, businesses can lose not only money but customers as well. Ultimately this can lead to shutting down of the business.

Question 7 also relates to residents mind set towards construction. Table 4.17 and Figure 4.24 present the results to question 7.

Table 4.18 Results of Question 7

7. Instead of dealing with construction traffic what percentage of the time do you stay home rather than deal with the mess?		
Response	**No. of Respondents**	**Percentage of Respondents**
Less than 25%	29	63.0%
25-50%	25	32.6%
50-75%	1	2.2%
More than 75%	1	2.2%

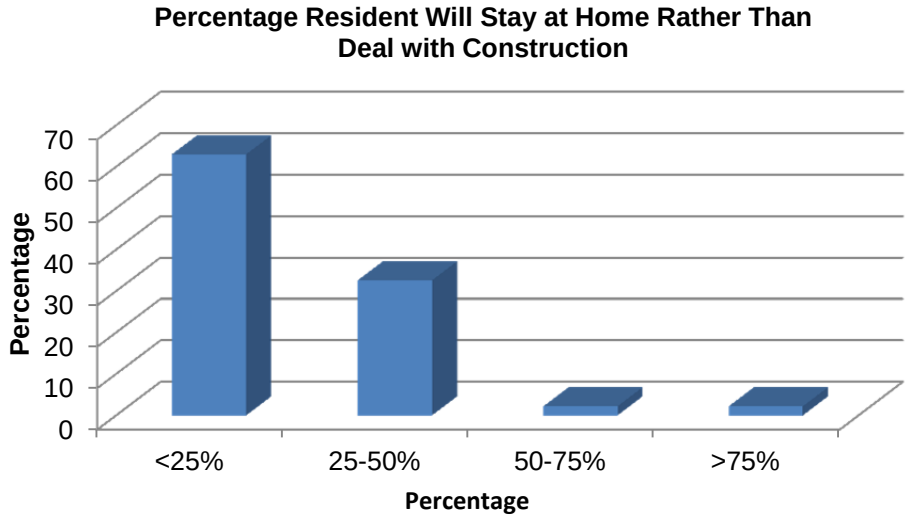


Figure 4.24 Results of Question 7

The results of question 7 indicate that, although individuals agree that construction is an annoyance, it is not something that keeps them off the roads. Of the 46 respondents, 29 said they would only stay at home less than 25% of the time. People have to be at work or have

errands to complete and sometimes construction is unavoidable. If there is a different route or different store location residents will use it but if not, traffic congestion and delays are inevitable.

The final question of the survey is a scaled question regarding resident's personal opinion of construction. Residents were asked to rank a statement on a scale of one to five with one meaning they strongly disagreed and five being they strongly agreed with the statement. Table 4.18 shows the results of question 8.

Table 4.19 Results of Question 8

NUMBER AND PERCENTAGE OF RESPONDENTS										
	1 - Strongly Disagree		2 - Disagree		3 - Neutral		4 - Agree		5 - Strongly Agree	
STATEMENT	No.	%	No.	%	No.	%	No.	%	No.	%
Construction negatively affects my mood.	1	2%	8	17%	8	17%	24	52%	5	11%
Construction detours are well thought out.	2	4%	13	28%	12	26%	17	37%	2	4%
I tend to take a different route to avoid construction.	1	2%	2	4%	3	6%	18	39%	22	48%
Dirt/dust pollution has increased with this construction project.	0	0%	2	4%	10	22%	23	50%	11	24%
Lane changes are well marked.	5	11%	20	43%	6	13%	14	30%	1	2%
I am more stressed when I reach my destination.	2	4%	9	20%	13	28%	18	39%	4	9%
I go to my typical stores even though I have to deal with construction.	1	2%	21	46%	5	11%	17	37%	2	4%
I feel safety has been thoroughly considered.	4	9%	9	20%	14	30%	19	41%	0	0%
I check online daily for new closures.	16	35%	18	39%	11	24%	1	2%	0	0%
Construction detours are well marked.	1	2%	19	41%	13	28%	13	28%	0	0%
Noise pollution has increased with this construction project and is a nuisance.	2	4%	10	22%	22	48%	10	22%	2	4%
I add extra time when figuring travel time.	0	0%	1	2%	5	11%	31	67%	9	20%
I feel that this construction is necessary	1	2%	4	9%	5	11%	19	41%	17	37%
I feel that the inconveniences I am dealing with now will be worth it after construction is complete.	1	2%	2	4%	9	20%	20	43%	14	30%

The responses to these statements provide an assessment of the public's opinion concerning the impacts of construction. Approximately half of the respondents agree that construction negatively affects their mood. This can be caused by a number of things including traffic delays, disruption of normal daily activities, or air and noise pollution. 40 of the 46 respondents either agree or strongly agree that they take a different route to avoid construction and add extra time when calculating travel time. Avoiding construction most likely adds minutes and miles to travel time which can lead to additional fuel consumption, extra maintenance and repair on vehicles, and agitation. Approximately 75 percent of participants agree or strongly agree that dirt and dust pollution has increased with the start of the construction activities. Not only can this affect people's physical health it can also harm nearby electrical and mechanical systems. Noise pollution is also a factor to consider but because of the two mile distance between a majority of these houses and the construction, residents are not affected by sound.

Several other comments were stated pertaining to the public opinions on contractor responsibilities. 19 of the respondents think that construction detours are well thought out while 15 feel that detours could be better planned. As far as the detours being well marked, 43 percent considered detour signs to be below average. When alternate routes are not well indicated it can cause frustration, most likely from getting lost, and in worse-case scenarios, it can cause accidents. Along with detour signage, 25 of the 46 participants think lane changes are not well marked, which can also cause traffic accidents. 41% of the respondents feel safety has been thoroughly considered and 30% are neutral on the subject. Safety is the number one issue for which a contractor should be responsible, both for the general public and his workers. If someone does not feel safe on a road near construction, it can cause more harm to other drivers.

Although local residents are directly affected by construction, 36 of the 46 participants say that they agree or strongly agree that this construction is necessary and 34 of the 46 state that they agree or strongly agree that the inconvenience they are facing currently will be worth it

once construction is complete. Regardless of the fact that construction may be necessary or that the outcome will be remarkable, the social costs that surface throughout the duration of the construction project should be comprehensively evaluated.

4.4 Quantification of Social Costs

Social costs are an obvious inconvenience to the community surrounding a transportation construction project, as seen in the results of the business and residential surveys. But without estimating these costs, there is no way they can be incorporated into the total cost of a construction project. Assigning an actual dollar amount to a social cost allows owners and contractors to budget for appropriate mitigation techniques to lower these costs. This section will briefly look at the results of the surveys to quantify the cost of traffic disrupted including the cost of fuel consumed due to additional miles traveled to work because of construction.

The frequency for which minutes were added to residents and business owners or managers travel time to work is shown in Figure 4.25.

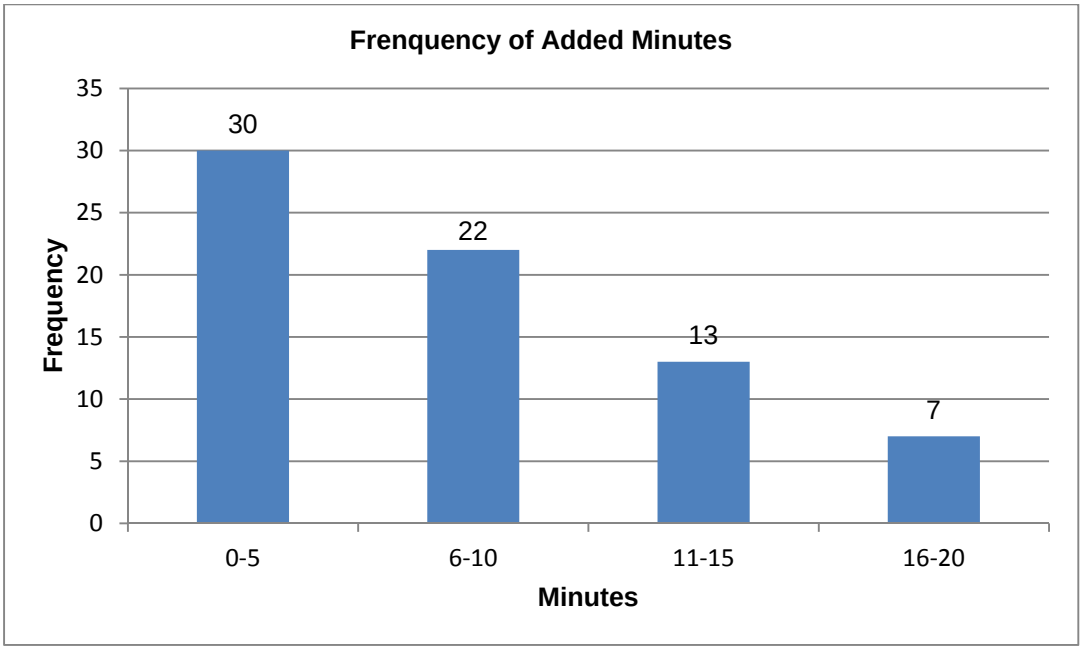


Figure 4.25 Frequencies of Added Minutes to the Work Commute

The average commute to work, based on the surveys conducted, has increased by six to ten minutes. The majority of the local commuters spent an extra zero to five minutes traveling to work due to construction. The addition in minutes can be attributed to traffic congestion caused by narrow lanes, lane closures, or detours.

Figure 4.26 shows the frequency with which the survey participants stated their work commute mileage had increased.

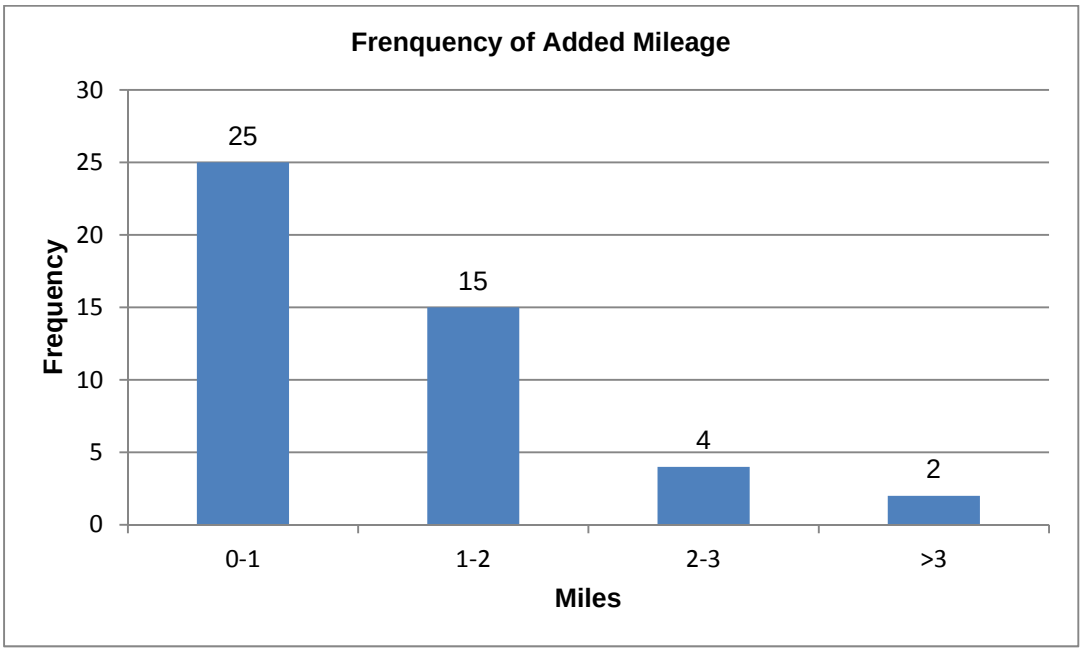


Figure 4.26 Frequencies of Added Mileage to the Work Commute

On average, residents drove one extra mile, daily, to work. The majority of residents drove between zero and one extra mile on their commute to work. This can be attributed to detours or the individual choice to take an alternate route because of construction.

Traffic congestion accounts for 6.8 billion gallons of fuel consumption and 4.5 billion hours of travel time per year (Gangavarapu 2004). Additional fuel consumption is not only harmful to the environment but is a burden on personal finances. For this specific transportation project and its location, the fuel consumption was estimated at 22.6 miles per gallon (Bureau of Transportation Statistics 2008) and the cost of fuel is estimated at $3.70 per gallon (Fuel Gauge

Report 2012). To determine the cost of fuel for detours, equation 4.1 was used (Najafi and Gokhale 2005).

Cost of fuel for detours = (average gallon/mile) x (additional mile) x (average cost of fuel/gallon) Eq. 4.1

From the results of the surveys performed in conjunction with this thesis, an additional one mile on average was spent in the car on work commutes due to construction delays. Table 4.20 presents the extra cost for fuel for additional miles. The added cost is calculated for a one way trip to work and for the duration of this project, which is five years. Both calculations are for one person and Figure 4.27 presents the results of the calculations.

Table 4.20 Additional Fuel Cost for Extra Miles to Work

Additional Miles	Additional Fuel Cost for a One Way Trip to Work ($)	Additional Fuel Cost for One Person for the Duration of the Project ($)
1	0.16	208
2	0.32	426
3	0.49	638
4	0.65	851
5	0.82	1,064

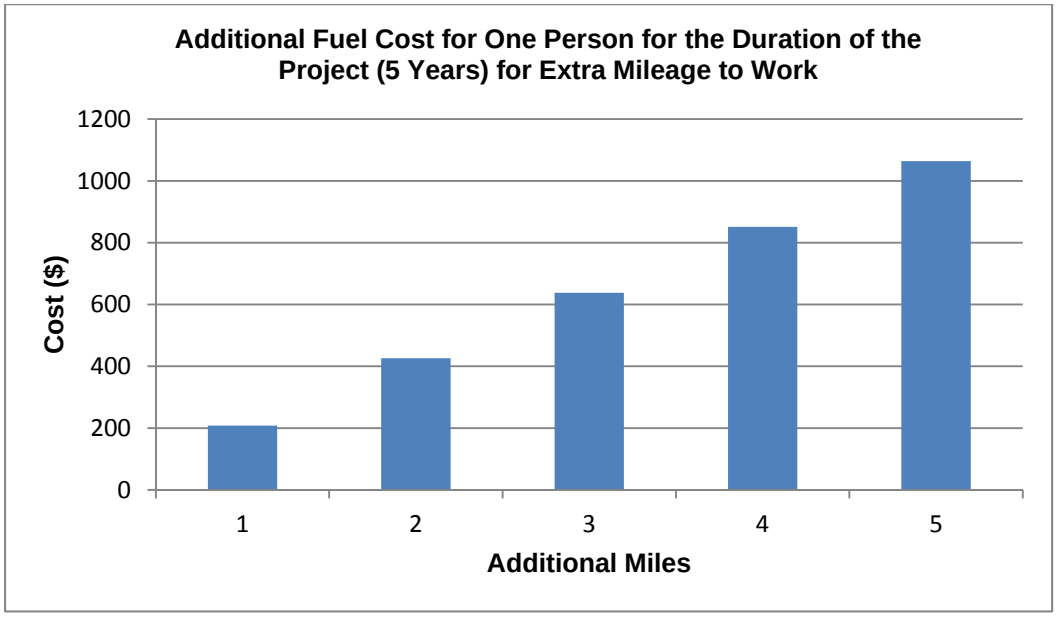


Figure 4.27 Additional Fuel Cost for One Person for the Duration of the Project for Extra Mileage to Work

On average, local residents spend an extra $0.16 for fuel per trip to work and will spend an additional $208.00 for the duration of the project. If a resident's commute increases by five miles it will cost an additional $1,064.00 in fuel. These numbers do not include additional miles traveled outside of the commute to work which can add more mileage and ultimately more costs.

Although this is a brief glimpse of the estimation of social costs, these costs are real and can be calculated to show the dollar amounts the public incurs, not only for this specific case study but for any transportation construction project. The monetary equivalent to extra time spent in the car, business loss, noise pollution, air pollution and more should also be quantified to determine the total cost of the project. Once this number is computed it can be incorporated into the construction budget to allow for mitigation methods.

4.5 Discussion of Results

According to the results of the surveys, it is evident that construction causes many inconveniences to the surrounding area. These social costs affect the livelihood of businesses and interfere with the day-to-day activities of residents. Both businesses and residents ultimately feel that the construction is necessary and will prove beneficial, but throughout the duration it causes more nuisances than advantages.

The biggest loss for businesses is financial. Thirty percent of the businesses who responded had currently lost between twenty and thirty percent of sales. It can be difficult to maintain a business with sales constantly below average. 76% of business respondents feel that they will or may lose customers permanently. If the customer base is not rebuilt after construction, business revenue may never return to normal, resulting in closure. Confirmation of local customers going elsewhere for the same goods or services can be seen in the results of the residential survey. 33 of 46 residential survey participants stated they would go out of their way to go to a different store in order to avoid construction. This result corroborates the loss of sales to the businesses. Most businesses service the local residents and, if over half of those

customers are going elsewhere, revenue will decrease. Unfortunately, there is no monetary compensation for the losses that construction causes to businesses but, according to Bruce Dinkheller, Senior Manager at Parsons Brinckerhoff, a consulting firm for infrastructure projects, measures are taken to “sustain the livelihood of businesses.” These actions may include additional business access, visible entry signs, and proactive notification.

Local residents do not face the same financial loss as businesses but endure additional social costs including traffic disruptions, dust, and noise. Results show that traffic disruptions, such as delays, congestion, and detours, are a major inconvenience to residents. 67 percent of respondents add extra time when figuring travel time and almost all participants’ drive to work has increased. Michael Fairchild, a consultant for MwF Buildingsmith, says this is mitigated by a thorough Traffic Management Plan which includes appropriate detours, signs, and maintenance. The next highest inconvenience is dust pollution followed by noise pollution. 34 of 46 residents believe that dirt/dust pollution has increased with the construction project. Dust can be a problem not only for health reasons but for the sustainability of other systems and equipment. Mr. Dinkheller comments that millions of dollars were spent on the President George Bush Turnpike Extension dust mitigation. These methods included keeping the site wet by watering and decreasing dust by power broom sweeping. City ordinances enforce time frames that work is permitted to reduce noise nuisances.

Though construction-related social costs are still apparent, public agency sensitivity to these inconveniences has improved, according to Mr. Dinkheller. Government agencies realize that the public funds these DOT Projects; therefore, measures should be taken to minimize the inconveniences of construction for the people ultimately paying for the project. Public relations, including website updates, city hall meetings, and attendance of Homeowner’s Association meetings, can be a major mitigation technique that alleviates the pressures of construction (Dinkheller).

4.6 Chapter Summary

This chapter presented the results and analysis of the surveys given to local business owners and residents near the State Highway 121 expansion. Both surveys concern the social costs that businesses and residents are confronted with during a construction project.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

5.1 Introduction

The previous chapter presented the survey results and analysis. This chapter discusses the conclusions from the research and recommends topics for future research in this area.

5.2 Conclusions

The subsequent list presents conclusions of this research:

1. Negative impacts of construction are existent and affect both businesses and residents surrounding a construction site.
2. Increased travel time in a car has a negative impact on mood which in turn decreases productivity.
3. Additional mileage due to detours or construction avoidance can lead to additional fuel costs for residents. On average, residents drive an extra mile on their way to work which can cost an additional $208 for the five year duration of the project. If a resident drives three extra miles a day it could cost $638 for the five year duration of the project.
4. Construction causes business sales and customer traffic to decrease throughout the duration of the project. Sixty-nine percent of business respondents have lost customers and their revenue has decreased.
5. Contractors and/or owners provide minimal relief or mitigation strategies to business owners.

6. Residents will go out of their way for the same goods or services to avoid construction. 33 of 46 residential survey participants, or 72%, stated they would go out of their way to go to a different store in order to avoid construction. As previously stated, this leads to the reduction in sales and customers for businesses.
7. Although the inconveniences of construction are a nuisance throughout the duration of the project, 96% of businesses and 73% of residents feel that the results will be beneficial after completion of construction.

5.3 Recommendations for Future Research

The following is a list of recommendations to expand this study further:

1. Include the estimating techniques used to quantify the presented social costs and calculate such costs.
2. Study social costs for different types of projects.
3. Study the means and methods for social cost mitigation and their effectiveness.
4. Study ways to minimize social costs and incorporate them into construction contracts.
5. Investigate possible policies, regulations, and ordinances that identify financial responsibilities of contracting parties for resulting social costs.
6. Involve a larger sample size for an even more enhanced understanding of the general public's opinion on the impacts of construction.

APPENDIX A

BUSINESS AND RESIDENTIAL SURVEY

"Evaluation of Construction Related Social Costs and
Their Impact on the Community"
Business Survey

Business Name: _____
Respondent's Name: _____
Respondent's Title: _____
Respondent's Address: _____

Question 1: Before construction began, how many minutes did you travel to work?

0-10 mins 11-20 mins 21-30 mins 31-40 mins

Question 2: If your travel time to work has increased because of construction, how many extra minutes do you spend in the car?

0-5 mins 6-10 mins 11-15 mins 16-20 mins

Question 3: How is your work productivity affected when you get to work?

Negatively Not Affected Positively

Question 4: Were you forewarned about this extensive construction project in order to plan ahead?

Yes, via written communication
Yes, via verbal communication
No, the business was not forewarned.

Question 5: If yes, did the contractor express any methods to reduce the inconveniences of construction for your business?

Yes No

What were they: _____
_____

Question 6: Currently, has your customer traffic decreased?

Yes No

Question 7: If yes, by what percentage do you think your customer traffic has decreased?

Less than 10% Between 10% to 20% Between 20% to 30% More than 30%

Question 8: Have your sales reduced since the beginning of the construction project?

Yes No

Question 9: If yes, by what percentage do you think your sales have decreased?

Less than 10% Between 10% to 20% Between 20% to 30% More than 30%

Question 10: Is there any type of compensation for business loss?

Yes No

Question 11: Do you think you may permanently lose customers who will go elsewhere because of construction?

Yes No Maybe

Question 12: If yes, by what percentage do you think your customer will permanently go elsewhere?

Less than 25% 25% to 50% 50% to 75% More than 75%

Question 13: Throughout the construction process has it been difficult to maintain employees? If so, approximately how many do you lose per month?

1-3 employees

4-6 employees

7-9 employees

I have maintained all of my employees.

Question 14: Has productivity among employees decreased since the start of construction?

Yes No

Question 15: Do you think business will increase with the completion of this construction project?

Yes No

How come?

_____

_____

Question 16: Rank the following with regards to your business from 1-10, 10 being completely satisfied and 1 being completely dissatisfied.

	Dissatisfied									Satisfied
Property protection by the contractor	1	2	3	4	5	6	7	8	9	10
Customer/Employee Parking	1	2	3	4	5	6	7	8	9	10
Noise Disruption	1	2	3	4	5	6	7	8	9	10
Detours	1	2	3	4	5	6	7	8	9	10
Traffic Disruption	1	2	3	4	5	6	7	8	9	10
Dirt/Dust Pollution	1	2	3	4	5	6	7	8	9	10

Additional Comments:

_____

_____

"Evaluation of Construction Related Social Costs and
Their Impact on the Community"
Residential Survey

This survey will assist in the study of "Construction Related Social Costs" for a Thesis at the University of Texas at Arlington. The purpose of this survey is to better understand the negative impacts construction has on the surrounding community, namely residents located within a three-mile radius of the construction site. Thank you for your input.

NAME: _____
ADDRESS: _____

Question 1: Approximately, how many miles is your residence from State Highway 121?

0-1 miles 1-2 miles 2-3 miles More than 3 miles

Question 2: How many miles do you travel to work?

0-10 miles 11-20 miles 21-30 miles 31-40 miles More than 40 miles

Question 3: Before construction began, how many **minutes** did you travel to work?

0-10 minutes 11-20 minutes 21-30 minutes 31-40 minutes

Question 4: If your travel time to work has increased because of construction, how many **extra minutes and miles** do you spend in the car?

0-5 minutes 6-10 minutes 11-15 minutes 16-20 minutes
0-1 miles 1-2 miles 2-3 miles More than 3 miles

Question 5: Do you go out of your way to go to a **different** store/restaurant because of construction? (i.e.: Go to the Chili's off Glade Rd versus the Chili's off Central Road)

Yes No

Question 6: If yes, what percentage of the time do you do this?

Less than 25% 25% to 50% 50% to 75% More than 75%

Question 7: Instead of dealing with construction traffic what percentage of the time do you stay home rather than deal with the mess?

Less than 25% (Rarely)

25-50% (Sometimes)

50-75% (Often)

More than 75% (Regularly)

Question 8: Rank the following with regards to your personal opinion of construction from 1-5, **5 being you strongly agree** and **1 being you strongly disagree**.

	1	2	3	4	5
Construction negatively affects my mood.					
Construction detours are well thought out.					
I tend to take a different route to avoid construction.					
Dirt/dust pollution has increased with this construction project.					
Lane changes are well marked.					
I am more stressed when I reach my destination.					
I go to my typical stores even though I have to deal with construction.					
I feel safety has been thoroughly considered.					
I check online daily for new closures.					
Construction detours are well marked.					
Noise pollution has increased with this construction project and is a nuisance.					
I add extra time when figuring travel time.					
I feel that this construction is necessary					
I feel that the inconveniences I am dealing with now will be worth it after construction is complete.					

Additional comments concerning construction inconveniences:

_____

_____

APPENDIX B

BUSINESS SURVEY RESPONSE LOG

BUSINESS SURVEY RESPONSE LOG			
DATE	**BUSINESS**	**Address (All in Bedford, TX)**	**RESPONSE**
2/2/2012	Donut Shop	1220 Airport Fwy, Suite M, 76022	No
2/2/2012	Avalon Cleaners	2200 Airport Fwy, 76022	√
2/2/2012	Einstein's Bagels	2200 Airport Fwy #500A, 76022	No
2/2/2012	Jason's Deli	2200 Airport Fwy #470, 76022	No
2/2/2012	Ace Cash Express	2220 Airport Fwy, 76022	√
2/2/2012	SuperCuts	2220 Airport Fwy, #420, 76022	√
2/2/2012	Duke's Original Roadhouse	2250 Airport Fwy, #300, 76022	√
2/2/2012	First Eye Care	2400 Airport Fwy, #140, 76022	√
2/2/2012	State Farm	2400 Airport Fwy #150, 76022	No
2/2/2012	Lupe's Mexican Restaurant	2200 Airport Fwy, #505, 76022	√
2/3/2012	La Quinta Inn and Suites	1809 Hwy 121 S., 76021	√
2/3/2012	Texas Land & Cattle Steakhouse	1813 Hwy 121 S., 76021	√
2/3/2012	Northern Tool	2601 Airport Fwy, 76021	√
2/3/2012	America's Best Value Inn	2501 Airport Fwy, 76021	√
2/9/2012	Cheddars	1937 Airport Fwy, 76021	√
2/9/2012	Buffalo Wild Wings	1933 Airport Fwy, 76021	√
2/9/2012	Baatar Mongolian Grill	1925 Airport Fwy, 76021	No
2/9/2012	Big Shots Sports Bar and Grill	1833 Airport Fwy, 76021	√
2/9/2012	Sign-A-Rama	1727 Airport Fwy, 76021	No
2/9/2012	Harley Davidson	1839 Airport Fwy, 76021	No
2/9/2012	On the Border Mexican Café	2500 Airport Fwy, 76022	√
2/23/2012	Courtyard Marriot	2201 Airport Fwy, 76021	√
2/23/2012	Pappa Deaux	2121 Airport Fwy, 76021	No
2/23/2012	Spring Creek	1509 Airport Fwy, 76021	√
2/23/2012	Subway	1220 Airport Fwy, 76022	√
2/23/2012	Pack 'N' Mail	1220 Airport Fwy, Ste. G, 76022	No
2/23/2012	Cleaners	1220 Airport Fwy, 76022	No
2/23/2012	Mr. E's Music	1320 Airport Fwy, 76022	√
2/23/2012	Cycle Gear, Inc	1320A Airport Fwy, 76022	√
3/3/2012	J&G Jewelers	1737 Airport Fwy, 76021	No
3/3/2012	Toadies Bar and Grill	1705 Airport Fwy, 76021	√
3/3/2012	Posados	1601 Airport Fwy, 76021	No
3/3/2012	HEB Gold and Silver	1420 Airport Fwy, 76022	No
3/3/2012	Autosounds	1420 Airport Fwy, 76022	No
3/3/2012	911 Computers	1424 Airport Fwy, Suite K, 76022	√
3/3/2012	GNC	1424 Airport Fwy, Suite E, 76022	√
3/3/2012	Water	1424 Airport Fwy, Ste. P, 76022	No
3/3/2012	Fuddruckers	1612 Airport Fwy, 76022	No
3/3/2012	Super 8 Motel	1800 Airport Fwy, 76022	√
3/7/2012	McDonalds	2100 Central Dr, 76022	No
3/7/2012	Boomer Jacks	2300 Airport Fwy #222, 76022	√
3/7/2012	MK Sushi	2400 Airport Fwy #130, 76022	No

3/7/2012	Schlotzskys	2323 Airport Fwy, Euless, 76040	√
3/7/2012	Air Worth AC	10728 S. Pipeline, Hurst, 76053	√

APPENDIX C

CONSTRUCTION PHOTOS

Construction on South Side of SH 121 at Central Dr.

Construction Underneath SH 121 at Forest Ridge

Construction on the South Side of SH 121 at Bedford Road

Construction on the North Side of 121 Directly in Front of a Business

Construction of the SH 121 Northbound Connector

Contractor Supplied Access Sign

REFERENCES

Allouche, E.N., Gilchrist, A. (2004). "Quantification of Social Costs Associated with Construction Projects: State-of-the-Art Review." *Tunneling and Underground Space Technology,* 20, 89-104.

Ates, M., Harrison, R., Loftus-Otway, L., Matthews, R., Welter, D. (2009) “Estimating Texas Motor Vehicle Operating Costs.” *Center for Transportation Research at The University of Texas at Austin*, Austin, TX.

Bein, P. (1997). “Monetization of Environmental Impacts of Roads.” *Ministry of Transportations and Highways,* British Columbia, Canada, <http://www.th.gov.bc.ca/bchighways/> (January 7, 2012).

Boyce, G.M., Bried, E.M. (1994). “Estimating the Social Cost Savings of Trenchless Techniques.” *No Dig Eng.,* 1(2), 2-5.

Brock, W., King, G., Cunill, B., Dockter, S., Isom, J., Stevens, B., Sparklin, D., and Lindsey-Foster, L. (1996). *Community impact assessment: A quick reference for transportation*. <http://www.ciatrans.net/CIA_Quick_Reference/Purpose.html.> (October 13, 2005).

Burdge, R., and Vanclay, F. (1996). “Social Impact Assessment: A Contribution to the State of the Art Series.” 14, 59-85.

Caltrans. (1997). “Community Impact Assessment.” Environmental Handbook, Volume 4, Caltrans Environmental Program, Sacramento, CA.

“Cheers & Jeers.” (Dec. 24, 2011). Tarrant & Texas, Star Telegram, 11B.

Clower, T. L., Weinstein, B. L. (2006). “Impacts of Toll Roads on the Regional Economy: Suggested Measures.” Center for Economic Development and Research, University of North Texas*,* Denton, TX, 69-129

Ding, G. K. C. (2006). “Sustainable Construction – The Role of Environmental Assessment Tools.” *Journal of Environmental Management,* 86(2008), 451-464.

Forkenbrock, D., and Weisbrod, G. (2001). *Guidebook for assessing the social and economic effects of transportation projects.* National Cooperative Highway Research Program Report 456.

Gangavarupu, B.S. (2004). “Quantitative Analysis and Comparison of Traffic Disruption Using Open-Cut and Trenchless Methods of Pipe Installation,” NASTT.

Jiang, Y. (1999). "A Model for Estimating Excess User Costs at Highway Work Zones." *Journal of the Transportation Research Board,* 1657, 31-41.

Kamat, S.M. (2011). “Comparison of Dust Generation from Open-Cut and Trenchless Technology Methods for Utility Construction,” thesis, presented to University of Texas at Arlington, TX, in partial fulfillments of the requirements for the degree of Master of Science in Civil Engineering.

Lee, E., Ibbs, W., Thomas, D. (2005). “Minimizing Total Cost for Urban Freeway Reconstruction With Integrated Construction/Traffic Analysis.” *Journal of Infrastructure Systems,* 250-257.

Lewis, D. (1999). *Road User and Mitigation Costs in Highway Pavement Projects.* National Cooperative Highway Research Program Synthesis 269

McNamara, C. (1995). “Basics of Developing Questionnaires.” *Free Management Library,* < http://www.mapnp.org/library/evaluatn/questnrs.htm > (March 24, 2012).

Morrison, S., Seibert, T. (2002). “Designing Surveys That Count.” *Keene State College*, <http://www.keene.edu/crc/forms/designingsurveysthatcount.pdf> (March 24, 2012)

National Cooperative Highway Research Program (2002). *“*Desk Reference for Estimating the Indirect Effects of Proposed Transportation Projects.”*Transportation Research Board, National Academy Press, Washington D.C.*

National Cooperative Highway Research Program (2000). *“*Reducing and Mitigating Impacts of Lane Occupancy During Construction Maintenance.”*Transportation Research Board, National Academy Press, Washington D.C.*

National Transportation Statistics (2008). “Passenger Car and Motorcycle Fuel Consumption And Travel.” *Bureau of Transportation Statistics.* < www.bts.gov/publications/ > (April 25, 2012).

Najafi, M. and Gokhale, S.(2005). “Social Costs of Utility Construction: A Life Cycle Cost Approach.” *Trenchless Technology: Pipeline and Utility Design, Construction, and Renewal,* McGraw-Hill, New York, NY, 2-42.

NTE Mobility Partners. (2010). *North Tarrant Express,* < http://www.northtarrantexpress.com/AboutNTE.asp > (March 9, 2012).

Texas Average Gas Prices. (2012). Fuel Gauge Report, AAA. <www.fuelgaugereport.aaa.com>

Texas Department of Transportation. (2012). “North Tarrant Express.” *Texas Department of Transportation,* < http://www.txdot.gov/project_information/projects/fort_worth/north_tarrant_express/default.htm > (March 9, 2012).

Texas Department of Transportation. (2011). *State Environmental Assessment,* TxDOT, Denton County, TX.

United States Environmental Protection Agency. (2011). “Basic Information.” *National Environmental Policy Act (NEPA),* <http://www.epa.gov/compliance/basics/nepa.html > (March 11, 2012).

Wisconsin Department of Transportation. (2010). “Mitigating Work Zone Traffic Impacts.” *Wisconsin Transportation Economic Guideline Analysis,* < http://www.wisdot.info/economics/index.php > (March11, 2012).

BIOGRAPHICAL INFORMATION

Amanda Ferguson currently has a Bachelor of Science in Mathematics from Dallas Baptist University and is in pursuit of a Master of Science in Civil Engineering at the University of Texas at Arlington. Her area of concentration is in Construction Management and Engineering. Having maintained a strong academic standing her work has paid off and, Amanda is employed with Phillips/May Corporation, a general contractor in Dallas, Texas. Presently she is a Construction Project Engineer and her ultimate career goal is to be a Project Manager. Amanda is also the recipient of the Albert and Lee Halff Scholarship through the Department of Civil Engineering and the American Public Works Association Texas Chapter Scholarship.