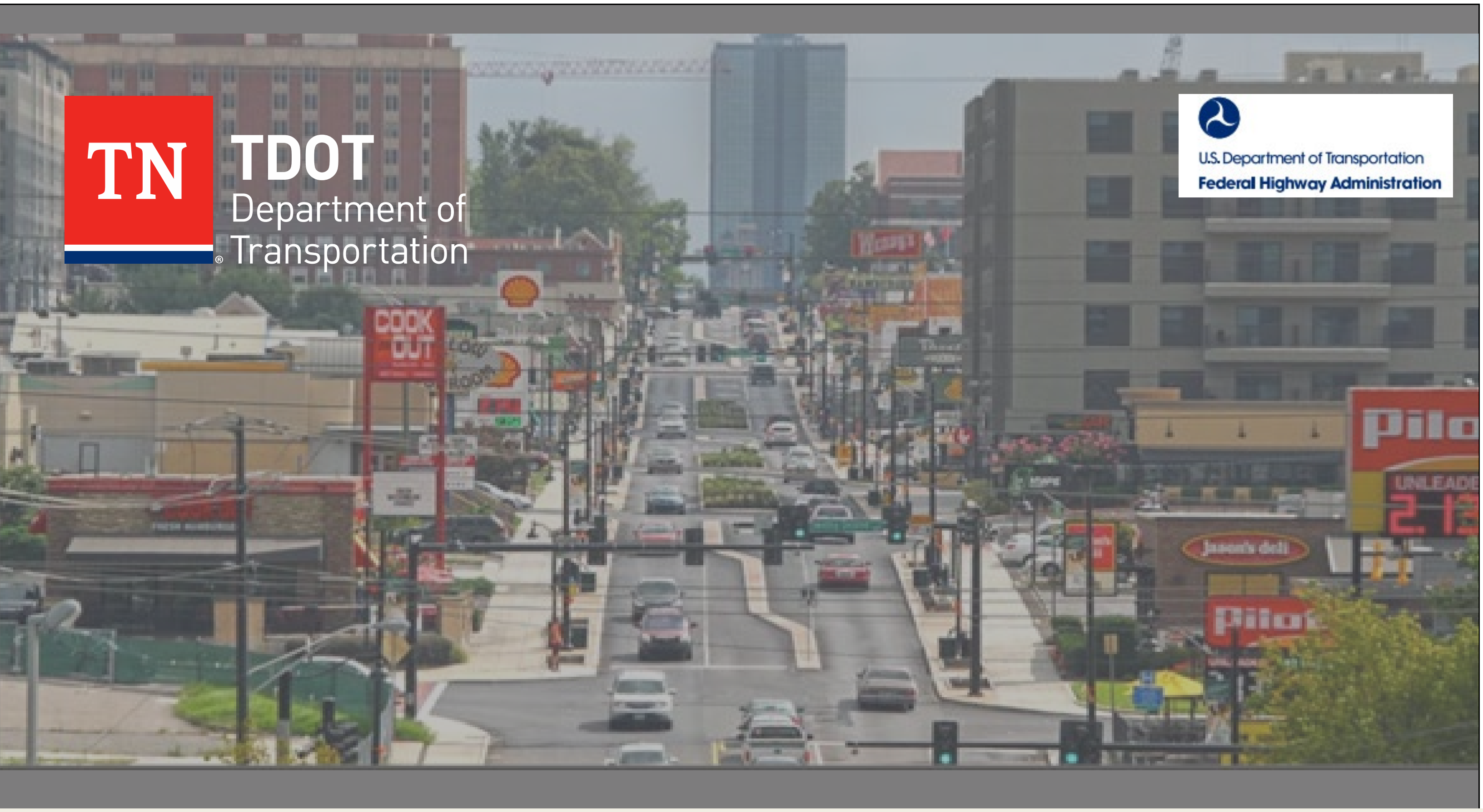

Evaluating Performance and Benefits of Road Reconfigurations in Tennessee

Research Final Report from University of Tennessee Knoxville

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May 31, 2021

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THE UNIVERSITY OF TENNESSEE KNOXVILLE

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16. Abstract

A vital issue evaluating road reconfiguration projects is quantifying the benefits provided to the corridor and surrounding community. Based on past studies, reconfiguring an automobile-oriented travel lane to accommodate other modes of transportation is found to have neutral, if not progressive, effects on factors such as livability, safety, and economics. This paper analyzes the safety, economic, and traffic impacts of road diets or road reconfiguration projects, using reconfigurations in Knoxville, Tennessee, as case studies. This study focuses on developing a practical, general, and theoretically sound methodology for evaluating future road reconfiguration projects. We expect it can be applicable in a wide range of traffic conditions, locations, and types of reconfigurations. We utilized statistical methods such as paired sampled t-tests and Mann-Whitney-U tests for the "*before*" and "*after*" corridor safety analysis based on Tennessee's Integrated Traffic Analysis Network (TITAN) dataset. Similarly, we used the Difference-in-Differences (DID) analysis to quantify the economic impacts of reconfiguration treatments based on parcel-level property value data. The methods showed that road reconfiguration positively affects the corridor's safety, traffic, and other less tangible benefits embodied by rising property values. We also observed that road treatments were more impactful along the corridors given heavy treatment than smaller road diet interventions in the city.

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EXECUTIVE SUMMARY

This study aims to advise TDOT on the preliminary best evaluation strategies to assess existing road reconfiguration projects (sometimes called road diets) and identify candidate locations where benefits can exceed the project costs. The framework provided here will also assist agencies in gathering appropriate data before implementing and evaluating road reconfiguration projects. The study can briefly be divided into three parts. First, an inventory of existing road reconfiguration projects in Tennessee is provided in addition to a review of published literature on road reconfiguration projects. Next, an evaluation framework for a complete road reconfiguration project is presented. Lastly, three road reconfiguration case studies are presented from Knoxville.

This study provides an inventory of different road reconfiguration projects completed in Tennessee based on interviews with agency staff in each region. The project inventory includes characteristics, context, and potential effects of individual road reconfiguration projects. Road reconfiguration literature published in the last 20 years was also synthesized in this study's first section. Overall, there was an effort to incorporate literature and case studies and evaluation efforts from primarily urban areas throughout this report.

Next, an impact assessment framework was developed to summarize the benefits of road reconfigurations and create a list of metrics to evaluate such projects. This report investigated the safety modeling methods to assess before/after and case/control evaluation framework for safety and traffic operation questions. A qualitative and quantitative approach to evaluate the economic impact associated with road reconfiguration projects was also created.

Last, using available data, we applied the evaluation framework applied to three reconfigured corridors: Cumberland Avenue, Central Street, and Broadway in Knoxville. Each of the selected reconfigured corridors have unique characteristics. Cumberland Avenue received heavy treatment (i.e., major reconstruction) and redesign in contrast to Broadway and Central Street, which both received relatively light treatment (i.e., Broadway was painted with a new lane configuration as part of Knoxville's annual roadway resurfacing contract). This research explicitly assesses the impact of a reconfiguration project on the corridor's operations, safety, and economics using before and after data. This study aims to guide city planners and decision-makers about road reconfiguration projects' potential safety and economic benefits. The case studies presented in this report also serve as representative examples that resemble road reconfiguration candidates.

KEY FINDINGS

The key findings from the study are as follows:

- There was a 55% and 50% decrease in the number of crashes involving VRUs (Vulnerable Road Users) on Cumberland Avenue and Broadway after reconfigurations.
- After the reconfiguration project, there was a 16% decrease in peak hour traffic volume on the Cumberland Avenue corridor.
- The 85th percentile speed remained similar and under the marked speed limit for a simple restriping project.
- There was an increase in the land value for the parcels along Cumberland Avenue which, was increased at a rate five times higher than that of the land value increase over the City of Knoxville.

KEY RECOMMENDATIONS

The following are key recommendations.

- We recommend maintaining a statewide inventory of completed, planned, and potential candidate segments of road reconfiguration projects and develop an evaluation framework to maintain consistency. Such a process will improve decision-making and support future studies and projects. In addition, an inventory would provide the foundation for different future research.
- While road interventions are of different types and have their respective benefits, we recommend a site-specific intervention at a corridor based on respective site-specific characteristics and requirements. For example, it is necessary to keep two lanes in each direction for capacity purposes in some cases. In such cases, the choice between narrowing lane width to include Two-Way Left Turn Lane (TWLTL) or bike lane can be decided based requirement of the neighborhood. Similarly, converting an existing three-lane road to a three-lane cross-section with narrowed lanes can accommodate bicycle lanes or parking lanes and provide traffic calming benefits. One of the case study corridors in this study, Cumberland Avenue, was often congested with high volumes of through traffic, unexpected turning vehicles, and no parking regulations. Unfortunately, many of these conditions led to higher crash rates. To solve these problems, Cumberland Avenue went through a complete reconfiguration.
- We recommend strengthening the safety analysis of treated corridors by specifically investigating the effects of the reconfiguration on the safety of Vulnerable Road Users (VRU), such as crash rate analysis, safety, and risk performance analysis. We also recommend exploiting Intelligent Transportation System (ITM) technology to determine different contributing factors of crashes, crash hotspot identification, and driving behavior analysis for analyzing Vulnerable Road User (VRU) safety.
- We recommend developing a cross-sectional research design framework to compare the traffic volumes and speeds at the treated corridor and the outside the project neighborhood. A cross-sectional design framework examines the changes in such factors at a considered location over the period. In the case of traffic speed, we recommend analyzing the number of vehicles and their speed that falls above the 85^{th} percentile limit rather than exploring the average 85^{th} percentile speed over time through the treated corridor.
- We recommend presenting the results such as before and after through clear graphical representation that reflects the before and after changes with normalized data, which better emphasizes which parcels are being redeveloped, which are increasing in value, and which are collectively growing economic productivity by using land value as a proxy. We highly recommend the stack plot over the parcel map (as used herein this report for economic analysis) to visually represent the before and after economic difference. Based on this analysis, it can be concluded that a given treated corridor and its surrounding area would achieve substantial benefits from a road reconfiguration project accommodating different modes of transportation within its existing cross-section.

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Chapter 1 INTRODUCTION

> *"A street is a publicly-owned canvas. How that space is allocated – to vehicles, to pedestrians, to cyclists, to art, to ecology, to play – is not a technical decision, but a political one." (Schlossberg et al., 2019)*

1.1 BACKGROUND

Cities throughout the United States are progressively employing bicycle infrastructure and related roadway modifications as a cohesive approach to improve traffic safety measures. Among many different modifications, the road diet is one by which existing lanes are modified to introduce bike lanes, widened sidewalks, or street parking. Burden and Lagerway (1999) first coined the term "Road Diet" in the late 1990s as a memorable way to describe a general method of reducing the extent of auto-centric elements within a roadway corridor while emphasizing the connection between health and infrastructure (Burden & Lagerwey, 1999). Numerous road diets have been implemented across the United States, most frequently by transforming a roadway with four general-purpose travel lanes into a corridor with three general-purpose travel lanes (including a center two-way left-turn lane), with the recovered pavement space reallocated for bicycle lanes or parking. However, many different reconfiguration and reallocation projects fall under the basic definition of "road diet".

Road diet projects are relatively low-cost measures that improve safety, multimodal accessibility, and quality of life in a neighborhood. In the United States, cities are ensuring the equitable distribution of street space for all users by changing their approach towards new street construction. Road diet projects are a fundamental step towards complete street design. Complete streets aim to balance the needs of all roadway users by encouraging and allowing safe travel for bicyclists, pedestrians, and other modes of transportation in addition to existing vehicle traffic. However, road diet projects might also come with concerns and reluctance from users. Merchants along treated sections of roadway are occasionally worried about losing the loading zones and parking spaces and, ultimately, losing business. Also, depending on the configuration and surrounding environment, some existing traffic can shift to alternate routes, eventually increasing the traffic volumes and speed on possibly less suitable streets.

This report analyzes the safety, traffic, and economic impacts of three different road diet projects in Knoxville, Tennessee. The before and after data on traffic crashes, vehicle speed, vehicle volume, and the property's assessed value (land parcel) from respective corridors were analyzed. The report also presents an inventory of road diet projects from four Tennessee cities, a detailed literature review of relevant road diet literature, and a thorough description of different road diet typologies. A reference document for road diet projects currently implemented in 4 major cities in Tennessee and their respective characteristics is included in Appendix A.

This report aims to contribute to the growing body of published road diet literature by analyzing the effects of reconfiguration projects at three different corridors in Knoxville, Tennessee. In 2015, the City of Knoxville implemented the streetscape project in Cumberland Avenue. The reconfigurations on North Broadway and Central Street were implemented in 2018. Cumberland Avenue runs through a predominantly commercial area, whereas North Broadway and Central Street have mixed land use. The study analyzed the before and after traffic crashes acquired from Integrated Traffic Analysis Network (TITAN) spanning January 2010 through June 2020. Similarly, the INRIX Speed historic speed and travel time data were utilized for each corridor's traffic analysis (traffic volume and 85th

percentile speed). Lastly, the Knox County Property Accessor office provided the parcel-level property information for the economic analysis conducted.

1.2 Research Objective

As right-of-way reallocations have become more numerous and creatively applied over the years, practitioners and researchers have built up a body of knowledge regarding benefits, costs, and considerations surrounding implementation. In Tennessee, agencies have implemented several high-profile projects, including Cumberland Avenue in Knoxville, Martin Luther King Boulevard in Chattanooga, Cleveland Street in Nashville, and Broad Avenue in Memphis.

However, the State's portfolio of road diet projects has yet to be systematically evaluated regarding safety, operations, and economic costs and benefits. This document aims at creating an initial inventory and developing an evaluation framework for road diets in Tennessee.

In this report, we have undertaken four tasks to accomplish the study objectives:

- Define the term road diet and identify subsequent typologies.
- Create an inventory of completed road reconfiguration projects throughout Tennessee.
- Develop a list of metrics to evaluate treated corridor performance.
- Conduct in-depth case study evaluations of three corridors from Knoxville.

1.3 Terminology

The terminology used to describe a road diet is changing. The word "diet" can give people a negative connotation of deprivation and discomfort. Accordingly, governmental organizations and consultants are shifting to more neutral or positive-sounding terminology such as roadway "reconfiguration", "reallocation", "rebalancing", or "right-sizing". Road "buffet" is also used colloquially in some public meetings to emphasize the array of mode choices and pleasurable experiences available via a complete street. Therefore, we have opted to use the neutral term "*road reconfiguration*" in place of "*road diet*" henceforth in this report.

1.3.1 Definition of Road Reconfiguration

Generally speaking, a "*road reconfiguration*" is the process of reallocating one or more vehicular travel lanes within the existing right-of-way to accommodate other modes or uses such as sidewalks, bicycles, transit vehicles, turn lanes, medians, or green infrastructure. Road reconfiguration techniques include, but are not limited to, lane reduction or lane width reduction, typically focused within the travel way. In addition to the reconfiguration of travel lanes, the pedestrian pathway may also be reconfigured during a corridor reconstruction project. For this report, this definition will be used to provide a consistent point of reference.

1.3.2 Cross Section Elements

In this section we have described the commonly used terms used to illustrate cross-sectional elements.

Lane Width

Lane width is a crucial aspect of street design. It influences the operational, safety, and quality of service experienced by the road user. Historically, travel lanes with widths of 11-13 feet have been preferred. Many researchers believe that such widths provide more buffers in high-speed environments. Lane widths of 10 feet are usually considered appropriate in urban areas, positively impacting street safety without impeding traffic operations.

Median

A median is a section in the street that separates the contra directional traffic lanes. Its primary purpose is to separate opposing traffic. Medians may be raised, depressed, or flush, depending upon their use and location. Design width significantly depends on the type of roadway and its location.

Urban Scale

Urban scale is a term used to describe the essential characteristics of a street cross-section which includes "the sense of height, bulk, and architectural articulation of a place or an individual building, often in relation to the size of a human body" (Saint Louis Green Streets Initiative, 2015). Characteristics such as building height, density, and floor area ratio correlate with aesthetic features like scale and ocular relationship to the adjacent building. The characteristics of buildings are the most pronounced element of urban scale. Two of such are described below.

- Building Height

  The building height is the primary feature for the urban context that creates a sense of enclosed thoroughfare. Building height to street width is an essential parameter for creating a visual enclosure for pedestrians. Visual enclosure occurs when most of the pedestrian's cone of vision is occupied by bordering high-rise buildings. The Saint Louis Green Streets Initiative (2015) helps to define this as "an area with buildings predominantly between four and eight stories is typically considered medium scale; however, the city context makes a difference."

- Building Width

  Building width is another measurement that adds up to the feeling of the enclosed thoroughfare. The percentage of building width fronting the street, ranging from 70 to 100 percent depending on development type, is considered a comfortable urban scale. Similarly, the distance between adjacent buildings and the appearance of the building fronting the street also adds up to the pleasant urban scale. Based on the Institute of Transportation Engineers (ITE) recommended practice, the distance between the building separation should be maintained up to 30 feet wherever possible, and the frontage of the building should be divided into distinct parts to minimize the uninviting blank walls (LA, 2011).

Sidewalks

Sidewalks are the portions of a street between the curb lines and the adjacent property lines. Sidewalks are the public right-of-way that typically includes frontage zone, pedestrian throughway zone, street furniture and vegetation zone, and buffer zones.

Setback

A setback is a minimum distance by which the building or adjacent structures must be set back from a street or a different structure estimated to need protection. Setbacks aim to provide buffer distance between buildings and sidewalks that allow pedestrians to browse and enter and exit a building without interfering with pedestrians in the throughway zone.

Pedestrian Facilities (Throughway zone)

It is a section of the roadside zone on which pedestrians travel. This facility should be designed to accommodate all pedestrians, including those with disabilities. Pedestrian facilities include but are not limited to sidewalks, curb ramps, marked crosswalks, transit stops, roadway lighting, pedestrian overpasses/ underpasses, and street furniture in walking environments. This section should always provide a minimum horizontal and clear vertical area.

Furnishing Zone

The furnishing zone is a multipurpose section of the pedestrian area. It also serves as a buffer between walking pedestrians and the moving vehicle, providing space for roadside features such as trees, signs, street furniture, above-ground utility, sidewalk cafes, signals, bicycle racks, and bus shelters.

Edge Zone

The edge zone is the transition area between corridor travel and furnishing zones on the street side and provides space for vehicle doors. In some of the literature, the edge zone is also referred to as the curb zone.

Frontage

As described in many works of literature, the building frontage is the main functional entry section on the front of the public space. We can distinctly recognize frontage at a street, square, store, park, or plaza, but not a parking lot. Frontage is the connection to sidewalks from public space for walking and easy accessibility for all user types.

Cross-section transition (Intersections)

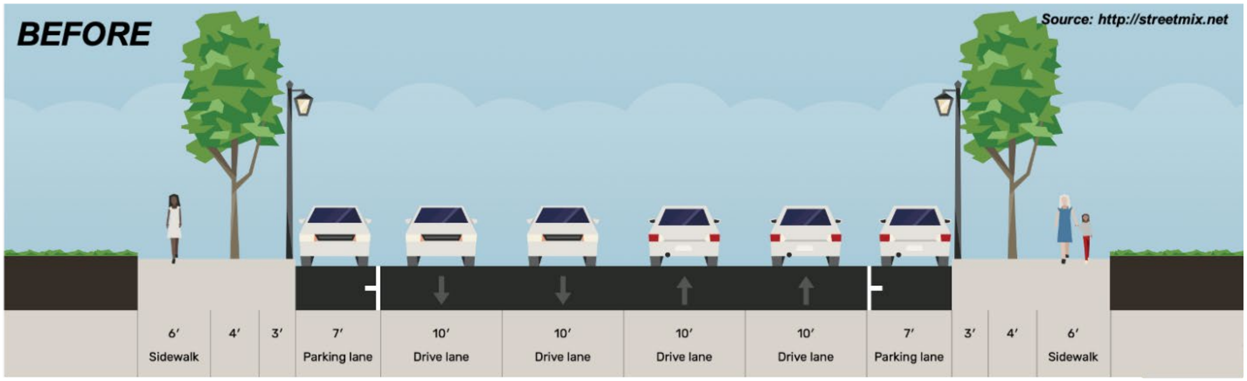
An intersection is a junction where two or more street sections convene, and pedestrians share the travel way with other modes of transportation. Cross-section transitions are portrayed by notable traffic activity and shared use, multimodal traffic conflict, complex traffic movement, and exceptional design treatment.

1.4 Typologies

Road reconfiguration has been deployed with countless variations and context-specific design elements. A simplified version of a “road diet” (removing a general-purpose travel lane) does not capture the full scale of what is possible with a reconfiguration project. This section describes major road reconfiguration typologies that allow the designer to identify the host of options available to them when assessing the potential use of the street right-of-way.

1.4.1 Reduction in Number of General-Purpose Travel Lanes

Type 1. Outer Lane Reallocation (4-3*)



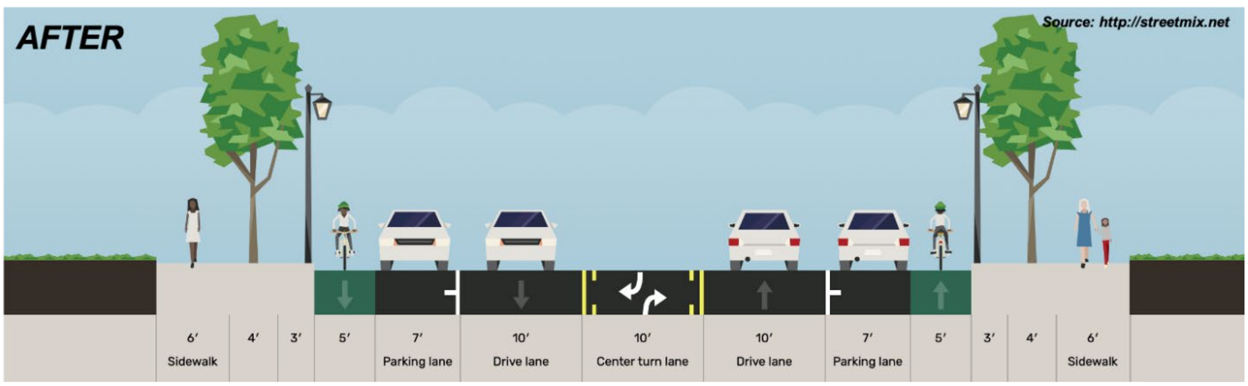


Figure 1-1 Outer Lane reconfiguration with center turn lane.

The four-lanes to three-lanes conversion are the most common form of road reconfiguration. This conversion includes converting a four-lane undivided roadway into a three-lane roadway. The final reconfiguration consists of two through travel lanes and a center two-way left-turn lane (TWLTL). This reduction in lanes allows for relocation/introduction of pedestrian refuge, an intermittent median, bicycle lanes, and parking.

Type 2. Outer Lane Reallocation (5-3*)

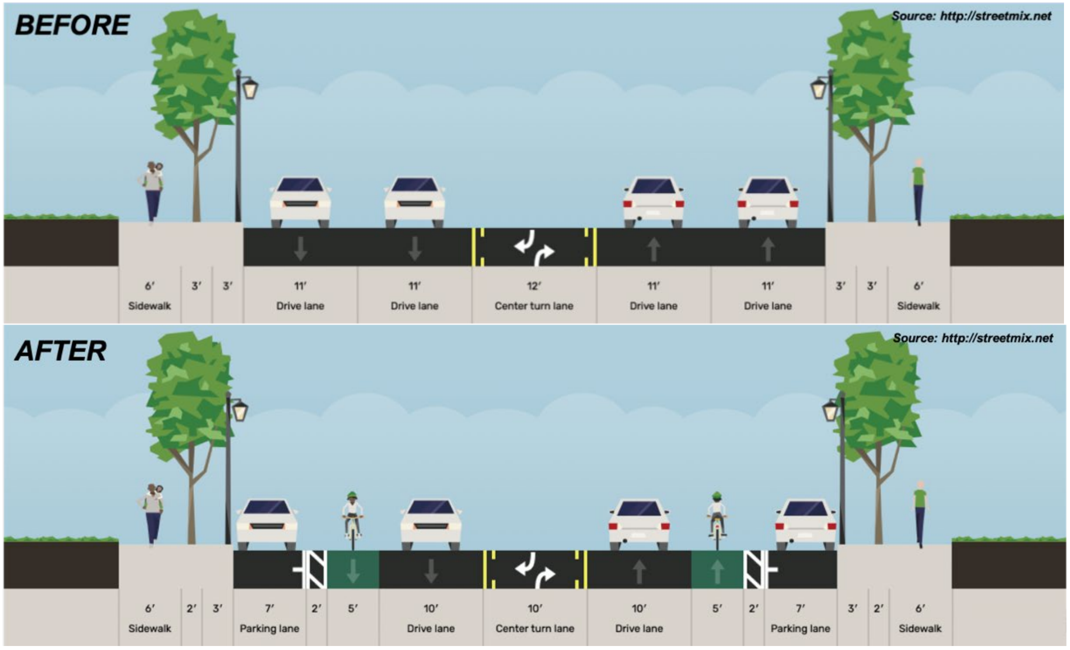


Figure 1-2 Outer Lane reconfiguration with on-street parking and buffered bike lane.

The outer lane reallocation (5-3) typology includes a five-lane undivided corridor converted into a corridor with two through travel lanes and a center turn lane. The new parking lanes and dedicated bike lanes are accommodated in the extra space available after the reconfiguration. A reconfiguration such as this is feasible for a street section that requires on-street parking with added micromobility lanes.

Type 3. Highways to Parkways (4-2)

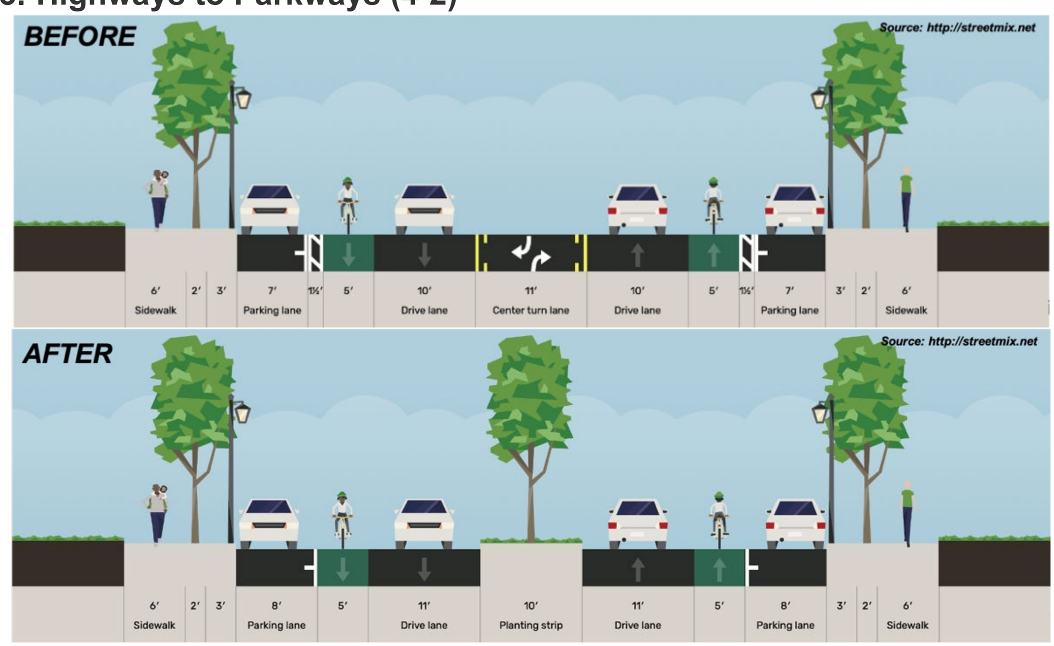


Figure 1-3 Highway to parkway lane reconfiguration.

A street configuration with four travel lanes is the most common form of street configuration for most highways. A four-lane road (highway) is converted into a two-lane roadway, with an added median and bicycle lanes (considered a parkway with such type of reconfiguration).

Type 4. On-Street Parking Repurposing (P-B)

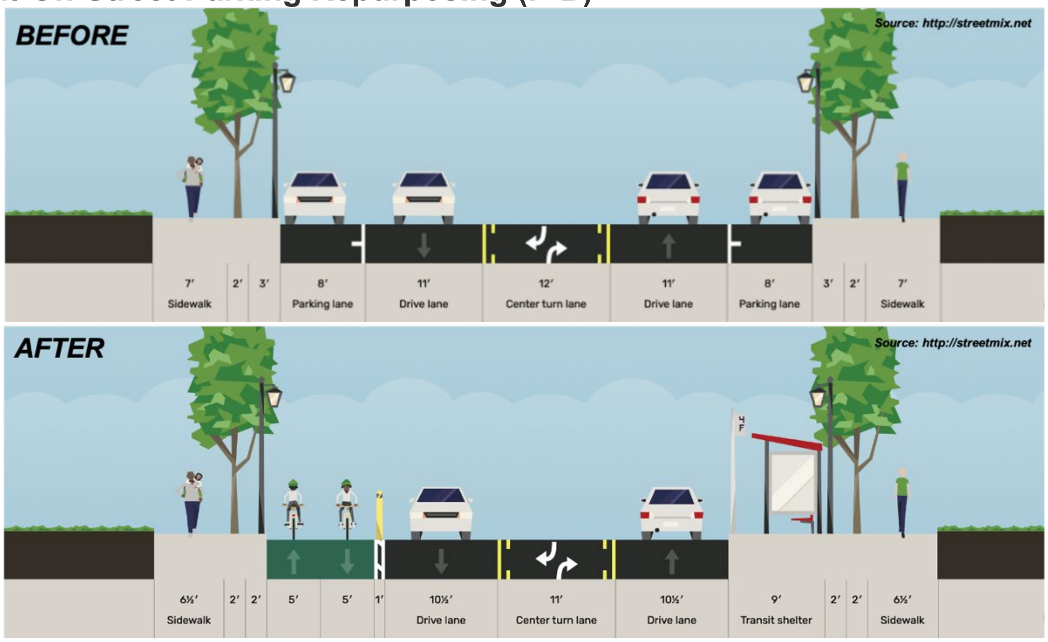


Figure 1-4 Parking Lane reconfiguration.

The *P-B (Parking to BRT)* street reconfiguration removes on-street parking lanes and repurposes the extra spaces for other dedicated facilities, such as transit and/or bicycle lanes.

Type 5. Transit Prioritization (XT)

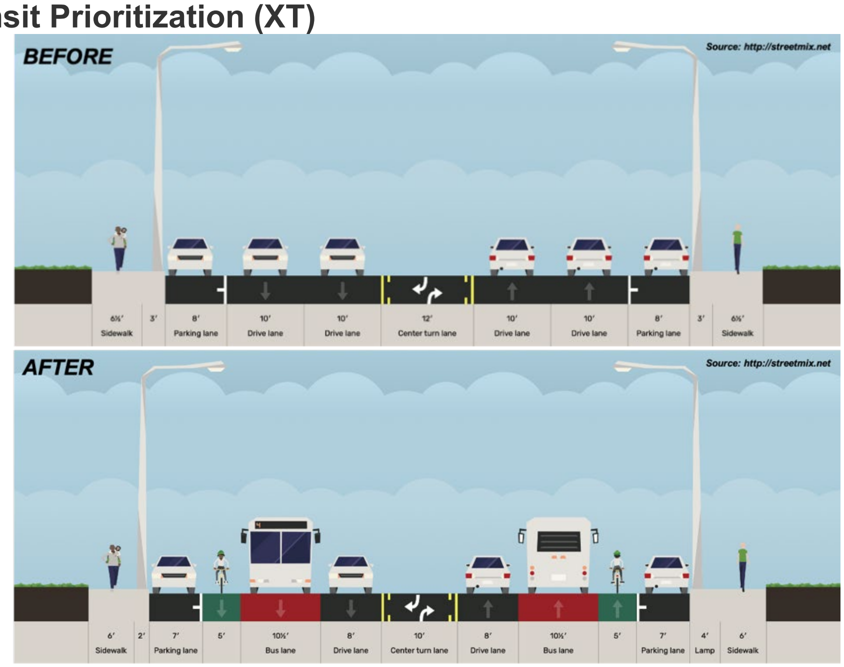


Figure 1-5 Lane reconfiguration with prioritization to transit and bicycle lane.

The *Transit Prioritization (XT)* reconfiguration converts a high-speed car-centric street configuration to a dedicated transit configuration with added bike lanes and pedestrian infrastructure. Effectively developing Bus Rapid Transit (BRT), a cost-effective solution, provides features similar to a light-rail train option in the context of speed and reliability.

Type 6. Green Street Retrofit (XG)

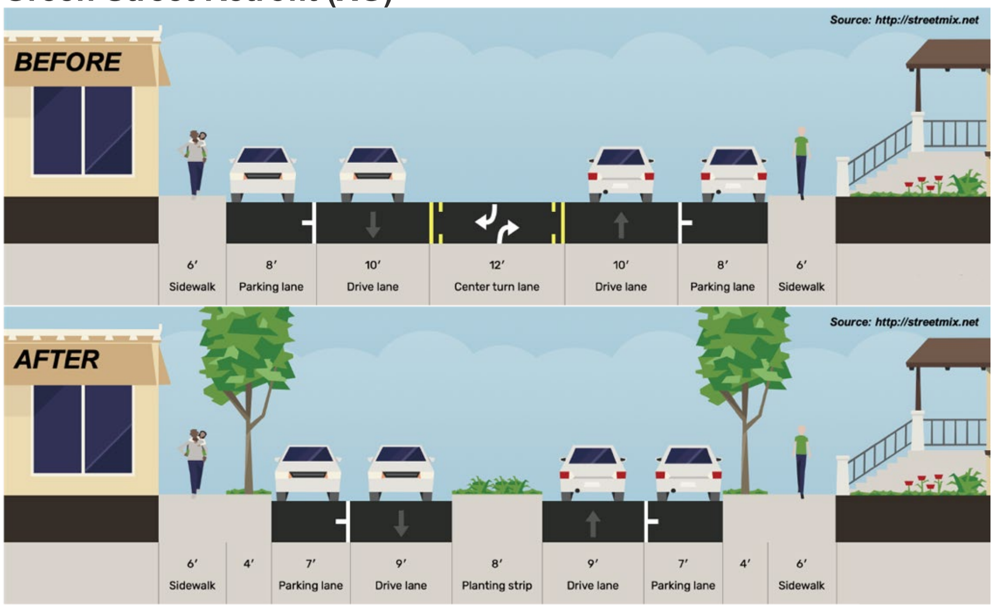


Figure 1-6 Street reconfiguration into a green street.

The *XG* street reconfiguration retrofits a car-centric street into a green street. A two-lane street with a center turn-lane and on-street parking is converted into a street with reduced travel and parking lane widths with extended sidewalks and a new raised median for vegetation.

Type 7. Skinny One-Way (3-2)

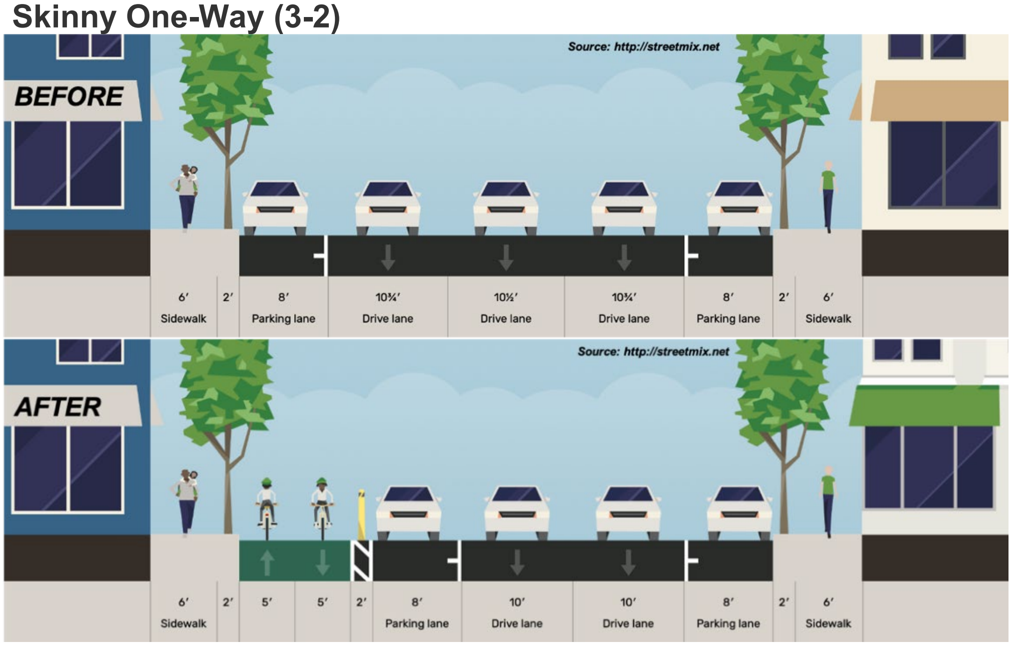


Figure 1-7 One way street reconfiguration for bike lanes.

A one-way street with three travel lanes is converted to a smaller two-lane street to accommodate dedicated bicycle lanes and transit lanes.

Type 8. One-Way Conversion (2-1)

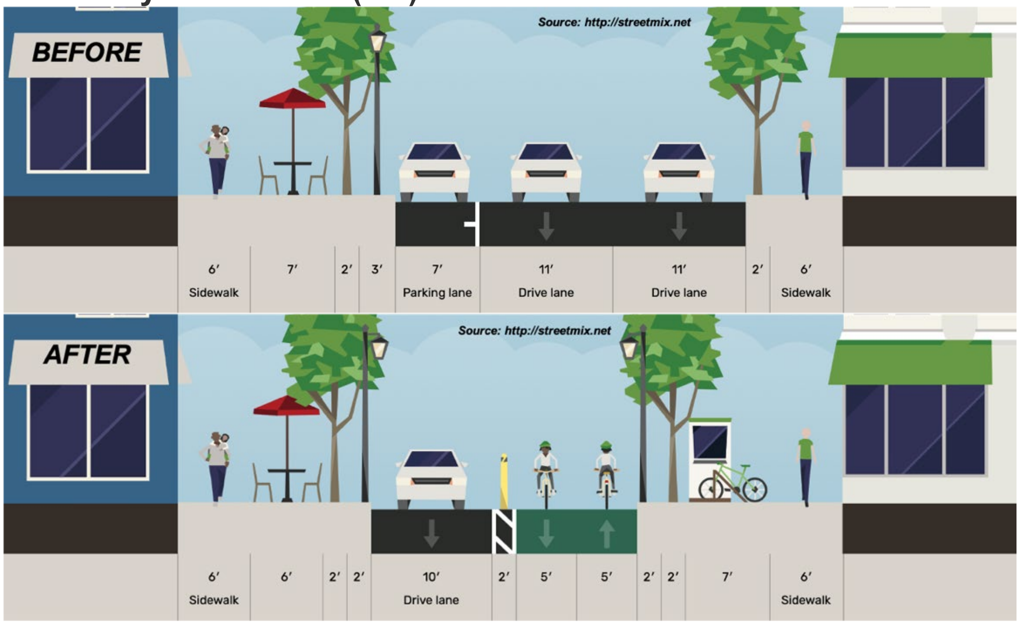


Figure 1-8 One way street reconfiguration with pedestrian and bicycle infrastructure.

Contraflow bike lanes are placed counter to the normal traffic flow to improve bicyclists' safety or access. Converting a two-lane one-way street into a single lane accommodating a contraflow bike lane creates a specialized facility for bicyclists that can be used to enhance bike connectivity and improve safety and bicyclist behavior by reducing wrong-way riding on a one-way street.

Type 9. Slow Street (Open Street) Conversion (2/1-B/E)

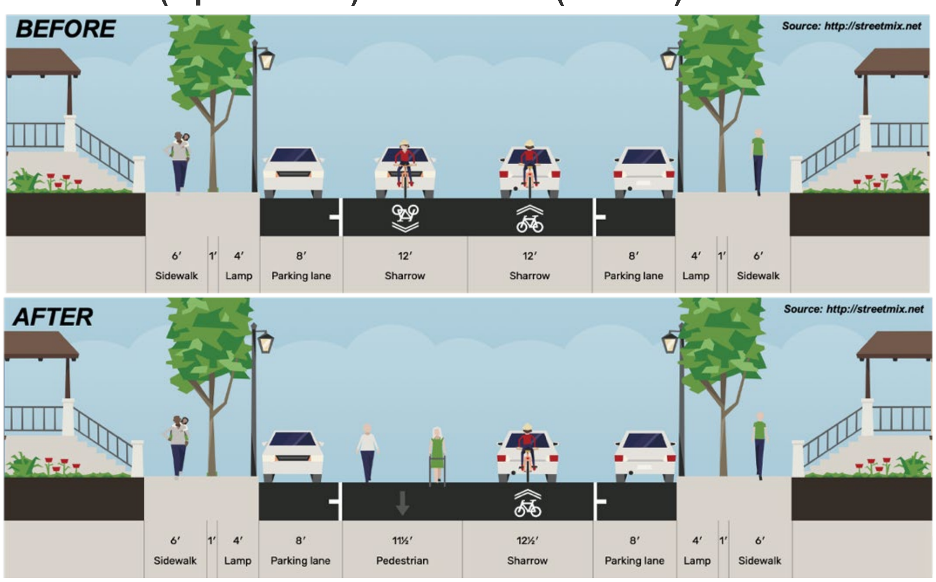


Figure 1-9 Open Street reconfiguration.

A slow street conversion limits traffic (speed and volume) on certain streets and allows vehicles to be used more as a shared space with foot and bicycle traffic. These converted spaces can comfortably be used for physically-distanced walking (during a unique situation like the COVID-19 pandemic), wheelchair rolling, jogging, and biking. For limited through traffic, the speed limit is generally set to 20 mph.

Type 10. Shared Street Conversion (2/1-S)

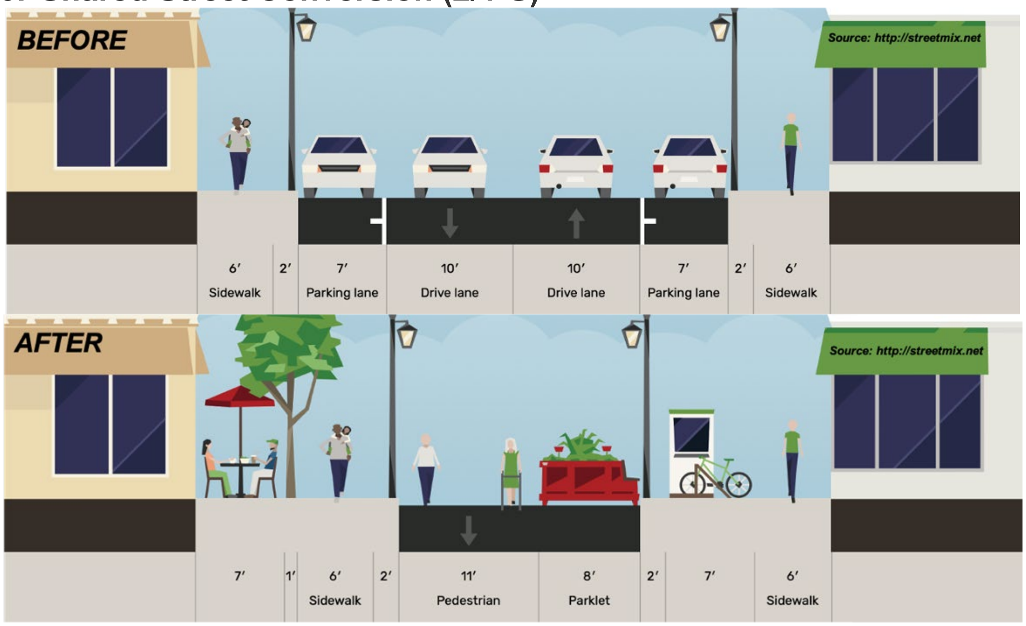


Figure 1-10 Street reconfiguration into a shared street.

The term “Shared Street” is based on the concept of "woonerf," which is Dutch for "street for living", sometimes also referred to as a "green street". A shared street, in general, is a "pedestrian-priority street" along a residential/commercial area that balances the parallel existence of different modes of transportation such as pedestrians, bicyclists, and low-speed motor vehicles. Such streets are mostly local-access with narrow cross-sectional width where *curbs* and sidewalks are with the travel lanes. The significant characteristics of shared streets include trees, planters, parking areas, and other obstacles that lower the traveling speed (Park, 2018).

Type 11. DePave (X-N)

Depaving (DePave) denotes the act of removing asphalt or concrete pavement and reclaiming the space for recreational or aesthetic uses such as parks or community gardens. Depaving is possible where excess lanes are available due to low traffic volume or excess parking spaces due to lack of traffic or proper maintenance funds. Previously paved spaces can now be returned to nature, reducing the heat island effect, enhancing air quality, and providing traffic-calming effects.

1.4.2 Reduction in Width of General-Purpose Travel Lanes

*A Policy on Geometric Design of Highway and Street (*AASTHO), the standard highway design reference document in the United States, recommends lane and shoulder widths to be 12ft and 10ft, respectively. With the increase in demand for additional capacity on urban streets, the need to optimize street configurations should improve capacity without impacting operational speed and safety. These projects can help with corridor speed control, safety, and access management and allow for the addition of multimodal elements. Lane-width reduction is often done in combination with lane reductions but can also stand alone.

Type 1. Lane reconfiguration (5-5, 3-3, 2-2 or 4-5, 2-3)

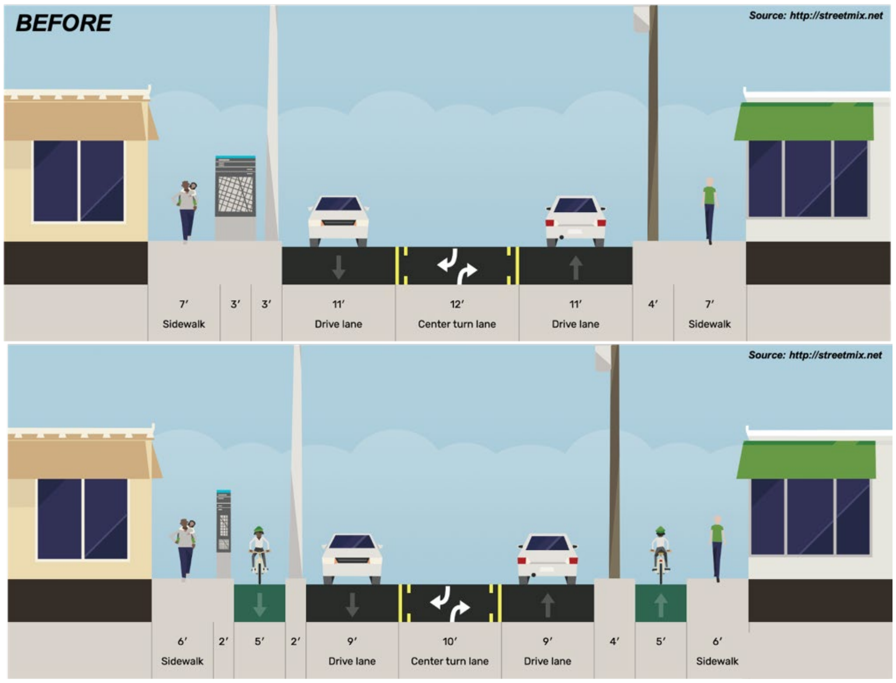


Figure 1-11 Lane reconfiguration to accommodate bike lanes.

Lane reconfiguration is the general process of decreasing a lane width to the minimum practical width. Narrow lanes provide more consistent traffic flow by reducing the speed differential along the corridor. Typically, the width of travel lanes is reduced to no less than 10 feet, whereas right turn lanes and storage lanes can be reduced to 9 feet. A more consistent flow of vehicles with reduced speed encourages other modes to use the street. The extra space from reduced lanes can also be used for pedestrian space, bicycle facilities, parking, and other green infrastructure.

Type 2. Median Addition (X+M)

Source: https://globaldesigningcities.org

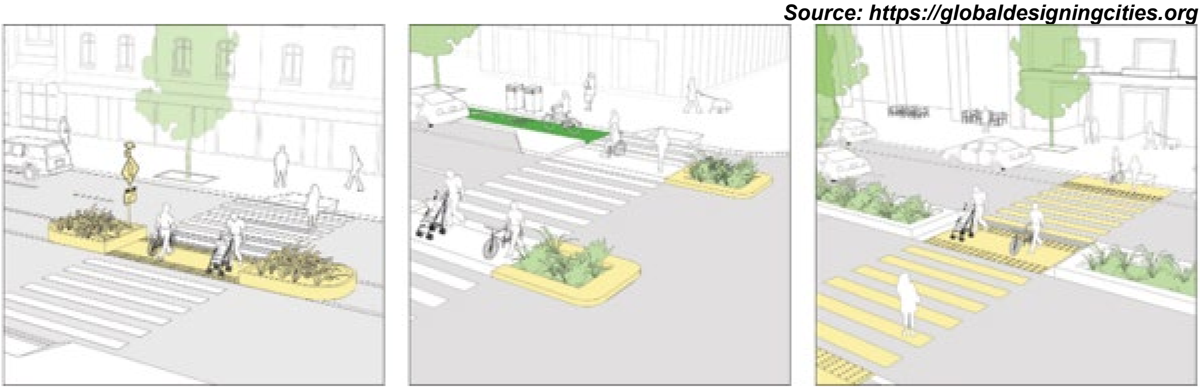


Figure 1-12 Pedestrian refuse island and medians.

Medians are islands located along the street's roadway centerline and assist in separating the opposing directions of traffic movement. They are mainly raised but can also be flush depending on the street surface. Raised medians can reduce lane width for vehicles and provide refuge for crossing pedestrians and bicyclists. The median can also accommodate transit stops and tree vegetation, converting a street into a boulevard in some cases.

Type 3. Advisory Bike Lane (2-1.5)

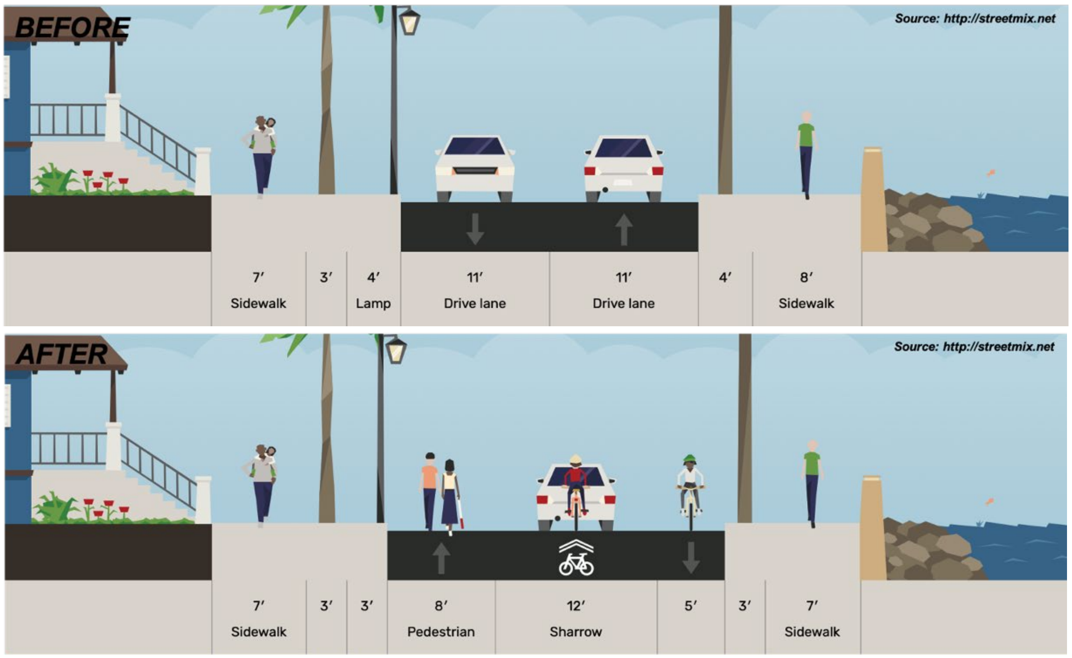


Figure 1-13 Lane reconfiguration with bicycle right of the way.

The Yield-to-Bike configuration provides space for vulnerable road users by reconfiguring the street section. In this reconfiguration, motor vehicles use the center lane, and vulnerable road users use edge lanes on either side. Thus, the two-way center lane is shared by motorists traveling in both directions, and the edge lane is used by the vehicles to pass the other car, but only after yielding to vulnerable road users.

Type 4. Pedestrian Striped Shoulder (2-2)

The pedestrian stripped shoulders are an interim or temporary pedestrian facility on the street with moderate traffic speed and volumes. Such a development is generally applied in rural applications primarily for traffic calming reasons. Public-Right-of-Way Accessibility Guidelines (PROWAG) recognizes such a development as pedestrian lanes).

1.4.3 StreetSide Reconfiguration

StreetSide reconfiguration is intended to improve the mobility of pedestrians and small micromobility vehicles. It could be implemented as a stand-alone project or accomplished during complete street reconstruction. Basically, for the purpose of such reconfiguration, curb space is utilized as an extension for bike lanes or pedestrian right-of-way. A new separate trail within the street's right-of-way can be introduced for more rural sections without curbs. Notable examples include elevated cycle tracks and wider pedestrian zones.

1.4.4 Full Reconstruction

Planners and engineers can accomplish full reconstruction for any street section using a combination of the typologies mentioned above.

1.5 JUSTIFICATION

Road reconfiguration is a federally recognized safety countermeasure to achieve the "Vision Zero" policy. Vision Zero is a policy that aims to eliminate traffic-related fatalities and severe injuries by reducing vehicular speeds on corridors shared by users of multiple travel modes. The resulting benefits include a reduction in crashes by 19 to 47 percent (Knapp et al., 2014). In addition, when applied correctly and in the right location, a road reconfiguration can maintain a roadway's adequate capacity by allowing left-turning drivers to exit the stream before turning. Some of the many benefits for road reconfigurations include:

- Reducing the width of the travel lane such that pedestrians can cross the street in minimal time, reducing the multiple crash threats typically present.
- Providing room for pedestrian islands, which are proven to increase safety for pedestrians.
- Improving speed limit compliance, further reducing the crash severity when crashes do occur.
- Creating a buffer between pedestrians and traffic through the addition of bike lanes and on-street parking.
- Improving qualitative livability factors.

1.6 REPORT ORGANIZATION

This report intends to assist in planning, design, implementation, and analysis of road reconfiguration projects with the Information provided. It is also designed to provide information on the effects of road reconfigurations on safety, traffic flow, and economic activity. A description of each of the six chapters is provided below.

Chapter 1 provides the background and states the research objectives. It also incorporates definitions and terminologies for different street cross-section elements and types of road reconfiguration projects. Chapter 2 summarizes the existing road reconfiguration research and literature, categorizing works into three sections: safety, traffic flow, and economy. This section also summarizes four different road reconfiguration guidelines regularly used in projects throughout the United States. Chapter 3 describes methodologies implemented to evaluate the reconfiguration projects from Knoxville, Tennessee. Three corridors were selected from Knoxville as the case studies for this report. The chapter also describes the statistics behind the methodology utilized and includes the description of other metrics that are commonly used to evaluate road reconfiguration projects. Chapter 4 includes the inventory of completed road reconfiguration projects from Tennessee. The inventory consists of the road reconfiguration projects from Nashville, Knoxville, Memphis, and Chattanooga. Chapter 5 provides detailed case studies of three selected corridors from Knoxville, Tennessee. The case studies include before and after safety, traffic, and economic analyses of the given corridor. Lastly, Chapter 6 concludes the report with recommendations for TDOT.

Chapter 2 LITERATURE REVIEW

Road configurations aim to balance the needs of all the road user types by encouraging safe travel by bicyclists, pedestrians, transit users, and freight, in addition to the existing traffic (Dumbaugh & Li, 2010). Based on development type, reconfigured road sections are assigned many names by different authors and respective governing bodies such as *Complete Street*, *Livable Street*, *Context-Sensitive Street*, or *Multimodal Street*. The Federal Highway Administration (FHWA) defines road reconfiguration (road diet) as "*converting an existing four-lane, undivided roadway segment to a three-lane segment consisting of two through lanes and a center, two-way left-turn lane*" (Knapp et al., 2014). In this literature review, we define road reconfiguration as one of the many practices that lead an existing street being reconfigured toward becoming a *Complete Street*. As recognized in this literature, the standard road reconfiguration eliminates extra travel lanes and uses the available space to accommodate other users and travel modes. Many cities have praised and accepted the idea of street reconfiguration throughout the United States. Cities have been transforming already-built street sections to install new bicycle lanes, crosswalks, sidewalks, median islands, curb extensions, and other road reconfigurations (Litman et al., 2002).

Road reconfiguration with lane reduction has been in existence for many years but lacks a definite recorded historical beginning. Harwood (1986) reports that the first documented road reconfiguration in the United States was conducted in 1979 in Montana (Harwood, 1986). In recent years, cities throughout the United States have implemented roadway modifications to make roads user-friendly and incorporate pedestrians and cyclists into the list of users. For example, San Francisco has completed the most road reconfiguration projects among all cities in the United States since 1970. Similarly, California, Florida, Vermont, Minnesota, Montana, Washington State, and Pennsylvania are some pioneer states for road reconfiguration (H. Huang et al., 2002).

In their published work, many authors have discussed the safety effects of converting a four-lane undivided street to a three-lane cross-section. The most common type of analysis measures the changes in motor-vehicle travel times, congestion, and crashes (Retallack & Ostendorf, 2019). In addition, some researchers have analyzed the before and after scenarios of the reconfiguration focused on resident, consumer, and business perceptions; business revenues (Volker & Handy, 2021); customer and delivery truck accessibility (Litman, 2008); and spending patterns by mode of transportation (Bent & Singa, 2009).

Road reconfiguration project evaluations are rarely formally published or adequately archived for future reference. A minimal number of accessible evaluations also vary in metrics used to evaluate the available data sets. The primary purpose of this review is to assess the available evidence regarding the safety, traffic operations, and economic impact (land value changes) due to the implementation of road reconfiguration projects.

2.1 ACADEMIC LITERATURE

Before the mid-1980's it was common practice to develop a two-lane road into a four-lane highway to accommodate increased projected traffic volume. Subsequently, a four-lane street became the model for arterials throughout the United States. It is impossible to locate the place and time for the onset of the era of expanded road reconfigurations. Nevertheless, the idea of road reconfiguration for the greater good of all road users has been in existence for decades. During the late 1990s, Preston (1999) presented a simple cross-sectional comparison for the Minnesota Department of Transportation using statewide crash data. The author compared the crash rate for urban four-lane undivided streets against similar three-lane streets. The study found that the crash rate was 27 percent higher for four-lane streets than three-lane (Preston, 1999). Welch (1999) also studied road reconfiguration projects in Seattle, Washington, and investigated the effects of road reconfiguration projects on crash rates and annual daily traffic (ADT). He concluded that such road reconfiguration is feasible and effective in roads with AADT 20,000 vehicles per day (Welch, 1999). However, most guidance suggests that road reconfiguration projects generally aim at roads with less than 20,000 vehicles per day traffic volumes. This maximum volume recommendation is the basis for project selection policy decisions today. Notably, the Cumberland Avenue case study in this report exceeded 20,000 vehicles per day when considered for a road reconfiguration.

This literature review for this study is broken down into three sections. The first section examines the published literature on the safety improvement experienced as road reconfiguration projects. The second section examines the literature on traffic flow to determine the feasibility of reducing capacity through reconfiguration projects. The third section discusses the correlation between street reconfiguration and economic activity. There are many other impacts of roadway reconfigurations, but this review focuses specifically on those included in our analysis and generally constitutes the significant impacts most important to TDOT.

2.1.1 Safety

Of all benefits from a road reconfiguration project, safety considerations have motivated most transportation infrastructure improvement studies. Almost all the published literature echoes the benefits of such reconfiguration. Many studies have evaluated the collision rates concerning street improvements (Griswold et al., 2011; Manuel et al., 2014). According to the Federal Highway Administration (FHWA), street reconfiguration offers low-cost and high-return improvements when applied to a typical four-lane highway. Such a conversion can result in a crash reduction from 19 percent to 47 percent (FHWA, 2016). The consistency of the findings differs for different street reconfiguration projects, varying based on the design implementation and traffic patterns. Some studies consider treatment sites and use advanced statistical methods to estimate total crash rates, while others use simple before and after analysis without controls. Pavlovich (2006) conducted a Bayesian analysis of 15 Iowa road reconfiguration treatment sites and 15 controlled sites over 23 years with a 2,000 to 15,000 AADT volume range. The study concluded that road reconfiguration resulted in a 25 percent reduction in crashes per mile and a 19 percent reduction in the crash *rate* over the 15 treatment sites in relation to comparison sites (Pawlovich et al., 2006).

Similarly, Noyce et al. (2006) analyzed the crash data for safety concerns using three different methodologies. Firstly, the crash data was analyzed using the traditional approach of comparing before and after crashes. Then Noyce also used Yoked-pair comparison analysis and the Empirical Bayes approach to analyze the before and after crash data. The traditional before-and-after system estimated a reduction in total crashes of approximately 42 percent. A Yoked-pair comparison analysis found a 37 percent reduction in total crashes and a 46 percent reduction in property damage only crashes, whereas the Empirical Bayes approach estimated a 44 percent reduction in total crashes (Noyce et al., 2006). Other early studies conducted in New York City also demonstrated that road reconfiguration as a traffic calming measure is an effective measure for significant safety benefits (Chen et al., 2013). The City of Orlando (2002) and Pawlovich (2006) also conducted individual studies to quantify the safety effect of road reconfiguration. Both studies concluded a positive impact of road reconfiguration on safety. Orlando evaluated a re-striping project that converted a four-lane street section into a three-lane with wide parallel parking and new bike lanes. During the first four months after lane reconfiguration, the annualized crash rate per million vehicle miles, as well as the injury rate, declined by 34 percent and 68 percent, respectively (Pawlovich et al., 2006; Zhao et al., 2002).

In contrast, a small number of studies conducted in cities, particularly in California and Washington State, have concluded the safety evaluation of a road reconfiguration project with insignificant results. For example, examining crash data on Valencia Street in San Francisco, California, and on Stone Way, North in Seattle reflected minor, positive changes in crash rates after the reconfiguration project.

Similarly, others also analyzed the safety effects of road reconfiguration projects with other methods, such as an observational study of real traffic (Chiforeanu, 2020; Grundy et al., 2009) and microsimulation of traffic using statistical tools (Liu et al., 2021). Overall results support theory on the effect of road configuration; that is, safety improvement after road reconfiguration is significant.

2.1.2 Traffic Operations

Despite growing interest in road reconfiguration projects among transportation planners, engineers, and community members, there is limited evidence of such interventions on traffic operations. Most of the literature on road reconfiguration focuses on the safety improvements or the access provided to travel modes other than private motor vehicles (Jouliot, 2018). A small number of studies concentrate their effort on travel speed and traffic volume changes due to road reconfiguration projects. Knapp and Giese (2001) carried out a detailed simulation sensitivity analysis to illustrate four to three-lane road reconfiguration projects' effects on traffic volume. The simulation results primarily confirmed that motor vehicles might have some impact during the peak period when traffic is greater than about 1750 vehicles per hour (both directions). Simulation results indicated average arterial speed reduction between 0 to 4 mph (Knapp & Giese, 2001).

On the contrary, Russell and Mandavilli (2003) examined the traffic flow impact of a street reconfiguration project. They explored an intersection where a four-lane undivided roadway was converted to a three-lane roadway with a two-way center turn lane and bike lanes on wider sides of the road (Russell & Mandavilli, 2003). They concluded that operational performance for three-lane streets was nearly equal to that of the four-lane street. Investigations with the use of model simulation also reflected that road intervention projects had no statistical impact on the level of service and traffic flow of personal vehicles (Stamatiadis, 2014), whereas the bicycle level of service improved by at least one letter grade in each section with reconfiguration (Elias, 2011).

The road reconfiguration from four- to the three-lane conversion of Valencia Street in San Francisco reduced the ADT by 10 percent (Sallaberry, 2000). The ADT on the other four parallel streets increased by 2 percent to 8 percent. The total number of crashes decreased from 73 to 62 crashes per year, and yearly injury rates fell from 59 to 50 injuries per year. Another street in San Francisco, Polk Street, was reconfigured from 3 lanes to 2 lanes reducing the ADT by 2 percent. The ADT on two parallel streets increased by 8 percent and 15 percent (H. F. Huang et al., 2002). Gates et al. (2007) concluded road reconfiguration is a recommended option with a given range of average daily traffic to improve traffic operations, mainly if the section of the roadway is experiencing conflicts between left-turning and through traffic vehicles (Gates et al., 2007). In another investigation of the feasibility of road reconfiguration, Noland. et al. (2015) conducted a study in the City of New Brunswick by analyzing the microsimulation of traffic networks. Their work exhibited that road reconfiguration, consistent with a complete street policy, will result in some extra delay to traffic both along the corridor and within the network. However, the cost of the delay to the traffic is less than the significant benefits associated with the reduction in traffic crashes based on cost/benefit analysis (Noland et al., 2015). Thus, the studies suggest that road intervention projects do not significantly slow traffic and improve overall traffic flow. Such road interventions can also be correlated with the decrease in traffic volume and increases in other active transportation modes, potentially shifting traffic operations in a helpful direction.

2.1.3 Economic Impacts

As evident from the above-discussed literature, road reconfiguration improves local access, safety, and environmental quality. However, only a few papers exclusively investigate the economic benefits of road reconfiguration projects. Reconfiguration projects are expected to include benefits to the adjacent businesses and landowners with a long-term effect on land value (Litman, 2012; Litman, 2017). Primarily, we expect a street reconfiguration to improve property value and adjacent housing prices, ultimately generating more revenue from property taxes to finance public services. Yet published literature lacks the comprehensive economic relationship and quantification of expected benefits associated with road reconfiguration. Some studies have been conducted to link road reconfigurations to both positive and negative financial outcomes. Still, very little literature emphasizes how precisely road reconfiguration affects specific components of surrounding local economies that can ultimately be internalized as property values and total business revenue.

Some researchers have attempted to assess the impact of road reconfiguration projects on regional employment and local economic activity (Garrett-Peltier, 2011). A positive relationship between the walkable built environment and property value is evident in some published literature (Leinberger & Alfonzo, 2012; Li et al., 2015; Sohn et al., 2012). Most previous studies use single-family housing value as an economic indicator to measure the extent of financial improvement through road reconfiguration projects, particularly internalizing “livability” benefits. A few studies have examined the impact of reconfiguration on housing value and found proximity to the public transit system and the accessibility it generates was positively associated with real estate value (Cervero & Duncan, 2002; Duncan, 2011; Yan et al., 2012). Such studies are based on the hypothesis that the alterations in travel patterns and neighborhood desirability caused by modifications in the street configuration positively influence factors like retail rents, business activity, and land value. Such analyses can control for different types of business turnover and overall value generation. For example, some land uses may experience diminished business from road reconfigurations (e.g., car-oriented, pass-by businesses like gas stations, parking lots), but increasing land value will generate business turnover toward higher-value land uses that generate more overall revenue.

As early as 1987, the Office of Planning in Seattle evaluated the Burke-Gilman Trail's Effect on property values and crime. Based on interviews with real estate companies, the study concluded that the walking trail helped attract buyers, and sales increased by 6 percent to the previous year (Puncochar & Lagerwey, 1987). A similar approach was implemented in a study in Delaware in 2006 (Dhanju & Racca, 2006) and (Du & Mulley, 2006). Hedonic price models employed in these studies found that the properties within 50 meters of the bike paths were sold at 4 percent higher than the average rate. In another study, the author used Kentlands, a New Urbanist project in Gaithersburg, Maryland (Eppli & Tu, 1999). That study revealed that consumers were willing to pay a 12 percent, or approximately $25,000, premium for single-family housing in Kentlands. One of the other most referenced studies, "The Effect of Greenway on Proper Values and Public Safety," also found that the effect of the neighborhood trail is beneficial to the property value (Alexander et al., 1995).

Similarly, bicycle lanes have been correlated with increased business activity. In San Francisco, a new bike lane on Valencia Street in San Francisco's Mission District resulted in increased economic activity (Drennen, 2003). Another similar study was undertaken for the City of Vancouver in 2011, evaluating the economic impacts of two separated two-way bike lanes constructed in Vancouver's downtown core on a trial basis in 2010 (Hirschberger, 2012). In recent years, StrongTowns has presented a new approach to evaluate the value of a property relative using a straightforward metric to compare disparate land uses. They have introduced the concept of value per acre (VPA) analysis to better grasp the economic value of built environment investments (StrongTowns, 2018). Their work uses the method to compare the value generated from big box stores to smaller neighborhood retail. Again, the cited literature shows the importance of walkability and bikeability on the appeal of adjacent property. However, the empirical literature still leaves gaps on local variation and the magnitude of road reconfiguration on adjacent or nearby land value.

2.2 ROAD RECONFIGURATION GUIDELINES

Many agencies across the United States have incorporated road reconfiguration in their guidelines and policy document. In addition, some agencies have developed standalone road reconfiguration documentation. In contrast, some others have included road reconfiguration plans and policies in their preexisting documentation. The following section describes and references some trusted partners, advocates, and practitioners for road reconfiguration.

2.2.1 Road Diet Information Guide (FHWA Safety Program)

The Federal Highway Administration (FHWA) comprehensive road reconfiguration guide, namely the "*Road Diet Information Guide*" covers the full range of road reconfiguration considerations beyond their proven safety benefits (Knapp et al., 2014). The FHWA guide details the history and different purposes of the implementation of road reconfiguration projects. Similarly, the guide also covers the feasibility determination of a project, road reconfiguration design type, and project effectiveness. FHWA's guidance recommends communities consider a range of factors to be considered before planning a road reconfiguration project, including:

1. Vehicle Speed
2. Level of Service
3. Quality of Service
4. Vehicle Volume (ADT)
5. The operational and volume of pedestrians, bicyclists, transit, and freight.
6. Peak hour and peak directional traffic flow.
7. Vehicle turning volume and patterns
8. Frequency of stopped and slow-moving vehicles
9. Presence of parallel roadways.

2.2.2 National Association of City Transportation Officials (NACTO), Urban Street Design Guide

With future expected transportation complexities and challenges in the street for the growing urban population, the Nation Association of City Transportation Officials (NACTO) published a guide for urban street design, namely the "*Urban Street Design Guide*". The Urban Street Design Guide focuses specifically on the design of city streets and public spaces. The NACTO Urban Street Guide shows how a road reconfiguration technique can improve different street typologies, like Downtown Thoroughfares, Neighborhood Main Streets, Residential Boulevards, and Transit Corridors (NACTO, 2012). The guide emphasizes city street design as a unique practice with its own design goals, parameters, and tools. The guide also provides readers with before and after descriptive diagrams and three treatment guidelines. The treatments are categorized as critical features that are necessary, recommended features that add value to the street reconfiguration, and optional features that vary across the city and across different project locations.

2.2.3 Rethinking Streets for Bikes (NITC)

Rethinking Streets for Bikes is an evidence-based report by National Institute for Transportation and Communities (NITC) with suggestions on how urban planners can design streets with all users in mind. The report aims to make it easier for cities to design complete streets accommodating efficient, sustainable, everyday forms of micro-mobility with case studies of different road configurations rather than hypothetical designs (Schlossberg et al., 2019). The case studies provided in the report showcase the best examples of street design to serve ordinary cyclists and keep them safe. Some of the profiles discussed in the study are

1. Advisory bike lanes (ABLs)
2. Cycle tracks (two-way)
3. Protected bike lanes (one-way)

4. Protected intersection
5. Raised facilities
6. Small investments
7. Off-street paths

2.2.4 TDOT Guidance

The Tennessee Department of Transportation (TDOT) Multimodal Project Scoping Manual is intended to provide designers, planners, and decision-makers with guidance for incorporating multimodal elements into transportation projects. Multimodal transportation includes walking, biking, transit, rail, cars, and trucks (TDOT, 2005). The report has been guided by the idea that developing infrastructure for transit riders, pedestrians, and bicyclists can improve mobility, access, and safety at local, regional, and statewide levels.

Chapter 3 METHODOLOGY AND EVALUATION

3.1 METRICS THAT CAN BE USED TO EVALUATE CORRIDOR RECONFIGURATIONS

Road reconfiguration projects are typically carried out with anticipation for the corridor's improved safety, livability, health, and economy. Figure 3-2 presents six different measures frequently used in literature to evaluate a completed reconfiguration project. Some of these performance measures used to assess pedestrian and bicycle transport projects are described later in this section.

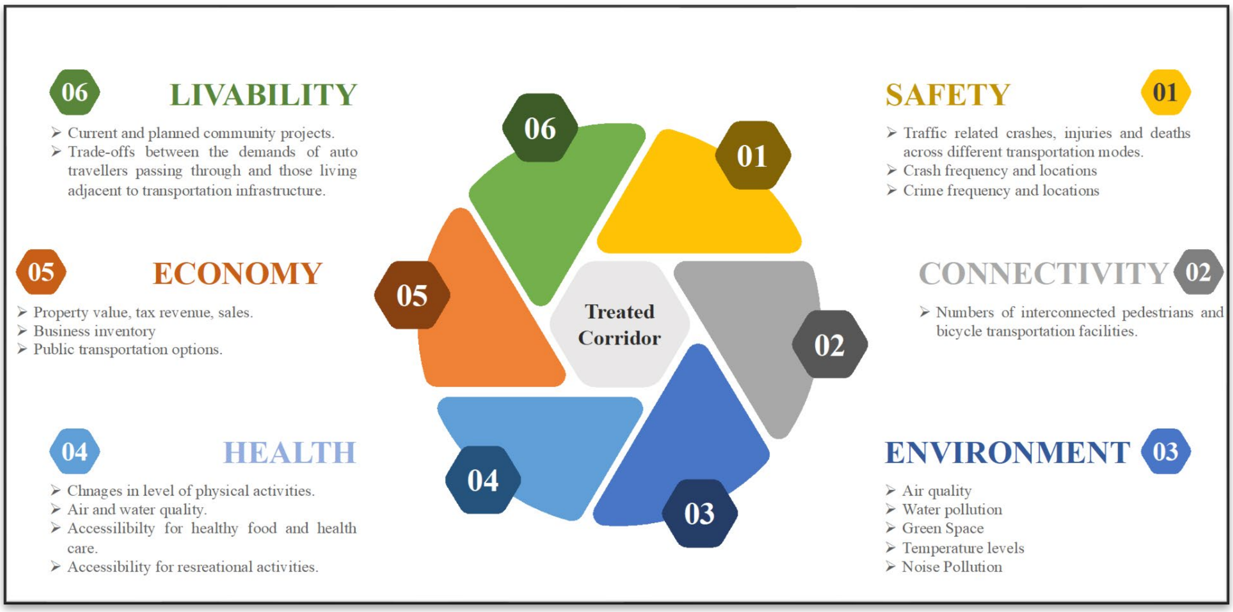


Figure 3-1 Different matrices used to evaluate road reconfiguration project.

3.1.1 Safety

In general, road reconfiguration projects are expected to improve safety by reducing speed differentials between all users. Safety can be significantly improved for vulnerable road users through the reallocation of travel lane space in a corridor’s cross-section for alternative modes of transportation, such as bike lanes and sidewalks. Lowering motorized vehicle travel speeds (implicitly through narrowed travel lanes or explicitly through lowered speed limits) can also improve the safety of both Vulnerable Road Users (VRUs) and motorized vehicle drivers and passengers. Moreover, road reconfigurations can be a low-cost safety solution when coordinated with pavement marking schedules or simple overlay projects. The impact of road reconfigurations can be measured by analyzing factors related to safety, such as traffic injury rates, crash frequency, crash severity, and crash types.

3.1.2 Operations / Connectivity

The evaluation of roadway reconfiguration projects includes analyzing traffic volumes, level of service, speed, connectivity, and bus operations (Knapp et al., 2014). Some of the matrices used to evaluate these measures analyze before and after traffic volumes to determine if any traffic diversions occurred due to road configuration projects. Researchers may consider additional operations measures on a newly treated corridor, such as how two-way left-turn lanes, traffic signals, queue lengths, and service levels have changed using before and after data.

3.1.3 Environment

Air quality is one of the most common environmental measures, but others include evaluating impervious surfaces, stormwater runoff, and noise pollution. Common environmental goals are to minimize air and noise pollution, create more recreational opportunities, and improve community vibrancy. Other measures used to evaluate road reconfigurations are emissions, temperature levels, green space, and water pollution metrics.

3.1.4 Health

In envisioning a healthy community, the street can be a common place where diverse populations of pedestrians and bicyclists can safely access and use the corridor with minimal risk of crashing and exposure to noise and air pollution. The street is also a space where motor vehicle traffic manages driver stress effectively and efficiently through its design. Social interactions in corridors can also lead to improved quality of life and a vibrant business environment. Road reconfiguration projects can result in several significant impacts on public health in the vicinity of the treated corridor, including but not limited to minimizing confusion and stress amongst all road users, ultimately improving the feeling of security (Together North Jersey, 2015).

3.1.5 Economic Vitality

One of the primary hypotheses of this study is that changes in travel patterns, spending patterns, and neighborhood desirability caused by the change in the street environment can impact businesses and property owners most directly by affecting retail sales and a rise in commercial property value. New buffers and the addition of on-street parking and transit stops can increase business and accessibility to local shops and storefronts. Rather than measuring the total number of visitors or spending per visit, the cumulative retail sales or change in assessed property value is the critical indicator of overall economic performance on a corridor.

3.1.6 Livability

Road reconfigurations are effective in achieving "complete street" designs by providing opportunities to accommodate all road users. The addition of bicycle lanes and pedestrian enhancements, such as traversable medians, encourages using alternative modes to reduce carbon emissions along the corridor. In addition, landscaping and crossable medians increase the community's green space and improve the visual appearance and perception of an area (FHWA, 2014).

3.2 OUR APPROACH TO EVALUATION

We employed a before and after evaluation framework to evaluate three corridors that underwent road reconfigurations in Knoxville, Tennessee. The changes in crash frequency, traffic volume and speed, and land value are used for analysis in this report. We have presented a brief description of each component of analysis in the following section. Extended descriptions of the evaluation framework methodology are provided in the respective sections of the report. The analysis was carried out for three corridors of interest to quantify the impact of road reconfiguration projects of different scales. The selected Knoxville corridors were Cumberland Avenue, North Broadway, and Central Street.

Cumberland Avenue received somewhat heavy treatment and redesign, which started in April 2015 and ended in August 2017. In contrast, Broadway and Central received relatively light treatment (i.e., Broadway was painted with a new lane configuration as part of Knoxville's annual roadway resurfacing contract). The reconfiguration project on Broadway street was started in July 2017 and was completed in October 2018. Similarly, the Central Street reconfiguration lasted from January 2018 until July 2019.

3.2.1 Safety Analysis

We utilized the crash data from each selected street segment for the safety analysis to conduct various statistical tests. First, comprehensive crash data for the state of Tennessee was obtained from Tennessee's Integrated Traffic Analysis Network (TITAN). The crash report from the TITAN database spanned from January 2010 to June 2020, from which personally identifiable information (PII) was removed. Second, crash data for the city of Knoxville as a whole was extracted by filtering the crash reports according to the city and county (Knoxville and Knox County, respectively). Extracting the crash data for all of Knoxville allowed for drawing a direct comparison between Knoxville crash trends and each of the road diet treatment corridors.

Similarly, the total number of crashes involving VRUs, such as bicyclists and pedestrians, was also extracted for each corridor. Determining the number of crashes involving bicyclists or pedestrians is critical in evaluating how the safety of VRUs on each corridor changed as a result of road diet treatment.

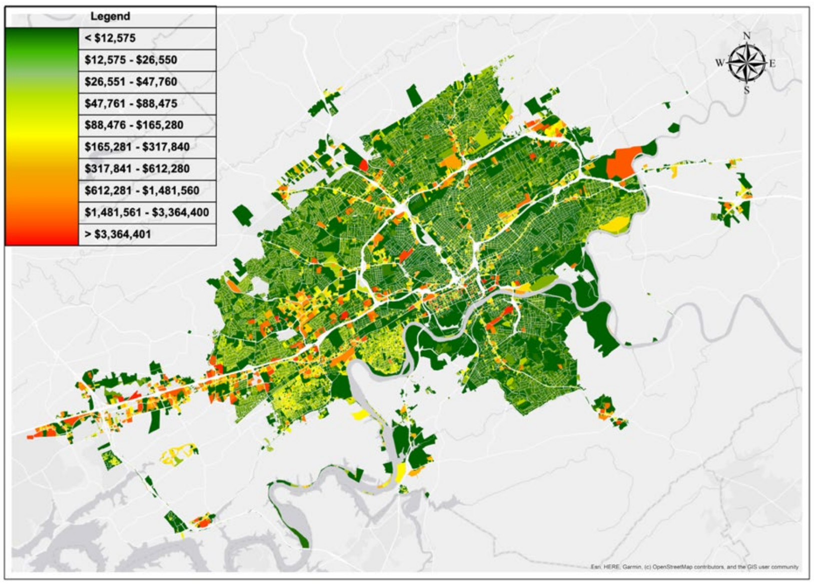
3.2.2 Traffic Operations

We conducted a quantitative assessment of the traffic operations for two corridors to understand the impact of the road reconfigurations. This report presents two different studies to exhibit before and after traffic effects of reconfiguration on traffic operations. First, five-minute interval average speed data provided by INRIX was used to analyze the before and after 85th percentile average speed on the North Broadway corridor. The reason behind choosing the 85th percentile speed instead of other percentile values to indicate the reference speed is that 15-minute data aggregation provided by INRIX removes most of the driver-to-driver variation. And due to the reduction in variability in the individual vehicle speed, the 85th percentile speed better approximates the reference speed. This is what traffic engineers use to set the speed limit at a safe speed, minimizing crashes and promoting uniform traffic flow along the corridor (City of Lincoln Nebraska, 2021). Second, we used Annual Average Daily Traffic (AADT) Maps by the Tennessee Department of Transportation (TDOT) for Cumberland Avenue and surrounding corridors to analyze the change in traffic volumes. The study can assess if any traffic diversions from the Cumberland Avenue corridor to other parallel corridors took place due to the reconfiguration.

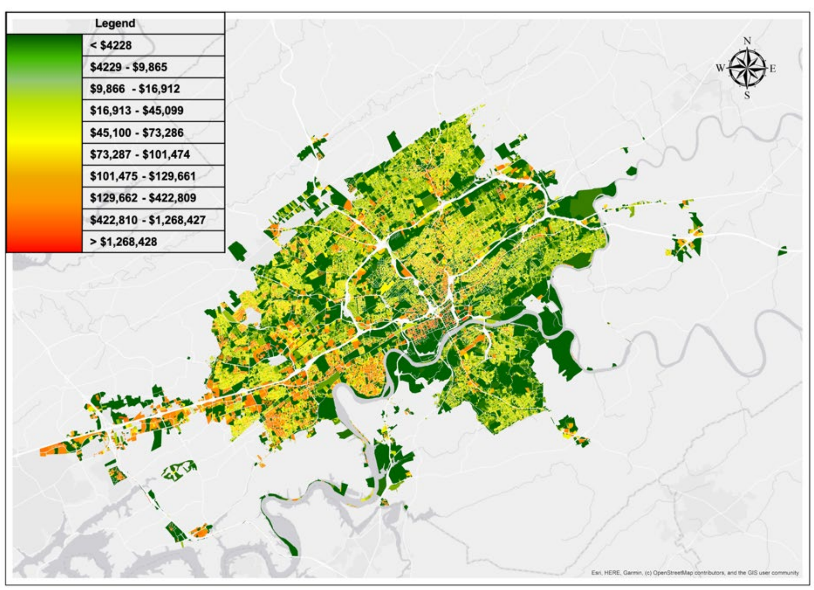
3.2.3 Economic Analysis

One of the most common methods used for economic analysis is to analyze the change in property value over time. Galster (2006) and an article by Daniel Herriges written for Strong Towns suggests that the value of the surrounding property is considered a good indicator of the desirability or perceived quality of the neighborhood (Galster et al., 2006; StrongTowns, 2018). Therefore, we expect the project's more qualitative (e.g., aesthetic, walkability) aspects to be embodied in adjacent and nearby property values. For the economic analysis, we evaluated the change in the value of the parcels of land adjacent to and a half a mile around the three different reconfigured street sections selected for analysis in Knoxville. We obtained the property appraisal and assessed the land value dataset from the Knox County Property Assessor Office for each of the selected corridors. Instead of directly using the assessed value of the individual parcel, the Value Per Acre (VPA) was used in the Difference and Differences (*DID*) statistical analysis method to quantify the comparable value of the respective land parcel with the city and county as a whole. The value per acre normalizes the overall revenue and tax value into a directly comparable unit, utilizing land consumed as a unit of productivity. This way, we can compare and contrast each parcel of land no matter its size and use, which allows us to quantify the land value changes that occurred.

As described above, Figure 3-1 reflects that compared to the assessed value of the property, the value per acre of individual property precisely reflects its worth and is normalized against size (e.g., large parcels are not given more value by nature of their size). The 2017 assessed value for the City of Knoxville is illustrated in Figure 3-1 (a). Similarly, Figure 3-1 (b) represents the 2017 VPA plot for Knoxville. Importantly, tax-exempt organizations do not have assessed land values, though their land still presumably holds market value, and the benefits of nearby developments are accrued. In the context of this study, major land use adjacent to Cumberland Avenue is the University of Tennessee, which does not have an assessed land value and is simply left blank.



a.



b.

Figure 3-2 The heat map of Knoxville with (*a*) property assessed value, 2017 and (*b*) Value per acre, 2017.

3.3 STATISTICAL METHODS

Three statistical tests were utilized for the following three purposes: (1) to determine if there were differences in the number of crashes occurring before and after each of the road reconfiguration, (2) to determine if the crash trends on each corridor significantly differed from that of Knoxville as a whole during the same time periods, and (3) to determine the significance of the change in the value of the property both along and half a mile around the treated corridor compared to the average change over Knoxville.

3.3.1 Paired Sample t-test

The first test selected was a paired samples t-test (also referred to as dependent t-test) to determine the statistical significance of the crash counts on each corridor from before to after the road reconfiguration project. More specifically, we used the test to determine if the average monthly crash count for the "*before*" period of the respective corridor is statistically different than that of the "*after*" period for the same corridor. We utilized the average monthly crashes for analysis rather than average annual crashes due to the brevity of the before and after periods for all three considered corridors.

We first identified the "*before*" and "*after*" period for each project to extract the crash data. The paired dependent samples used to conduct the paired samples t-test were the crash counts on the respective corridor during every given month during the "before" period, paired with the crash counts for the same months during the "*after*" period. Based on data availability, we respectively considered 36, 20, and 12 months "*before*" and "*after*" periods for Cumberland Avenue, Broadway, and Central Street corridor. The test hypotheses for the paired samples were as follows:

$$H0: \mu_{before} = \mu_{after}$$

$$Ha: \mu_{before} \neq \mu_{after}$$

Next, we used SPSS to test normality and carry out the paired samples t-test. This particular statistical test merits a test for normality of the distribution of differences between the two samples; once we confirm the normality by the numerical results from the Shapiro-Wilk test for normality (appropriate for small samples, N<50), we subsequently carried out the paired samples t-test in SPSS Statistics.

The second test was selected as an independent t-test to determine a statistically significant difference between Knoxville's crash trends and a designated corridor during the same period. Specifically, we conducted the test to determine if the percent change in monthly crashes from the "*before*" period to the "*after*" period of the respective corridor was statistically significantly different from Knoxville for the same periods. Rather than directly comparing the monthly crash counts to the individual corridor, we calculated the percent change in crashes for each month of the "*before*" and "*after*" periods. We analyzed a measure that normalizes the significant difference in scale of observations (i.e., Knoxville crash counts account for roadways all over the city) compared to the single road reconfiguration corridor.

Next, we utilized the SPSS Statistics tool to test normality, homogeneity of variances, and the independent t-test. An independent t-test merits a test for normality of each of the two samples compared to one another and a test for homogeneity of the variances among the samples. If the test for normality or test for homogeneity of variances showed that either of these assumptions (normality or homogeneity of variances) were not met, we used the Mann-Whitney-U test, a non-parametric alternative to the independent t-test.

3.3.2 Difference-in-Differences (DID) Analysis

Calculating the change in the land value at any specific corridor due to policies or reconfigurations requires understanding the trend in the absence of those programs. Different factors affect a property's value differently, and it is nearly impossible to determine the effect of each specific element by a simple comparison of price. We have opted for the Difference-in-Differences statistical approach to quantify the road reconfiguration project outcomes for the selected corridors. The *DID* method is based on natural experiments and is a widely used research tool in academic literature to quantify the effects of specific policy interventions. The *DID* statistical method sets up a quasi-experiment test for both cross-sectional and temporal variations of land value in the neighborhood of the road reconfiguration, compared to the overall growth in Knoxville.

The *DID* analysis method used in this report illustrates the temporal changes in the value of an acre of land before and after a road reconfiguration project. We have selected a half-mile radius around the treated corridor as the cut-off to delineate the treatment boundary of the road reconfiguration corridor. In this analysis, we have designated two cases for each treatment corridor in addition to block-facing parcels. The first case is the average value per acre of the parcels adjacent to the treated corridor. The second case is the average value per acre for the parcels within a half-mile radius around the treated corridor. The average value within the treated corridor's half-mile radius excludes the parcels adjacent to the corridor. Similarly, we have averaged the value per acre of all the parcels in the city of Knoxville for the control group, including the parcels already considered in two earlier cases. The *DID* specification uses a case-control methodology to match each of the two cases in our study with an appropriate control group. Card and Krueger (1993) described that in the experimental scenario when the assumptions of standard research design hold as they do in a pure experiment in which cases are assigned randomly to experimental and control groups before the reconfiguration, the simple difference-in-differences estimator is unbiased ∂ (Card & Krueger, 1993). With two groups, two time periods, and a sample of data from the population of interest, the *Difference-in-Differences* estimator ∂DD is the difference in average outcome in the reconfiguration group before and after treatment minus the difference in the average outcome in the control group before and after the reconfiguration.

$$\delta_{DD} = (\bar{Y}^{\mathrm{t}}_{after} - \bar{Y}^{t}_{before}) - (\bar{Y}^{c}_{after} - \bar{Y}^{c}_{before})$$

Where $\bar{Y}^{\mathrm{t}}_{after}$ and $\bar{Y}^{\mathrm{c}}_{after}$ are the sample means of the outcome variable after the reconfiguration for the treatment and control group, respectively, $\bar{Y}^{\mathrm{t}}_{before}$ and $\bar{Y}^{\mathrm{c}}_{before}$ are the sample averages before the period of reconfiguration for the corresponding groups. For a valid selection of comparison groups, *t* with the corresponding control group*, c*, $\bar{Y}^{\mathrm{c}}_{after} - \bar{Y}^{\mathrm{c}}_{before}$ provides an unbiased estimator of the change in mean growth for spatial units in the experimental group had those spatial units never received the road reconfigurations.

Some may argue that before and after differences in the assessed value of parcels could have been driven by other factors and uncorrelated variables with the road reconfiguration project. For example, local development projects in the neighborhood may trigger a pre-existing change in land value before the road reconfiguration project. We used an interaction term, "*Treat × Post*" in our statistical analysis, which, if significant, reflects that the increase in land value as reflected by the given term was caused by the impacts of the road reconfiguration project. The land value trend in the treatment neighborhood post-reconfiguration is expected to differ from the trend in land value in the control neighborhood.

Chapter 4 TENNESSEE APPLICATIONS

For this study, an inventory is provided for road reconfiguration projects accomplished in Tennessee. Completed projects from four cities (Knoxville, Nashville, Memphis, and Chattanooga) have been inventoried. These chosen road reconfiguration projects reflect typical projects with different types of conversions.

4.1 INVENTORY OF PROJECTS

The summary table is provided herein Table4-1. The detailed description for each reconfiguration project is provided in Appendix A.

Table 4-1 Summary table of road reconfiguration project.

City	Street	Leading agency	Conversion type
NASHVILLE, TN	51ST Avenue North	Tennessee Department of Transportation (TDOT)	4-2 conversion with a center turn lane, on-street parking, and a two-way bike lane on one side.
	Church Street	Tennessee Department of Transportation (TDOT)	4-2 conversion with a center turn lane and buffered bike lane in either direction.
	Commerce Street	Tennessee Department of Transportation (TDOT)	5-3 conversions with a parking lane and two-way bike lane in each direction.
KNOXVILLE, TN	Cumberland Avenue	City of Knoxville (COK)	4-2 median divided conversion with intense streetscaping.
	Broadway	Tennessee Department of Transportation (TDOT)	4-3 conversion with a two-way bike lane in either direction.
	Sevier Avenue	City of Knoxville (COK)	3-2 conversions with bike lanes in each direction.
MEMPHIS, TN	Riverside Drive	City of Memphis	4-2 conversion with a two-way bike lane and pedestrian space (converted back to 4-lane).
	South Manassas Street	MMDC and City of Memphis	6-4 lane conversion with a buffered bike lane in either direction.
	Madison Street	City of Memphis	4-2 conversion with a center turn lane and buffered bike lane in either direction.
	Hampline Street	City of Memphis and Public Funded	Both directional bike lanes shifted towards the street side and were protected by a median and parking.
CHATTANOOGA, TN	Broad Street	City of Chattanooga	8-6 conversion with a buffered bike lane.
	N Market Street / Dallas Road	Chattanooga Department of Transportation.	4-2 conversion with a center turn lane, side street parking, and a bike lane in each direction.
	Station Street	Chattanooga Department of Transportation and Local Businesses.	Complete street reconfiguration for multimodal use.

Chapter 5 DETAILED CASE STUDIES

5.1 CASE STUDY SECTIONS

5.1.1 Cumberland Avenue

The Cumberland Avenue corridor serves as the major transportation facility for the University of Tennessee, Fort Sanders Regional Medical Center, the East Tennessee Children's Hospital, and downtown Knoxville. Initially, it was a four-lane undivided corridor often congested with turning vehicles, unregulated parking, and delivery trucks frequently parked in the middle of the road. It was converted into a two-lane street with a raised median and intense streetscaping. Intersections were redesigned with smaller medians to accommodate the left turn lane in each direction. The project took a suburban-style, auto-oriented pass-through corridor and reconfigured it into an urban multi-modal corridor incorporating pedestrian, bicyclist, transit, and cars while creating a unique urban district. The original plan for Cumberland Avenue assumed a 70-foot right-of-way, a continuous left-turn lane, and the closure of most of the driveway curb cuts, but the use of the Federal Highway Administration (FHWA) funds restricted driveway curbs closures under the Uniform Act for land acquisition. The cross-section finally was made with an average right-of-way of 65 feet. The Cumberland Avenue Streetscape project was envisioned in 2007, but the construction began in April 2015 and reached its subsequent completion in August 2017. Figure 5-1 shows the reconfigured Cumberland Avenue corridor, and Figure 5-2 illustrates the before and after cross-sectional configuration. A complementary policy enacted a form-based zoning overlay that encouraged and enabled different types of mixed-use development. Notably, much of the intense land development along the corridor came after the subsequent rezoning and road reconfiguration.

Source: The City of Knoxville, Department of Engineering

Figure 5-1 Reconfigured Cumberland Avenue Corridor.

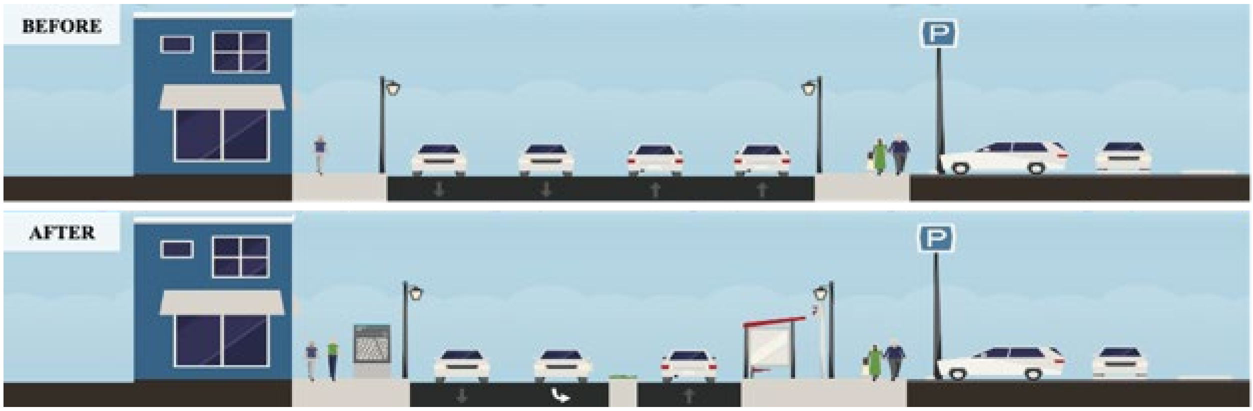


Figure 5-2 Cumberland Avenue before and after reconfiguration.

Typical “rule of thumb” guidelines call for widening a street to five lanes as traffic approaches or exceeds 20,000 average daily traffic (ADT). On the contrary, even though the ADT at Cumberland Avenue year before reconfiguration was recorded 20,800 ADT, this project chose a different approach. The project reduced the existing travel lanes and added wider sidewalks featuring decorative brick details. Overhead utility lines originally planned to be moved a block away were buried underground in the final design. Improvements to the street furniture included adding and installing benches, kiosks, waste receptacles, energy-efficient streetlights, and ADA-accessible transit stops. Landscaping was planted in the medians, and additional 93 canopy trees were added to the corridor, providing shade to the pedestrians.

5.1.2 Broadway Street

The city of Knoxville and the Tennessee Department of Transportation (TDOT) extended a bridge replacement project into a street reconfiguration on the Broadway corridor. The total cost of the reconfiguration project was kept relatively low by aligning the timing with the already planned corridor resurfacing project. Figure 5-3 shows the reconfigured corridor with a brown rectangular box and the adjacent bridge replacement project site with a green rectangular box. The reconfiguration through the Broadway section reduced lanes from two each way to one in each direction. The additional space was used for a center turn lane and bike lanes in each direction. We have presented the before and after configuration of Broadway Street in Figure 5-4. The section of Broadway was already three lanes north of Central Street, and the state’s Broadway viaduct replacement also converted the bridge to three lanes.

Figure 5-3 Broadway Street reconfiguration project section and adjacent bridge replaced site.

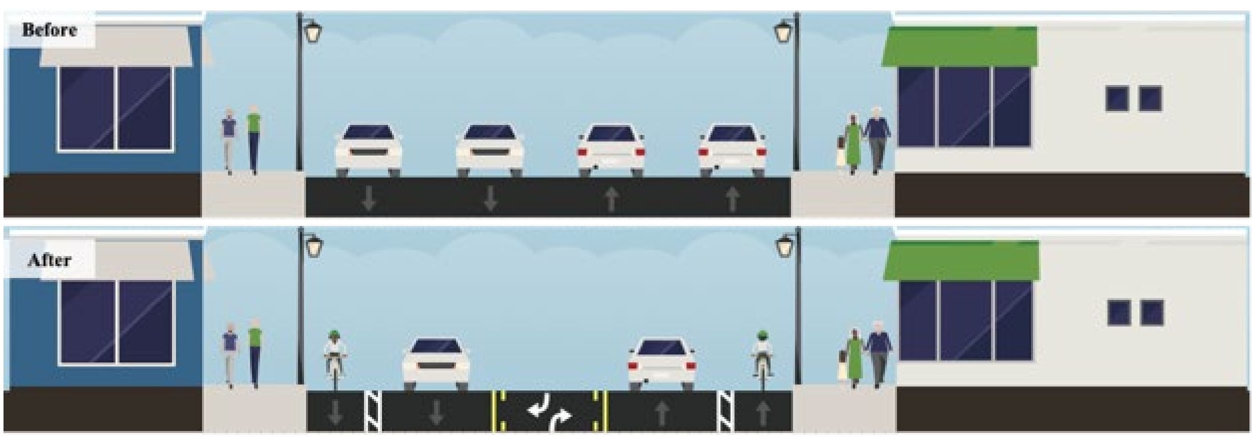


Figure 5-4 Broadway street before and after road configuration.

The Broadway reconfiguration project spanned 0.7 miles between Depot Avenue and Central Street, as shown in Figure 5-3. With the reconfiguration, the street was expected to improve safety with traffic calming, development in the economic activity and aesthetics of the corridor, and most importantly, improve and expand the bike connectivity through the city. The street is predominantly surrounded by commercial entities, social services, and a large historic cemetery. The original plan of the Broadway reconfiguration project was to connect downtown Knoxville with World's Fair Park in the downtown area.

5.1.3 North Central Street

This North Central Street corridor included more incremental changes over time, beginning with a restriping from a four-lane cross-section to a three-lane cross-section on the north end of the corridor from Woodland Avenue to Baxter in 2008. Later, the street streetscaping on the 0.7-mile section was started in January 2018 and completed in July 2019. The streetscape project traversed along Central Street from Broadway to Woodland Avenue. The project spanned 13 blocks, added 43,000 square feet of green space, resurfaced streets, and fixed sidewalks from Broadway to Woodland Street. The project was combined with the Knoxville Utility Board's (KUB) project of maintaining existing infrastructure by upgrading gas lines, water mains, and fire hydrants. The project area is presented in Figure 5-5.

Figure 5-5 North Central Street streetscaping project section.

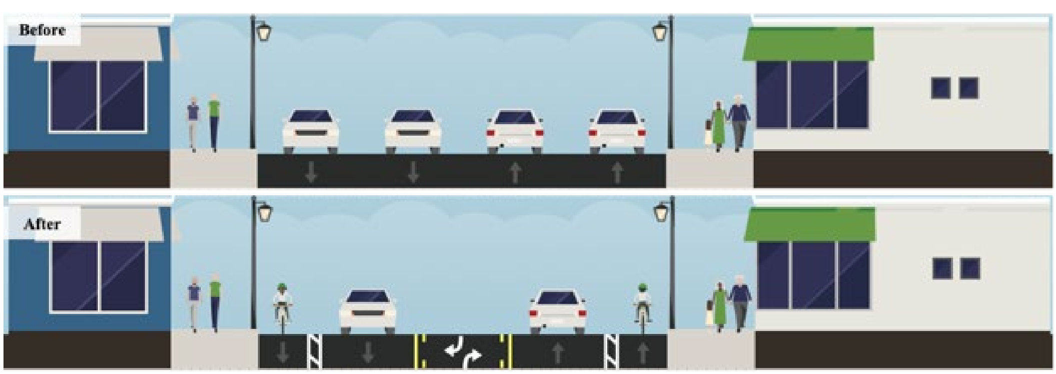


Figure 5-6 North Central Street before and after reconfiguration.

The North Central Street streetscape project cost $5.8 million, which was provided by the Federal Highway Administration (FHWA) (80 percent) with management and oversight by the Tennessee Department of Transportation (TDOT). The City of Knoxville provided the remaining 20 percent match in local funding. The streetscape project reduced four lanes of the street into a two-lane street in each direction. The extra space was used to accommodate a 10-foot center turn lane, a 5-foot bike lane, and 8 feet of parking lanes in each direction. The before and after configuration of North Central Street is presented in Figure 5-6. The project repaired and replaced sidewalks, constructed new curbs and bulb-outs, installed on-street parking, and marked bike lanes. The project aimed to make North Central Street a Complete Street, revitalizing the community and bringing back the economy to the corridor by installing bike lanes and streetscaping.

5.2 Safety Analysis

The total crashes before and after the road reconfigurations on all three corridors are shown in Figure 5-7. Through observation of the simple measure of total crashes for an equal period before and after the treatment, all three corridors exhibited a reduction in total crashes after the treatment. Based on the availability of safety data for the respective corridor, 30 months before and after period was considered for Cumberland Avenue. Respectively, 20 and 12-month before and after periods were considered for Broadway and Central Street.

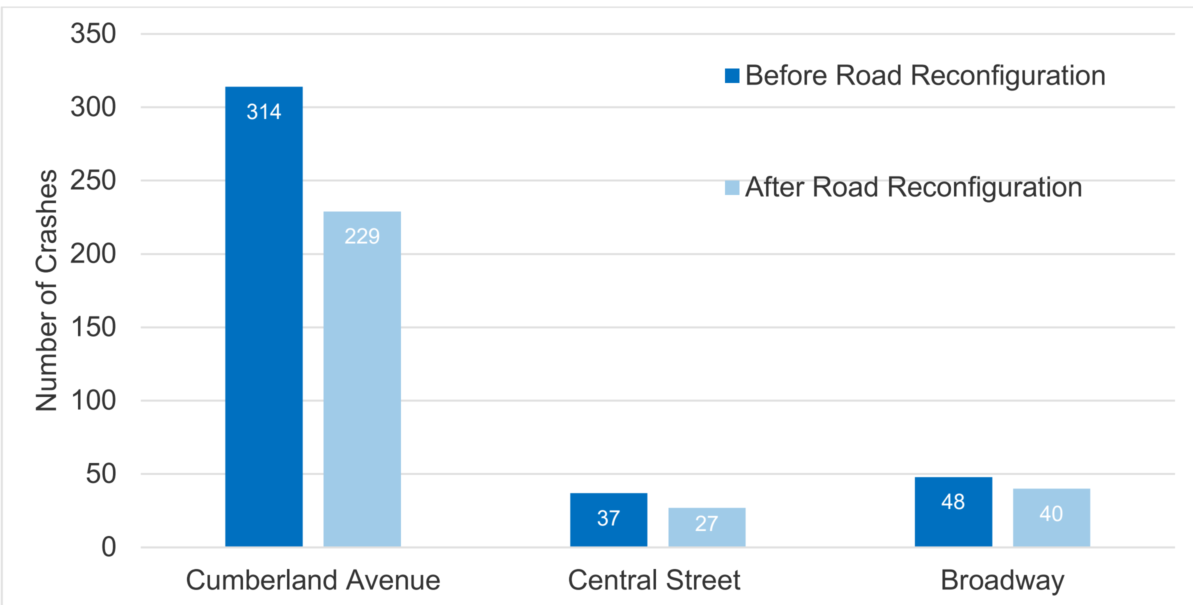


Figure 5-7 Total crashes before and after road reconfigurations on each corridor.

Additionally, the change in the proportion of total crashes attributed to various crash types after the reconfiguration project on Cumberland Avenue is illustrated in Figure 5-8. It should be noted that not all crash types are represented in this figure. The proportion of total crashes is the measure utilized in Figure 5-8 rather than raw crash counts in order to normalize the change that occurred for each crash type represented in the figure, thus allowing comparison between crash types. The proportion of crashes with more severe or fatal injury outcomes, such as head-on and angle crashes, significantly decreased after the reconfiguration project. Similarly, both variations of sideswipe crashes also decreased after the road reconfiguration. However, it is essential to note that front to rear-end crashes significantly increased after the reconfiguration. The proportion of crashes involving vulnerable road users also notably decreased following the reconfiguration.

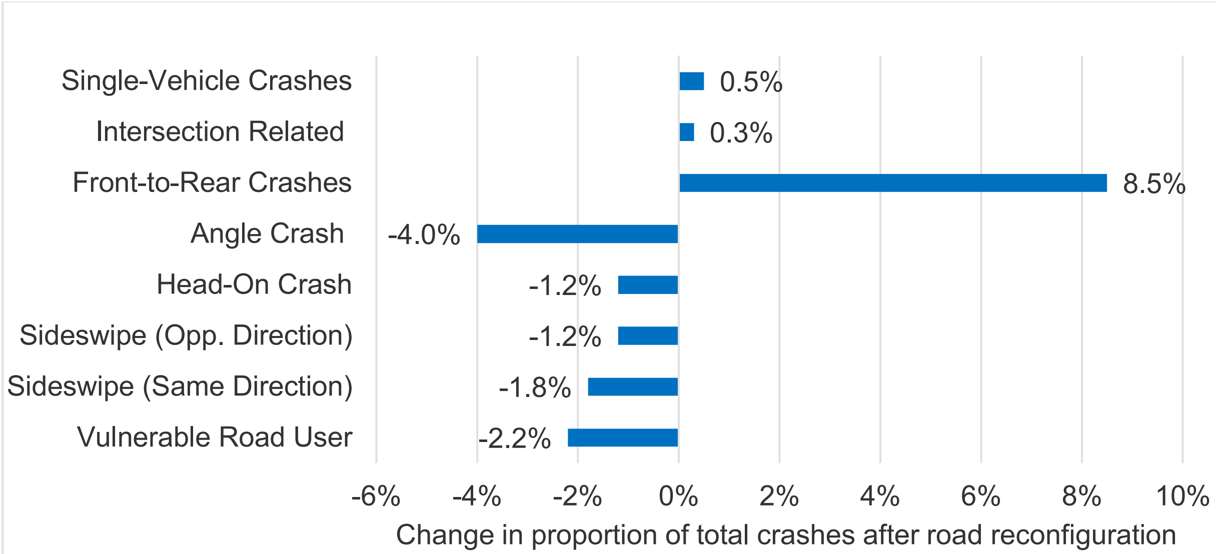


Figure 5-8 Change in proportion of total crashes for various crash types after road reconfiguration.

The more detailed extracted monthly crash data for all three corridors during the selected equal length period before and after the reconfiguration are presented in Figures 5-9, 5-10, and 5-11. The figures represent monthly crash data for Cumberland Avenue, Central Street, and North Broadway, respectively. It should be noted that the "after" period for Broadway and Central Street includes four months in the spring of 2020 (March-June) that were likely affected by the significant reduction in traffic due to the COVID-19 global pandemic. The affected months are highlighted in Figure 5-10 and Figures 5-11. Also, a primary viaduct providing access to Broadway was closed on November 3, 2019, likely impacting the amount of traffic experienced by the Broadway corridor. This is also highlighted in Figure 5-11.

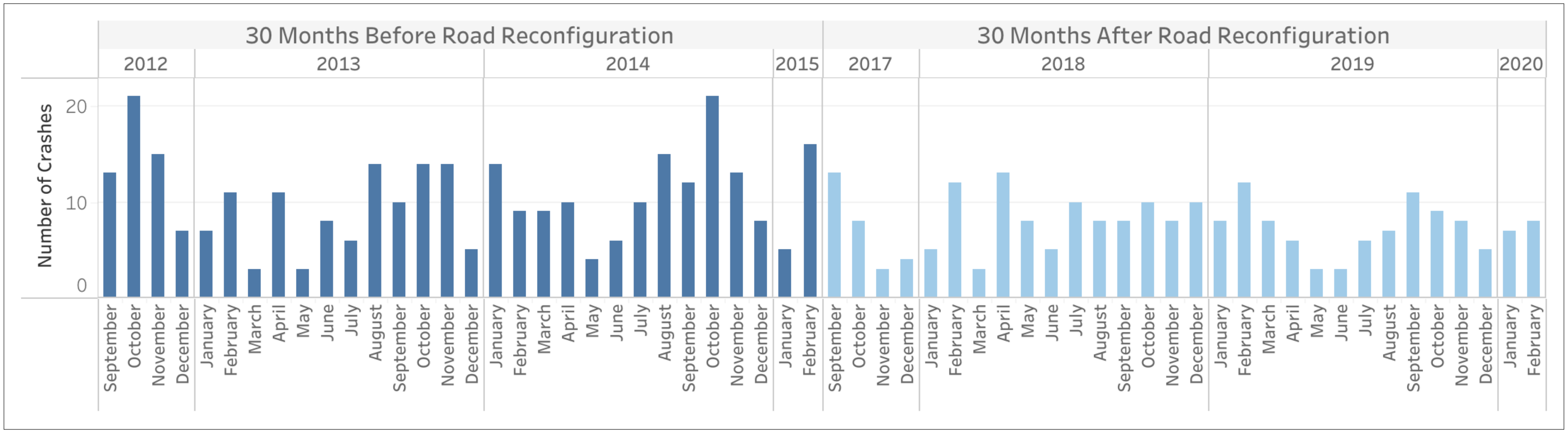


Figure 5-9 Cumberland monthly crashes before and after road reconfiguration.

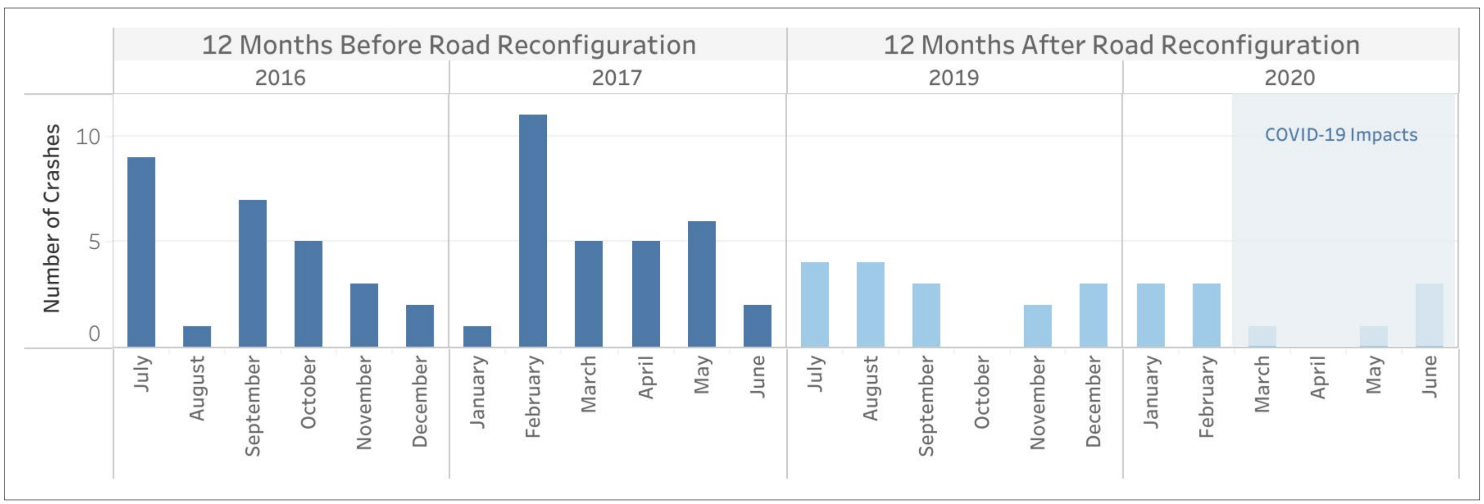


Figure 5-10 Central monthly crashes before and after road reconfiguration.

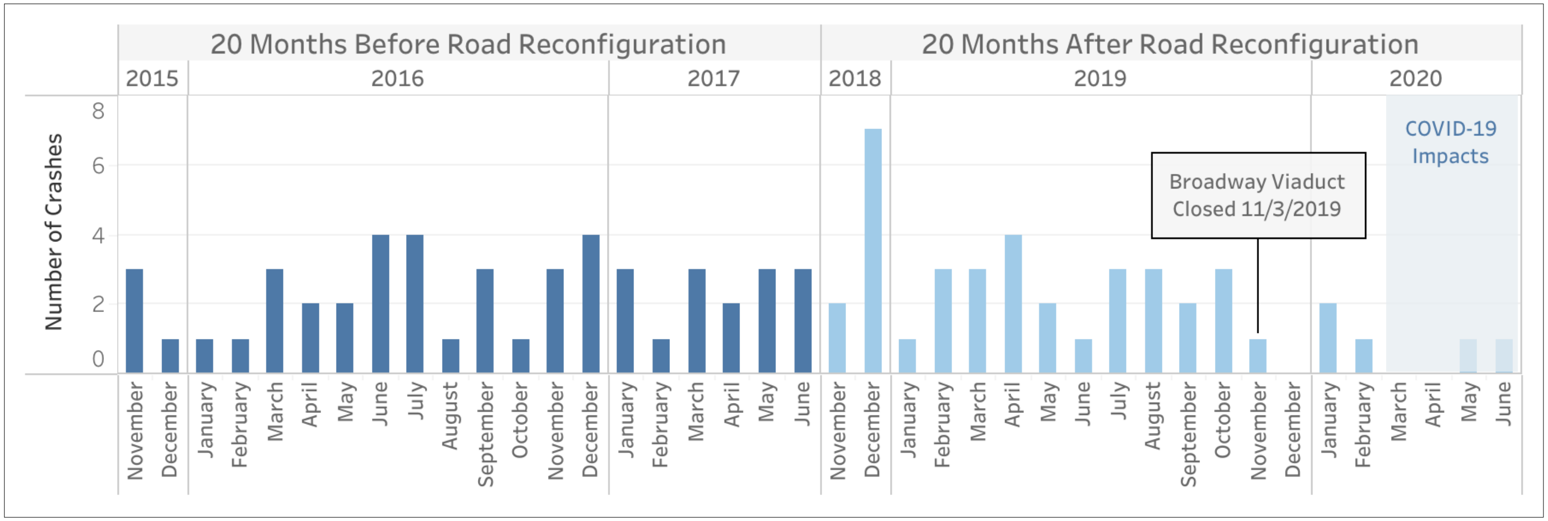


Figure 5-11 Broadway monthly crashes before and after road reconfiguration.

5.2.1 Safety of Vulnerable Road Users

The number of the total crashes before and after the road reconfiguration treatment on each of the three treated corridors is presented in Figures 5-12. Looking simply at the crash counts that involved pedestrians/bicyclists, there was a decrease in the overall number of crashes on both the Cumberland and Broadway corridors, but a slight increase on Central (by a measure of one crash). More specifically, and according to raw crash counts, there was a 55% and 50% decrease in crashes involving Vulnerable Road Users (VRUs) on Cumberland and Broadway, respectively. Without statistical analysis, simple crash counts cannot definitively show improved roadway safety yet may still communicate initial indications of safety conditions and provide a direction for future investigation. Therefore, simple observation indicates that pedestrian and bicyclist safety on Cumberland Avenue and Broadway may have improved following the reconfiguration.

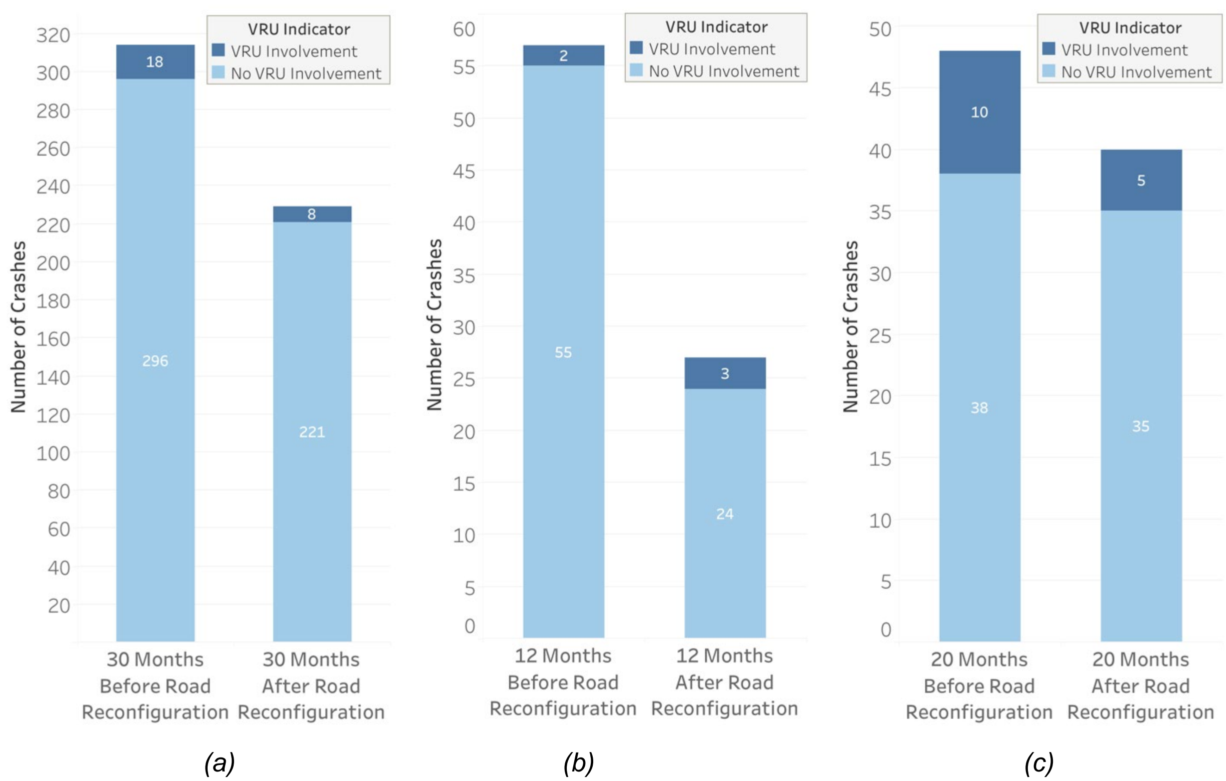


Figure 5-12 Total crashes and VRU involvement on (a) Cumberland, (b) Central, and (c) Broadway.

5.2.2 Paired Samples T-Test

To conduct the Paired Samples T-Test, it is essential for the data set to meet the assumption of normality. To check for normality, we first conducted the Shapiro-Wilk test. The results of the Shapiro-Wilk test of normality on the distribution of differences between the "*before*" and "*after*" paired samples for all three corridors are presented in Table 5-1. Since the significance level (sig.) is larger than 0.05 for each corridor, it can be concluded that the distribution of differences between the samples for all three corridors is normally distributed. This result met the assumption of normality for the paired samples t-test.

Table 5-1 Test of Normality Results for The Difference In Crashes After Each Road Reconfiguration

Corridor	**SHAPIRO-WILK TEST OF NORMALITY**		
	Statistic	df	Sig.
Cumberland Ave	0.964	30	0.394
Central St.	0.896	12	0.141
Broadway	0.918	20	0.089

The test results for the paired samples t-test are presented in Table 5-2. For Cumberland Avenue, since the significance level is less than 0.05, we can reject the null hypothesis and accept the alternative hypothesis: a statistically significant difference in the average monthly crashes before and after the road reconfiguration on the corridor. The samples' positive mean difference indicates a statistically significant decrease in the average monthly crashes on Cumberland Avenue after the road reconfiguration was implemented. For Central Street, since the significance level is less than 0.05, we can reject the null hypothesis and accept the alternative hypothesis: a statistically significant difference in the average monthly crashes before and after the road reconfiguration on the corridor. More specifically, the positive mean difference in the samples, like Cumberland, indicates a statistically significant decrease in the average monthly crashes on Central Street after the road reconfiguration. For Broadway, since the significance level is greater than 0.05, we can accept the null hypothesis: there is no statistically significant difference in the average monthly crashes on the corridor after the road reconfiguration. This means that there is currently no substantial evidence that the reconfiguration reduced the total number of crashes for that portion of the corridor in the short term.

Table 5-2 Paired Samples T-Test Results For Difference In Crashes After Each Road Reconfiguration.

Corridor	**Paired Differences**							
	Mean	St. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				Lower	Upper			
Cumberland Ave	2.833	4.757	0.868	1.057	4.610	3.262	29	0.003
Central St	2.500	3.529	1.019	0.258	4.742	2.454	11	0.032
Broadway	0.400	2.326	0.520	-0.689	1.489	0.769	19	0.451

5.2.3 Independent T-Test and Mann Whitney-U Test

The results of the Shapiro-Wilk test for normality of the percent change in monthly crashes for all of Knoxville and each of the respective corridors are presented in Table 5-3. The sample of percent change in monthly crashes on Cumberland Avenue has a significance level less than 0.05. This significance level indicates that the data sample is not normally distributed. The sample of percent change in crashes in Knoxville corresponding to Cumberland Avenue before and after periods had a significance level greater than 0.05, indicating that the data sample for Knoxville was normally distributed. The data fails to meet the normality assumption necessary for an independent t-test. One of the two samples is not normal, therefore meriting using the non-parametric alternative test: the Mann-Whitney-U test.

Similarly, at least one of the samples for both Central and Broadway is not normally distributed, according to significance levels less than 0.05. As a result, the data for both the Broadway and Central corridors fails to meet the normality assumption necessary for an independent t-test, therefore meriting the use of the Mann-Whitney-U test. A test for homogeneity of variances is no longer required and would otherwise be redundant due to the failure of the data samples to meet the normality assumption.

Table 5-3 Test of Normality Results For The Percent Change In Crashes After Each Road Reconfiguration.

Corridor	SAMPLE	SHAPIRO-WILK TEST OF NORMALITY		
		Statistic	df	Sig.
Cumberland Ave	Cumberland	0.814	30	0.000
	Knoxville	0.969	30	0.513
Central St.	Central	0.774	12	0.005
	Knoxville	0.921	12	0.292
Broadway	Broadway	0.708	20	0.000
	Knoxville	0.857	20	0.007

The results of the Mann-Whitney-U test for Cumberland are presented in Table 5-4. According to the sum of ranks, the mean percent change in crashes on Cumberland is less than that of Knoxville during the same period. Since the significance level of the test is less than 0.05, we can conclude that the mean percent change in crashes in Knoxville is statistically significantly higher than that of Cumberland. In other words, Cumberland had an overall reduction in crashes that differed from the increase in crashes Knoxville experienced during the same period.

Table 5-4 Cumberland Ave Mann Whitney-U Test Results.

Ranks			
Sample	**N**	**Mean Rank**	**Sum of Ranks**
Cumberland Avenue	30	20.35	610.50
Knoxville	30	40.65	1219.50
TEST STATISTICS			
MANN-WHITNEY U		**Z**	**Asymp. Sig. (2-tailed)**
145.500		-4.504	0.000

The results of the Mann-Whitney-U test for Central are presented in Table 5-5. According to the sum of ranks, the mean percent change in crashes on Central is less than that of Knoxville during the same period the significance level is more significant than 0.05; we cannot conclude that the mean percent change in crashes in Knoxville is statistically significantly higher than that of Central. In other words, Central had an overall reduction in crashes that did not differ significantly from the decrease in crashes that Knoxville experienced during the same period.

Table 5-5 Central St Mann Whitney-U Test Results.

Ranks			
Sample	**N**	**Mean Rank**	**Sum of Ranks**
Central street	12	10.83	130.00
Knoxville	12	14.17	170.00
Test statistics			
MANN-WHITNEY U		**Z**	**Asymp. Sig. (2-tailed)**
52.000		-1.156	0.248

The results of the Mann-Whitney-U test for Broadway are presented in Table 5-6. According to the sum of ranks, the mean percent change in crashes on Broadway is more diminutive than Knoxville's during the same period. However, the significance level is more significant than 0.05; it cannot be concluded that the mean percent change in crashes in Knoxville is statistically significantly higher than that of Broadway. In other words, Broadway had an overall reduction in crashes that is not statistically significantly different from the decrease in crashes that Knoxville experienced during the same period.

Table 5-6 Broadway Mann Whitney-U Results.

Ranks			
Sample	**N**	**Mean Rank**	**Sum of Ranks**
Broadway	20	17.75	355.00
Knoxville	20	23.25	465.00
Test statistics			
MANN-WHITNEY U	**Z**	**Asymp. Sig. (2-tailed)**	
145.000	-1.490	0.136	

5.3 TRAFFIC ANALYSIS

For the traffic analysis of the street reconfiguration project, the before and after traffic volume and 85^{th} percentile speed at two different corridors were evaluated. A before and after traffic volume study was conducted for the Cumberland Avenue corridor and three of its parallel routes. Similarly, the before and after 85^{th} percentile speed at Broadway Street's reconfigured section was analyzed.

5.3.1 Traffic Volume Study at Cumberland Avenue

Before the reconfiguration project, the Cumberland Avenue corridor was a highly congested mixed-used street servicing the University, Downtown, Fort Sanders, and Cumberland commercial strip. The Cumberland Avenue corridor is also one of the main routes for traffic from west Knoxville to downtown and to commercial areas north and east of Knoxville. The map in Figure 5-13 represents the major streets discussed in this section. In the Figure and the plot below, red represents Kingston Pike, blue represents the Cumberland Avenue treated corridor, and brown and yellow represent the major alternative route, Neyland Drive. Figure 5-14 describes the all-day average traffic volumes from 2002 to 2019 for the four streets mentioned earlier.

Figure 5-13 Evidently, the road diet had marginal impact on the 85th percentile speed due to reconfiguration Cumberland Avenue treated corridor with parallel alternate routes.

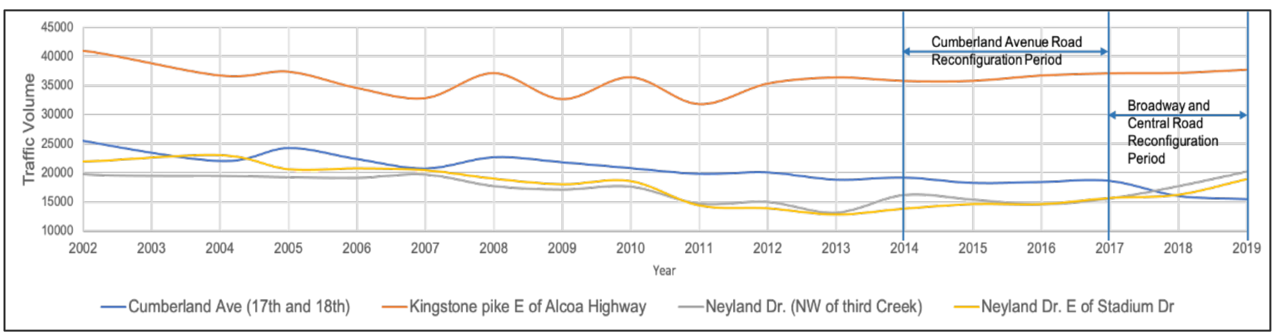


Figure 5-14 Average annual daily traffic for Cumberland Avenue and other parallel streets from 2002 to 2019.

The higher volume of average all-day traffic at Kingston pike east of Alcoa highway supports the traffic demand of Cumberland Avenue and the surrounding area. This indicates that Alcoa highway is a significant source of traffic that passes through the Cumberland Avenue corridor and surrounding parallel street sections. Neyland Drive is one of the notable alternative routes for Cumberland Avenue traffic. The average daily traffic volume at Neyland Drive followed the traffic trend of the Kingston Pike (traffic source street), as observed in Figure 5-14. The average daily traffic volume decreased from 2002 until 2012 for all the street sections and gradually increased in the following years. In contrast with other parallel corridors, the Cumberland Avenue corridor drastically decreased traffic volume after 2017. Table 5-7 represents the before and after traffic volume difference on Cumberland Avenue and the surrounding streets.

Table 5-7 Change in pre and post average annual daily traffic at Cumberland Avenue Street reconfiguration section.

Category	*Street Name*	*Pre-Road Reconfiguration*	*Post-Road Reconfiguration*	*Change in Volume*	*Change (%)*
Treated Section	Cumberland Avenue	19,185	16,020	-3,165	-16.50%
Untreated section	Cumberland Avenue	35,802	37,181	1,379	3.85%
Alternative route	Neyland Drive (Major Street)	16,210	17,710	1,500	9.25%
Parallel streets	Clinch Avenue	5,181	5,454	273	5.27%
	Grand Avenue	3,002	4,931	1,929	64.26%

The average daily traffic through the reconfigured section of Cumberland Avenue decreased from 19,185 daily to 16,020 after the reconfiguration. Contrary to the decrease of 3,165 in traffic volume on Cumberland Avenue, Neyland drive experienced an increase in average daily traffic of 1,500 after the completion of the Cumberland Avenue reconfiguration. Likewise, the non-road reconfiguration section of Cumberland Avenue also had an increase in average traffic volume of 1,379 trips daily. In the meantime, the average daily traffic at Neyland Drive rose from 16,210 to 17,710 after the completion of the Cumberland Avenue reconfiguration. Other smaller parallel streets, such as Grand Ave and Clinch Avenue, also experienced increased traffic volume after the Cumberland Avenue reconfiguration project.

5.3.2 85th Percentile Speed Analysis at North Broadway

North Broadway is one of the main arterials into the downtown area. But the North Broadway had also been one of the worst-performing corridors in Knoxville for pedestrians, and bike-related traffic crashes before the reconfiguration. This straight section of street to and from the city had been an accident blackspot. Mostly, the section of Broadway between Magnolia and 5th Street has been most vulnerable. This section is primarily associated with foot traffic concentration because of social services that cater to a high volume of people without housing. With the addition of the center turn lane and bike lane, the street reconfiguration was expected to increase the driver's awareness of the surroundings and lower the average speed. Figure 5-13 provides a general idea for the average morning and evening peak hour traffic before and after the reconfiguration project at the North Broadway corridor. In the figure below, the green plot represents the fitted line for morning peak hour average speed, and the red plot represents the fitted line for evening peak hour average speed. Additionally, shades of blue and black represent before, during, and after period of road reconfiguration project.

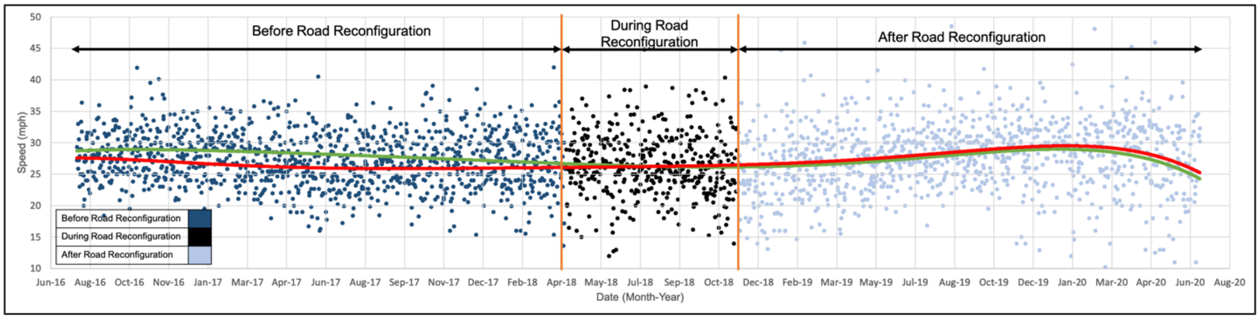


Figure 5-15 Peak hour average 85th percentile speed at North Broadway between Magnolia and 5th Street.

Based on Figure 5-15, it can be stated that drivers reflect similar speeding behavior at both the morning and evening peak hours. Figure 5-15 also shows that the average 85th percentile speed falls well below the speed limit of 35 mph for the street section. During road reconfiguration, both the morning and evening peak hour speeds averaged about 28 mph. The average 85th percentile speed remained almost identical even after the completion of the road reconfiguration project whereas the visible drop in the average 85th percentile speed through April and June 2020 can be attributed to the Safer at Home order issued by the Knox County mayor's office. The road diet had a marginal impact on the 85th percentile speed due to reconfiguration. Still, it is essential to note that the average 85th percentile speed along the corridor was already below the speed limit.

A speed assessment was not conducted for Cumberland Avenue or Central Street because of a lack of before and after speed monitoring data.

5.4 Economic Analysis

The economic analysis conducted in this section measures the ratio of change in the land value on and around a given corridor. The land parcels were divided into three groups for this study: (1) the block-facing parcels adjacent to the treated corridor; (2) the parcels within a half-mile radius around the treated corridor, excluding the parcels adjacent to the corridor; and (3) all the parcels for the City of Knoxville, including parcels from previous groups. The goal is to understand how road reconfiguration changes the pattern of economic growth of the adjoining land parcels and the parcels within a half-mile radius compared to the average growth over the City of Knoxville in the short term. Before describing the results, it is essential to understand the trend of land value change in the city of Knoxville over the period between 2008 and 2019. Figure 5-16 represents the average value per acre and percent change in the average value of the prior year.

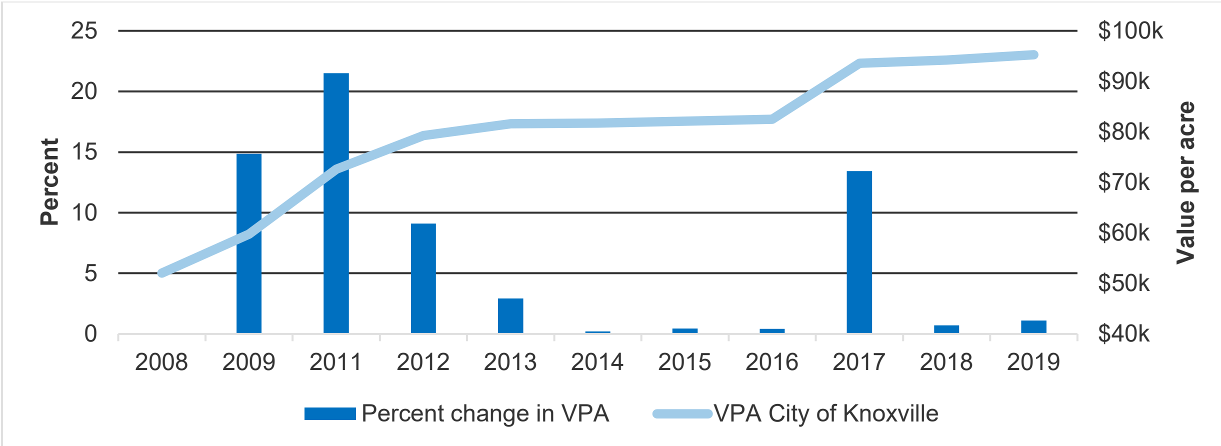
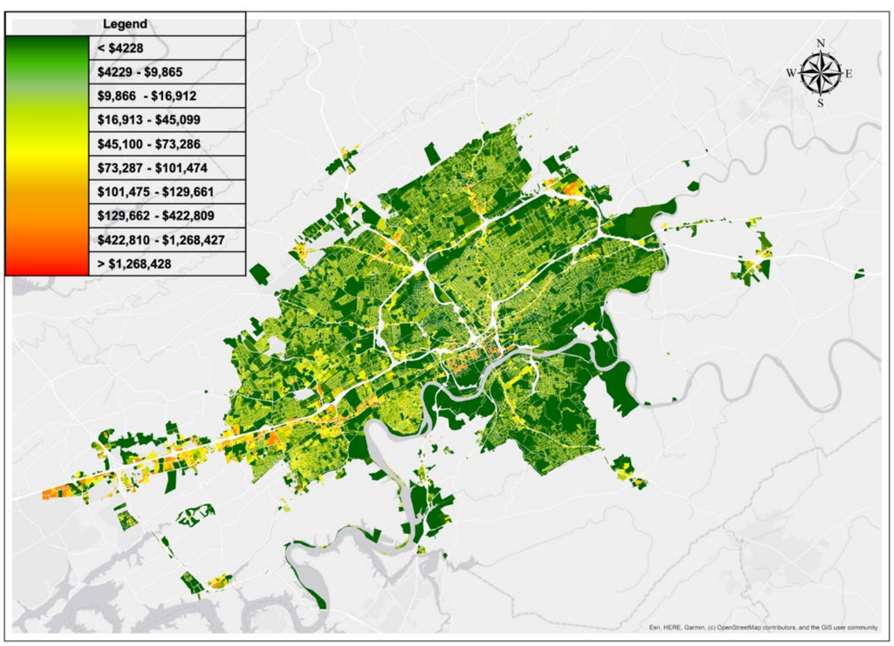
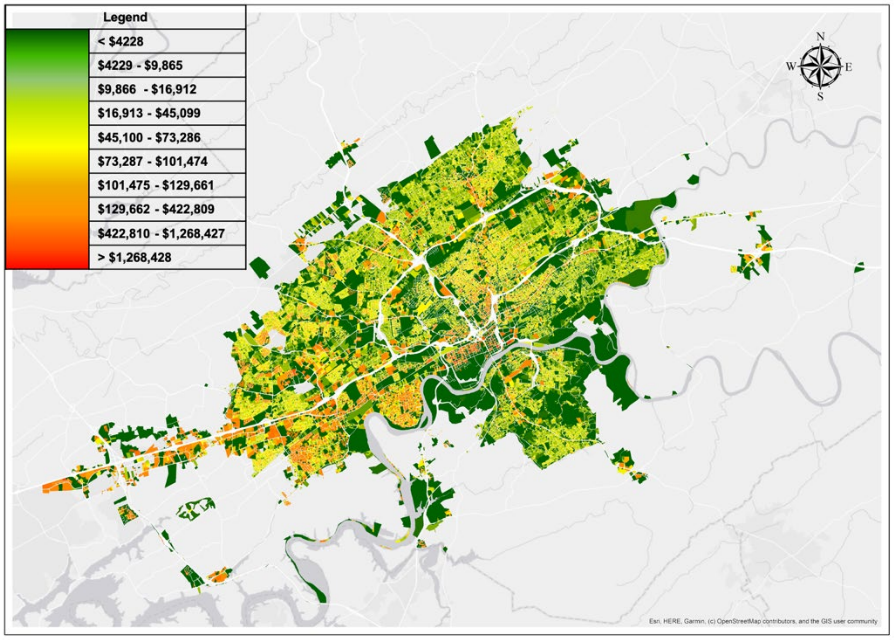


Figure 5-16 Average value per acre for the City of Knoxville.

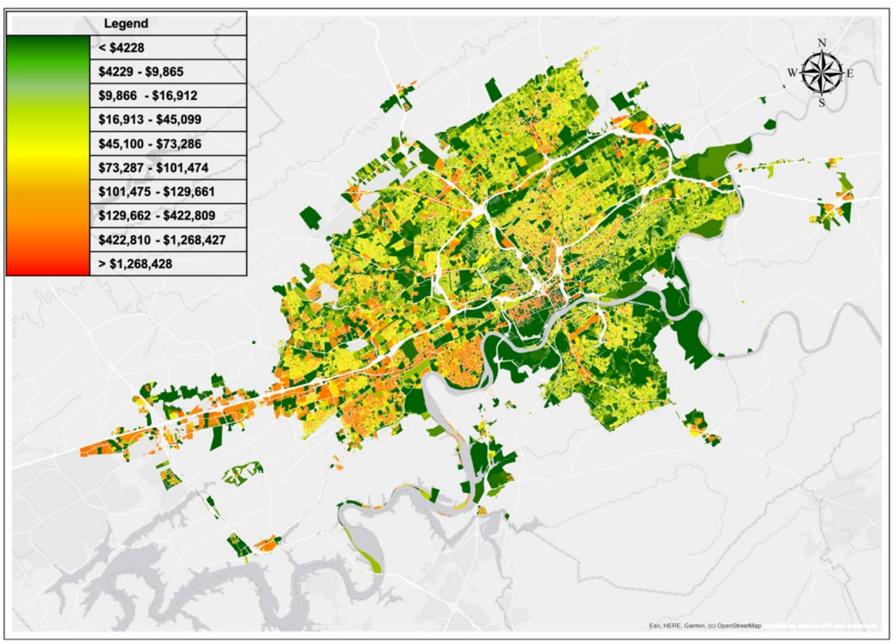
In Figure 5-16, the light blue line represents the average dollar value for an acre of land, and the blue stack plot represents the percentage change in value per acre over the preceding year. The y-axis on the right reflects the dollar value and, on the left, represents the percent change. It should be noted that the 2008 economic collapse caused by the housing bubble had a direct impact on home and land values. After the most significant price drop in real estate history in 2008, the country (and therefore the city of Knoxville) was in a great recession. Though Knoxville did experience reduced property values during that time, it did not experience the extreme swings that other cities experienced. The upsurge in land value from 2008 until 2012 can be attributed to Knoxville recovering from the recession and somewhat balancing the housing market economy by 2012. Figure 5-17 presents a visual representation of the Value Per Acre (VPA) change in Knoxville. Figure 5-17 (a) represents the value per acre plot for the year 2008. Figures 5-17 (b) and (c) illustrate the value per acre in Knoxville for 2012 and 2017, respectively. The shades of green drastically change to shades of yellow and orange, indicating overall growth in value between 2008 and 2012.



(a)



(b)



(c)

Figure 5-17 Value per acre plot for the city of Knoxville for the year (a) 2008, (b) 2012, and (c) 2017.

In the following section, the detailed Difference-in-Differences analysis for each road reconfiguration corridor is presented. The corridors selected for economic analysis are Cumberland Avenue, North Broadway, and Central Street.

5.4.1 Cumberland Avenue

The Cumberland Avenue Road reconfiguration project was initially envisioned in 2007, but reconfiguration did not begin until 2014. Even though the project was delayed for seven years, the sheer intensity of the proposed project significantly impacted the surrounding property value. We could observe the proposed project's effect on surrounding property values even before the project was underway. We have presented the intensity of value per acre for the individual parcel half a mile around the treated corridor before and after the treatment in Figure 5-19. In Figure 5-19, the shades of green represent the lower value per acre of land, and the shades of red represent the higher value per acre of land. Similarly, the stack height over the parcel represents its respective value per acre. The increase in property value after completing the project can be visualized in the figures below.

Figure 5-18 demonstrates the average value per acre for the parcels along Cumberland Avenue and the half-mile around from 2008 through 2019. Figure 5-18 reflects an upsurge in land value around the Cumberland Avenue corridor after completing the reconfiguration. It is necessary to understand that the general trend of growth over the years is a quantification of economic growth along the corridor due to any project. Figure 5-18 represents the value per acre of land on the y-axis and the year on the x-axis. The x-axis with years is divided into three sections: before, during, and after the reconfiguration project. The average cost for an acre of the parcel adjacent to Cumberland Avenue is determined to be around $298,000 in 2008. When the project was formally approved at the end of 2013, the price per acre of land reached $583,006. Finally, the cost of an acre of land, which started at $583,006 per acre before the project, ended up at $793,935 after completing the project. Similarly, for the parcels half a mile around the Cumberland Avenue treated section, the value per acre at the end of 2008 was calculated to be $178,000. The parcels half a mile around the treated corridor also reflect a similar trend in the change of land economy over the year. The average value per acre for parcels half a mile around Cumberland Avenue was determined to be $540,821 and $766,907, respectively, before and after the reconfiguration project. Along with the economic impact of reconfiguration, the upsurge in land value in 2017 can also be attributed to the reappraisal conducted throughout the county. Hence, to eliminate the impacts of such factors and determine only the effect of a road reconfiguration on land values, we present the difference-in-differences analysis of average values per acre land before and after the reconfiguration project.

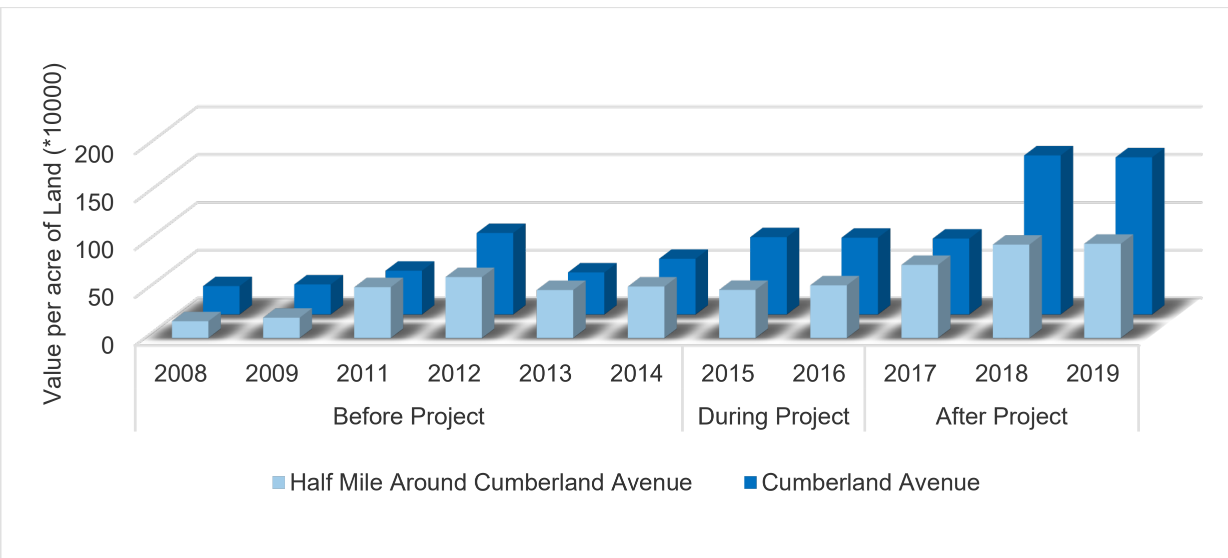


Figure 5-18 Assessed parcel value per acre at and half a mile around Cumberland Avenue before, during, and after the road reconfiguration.

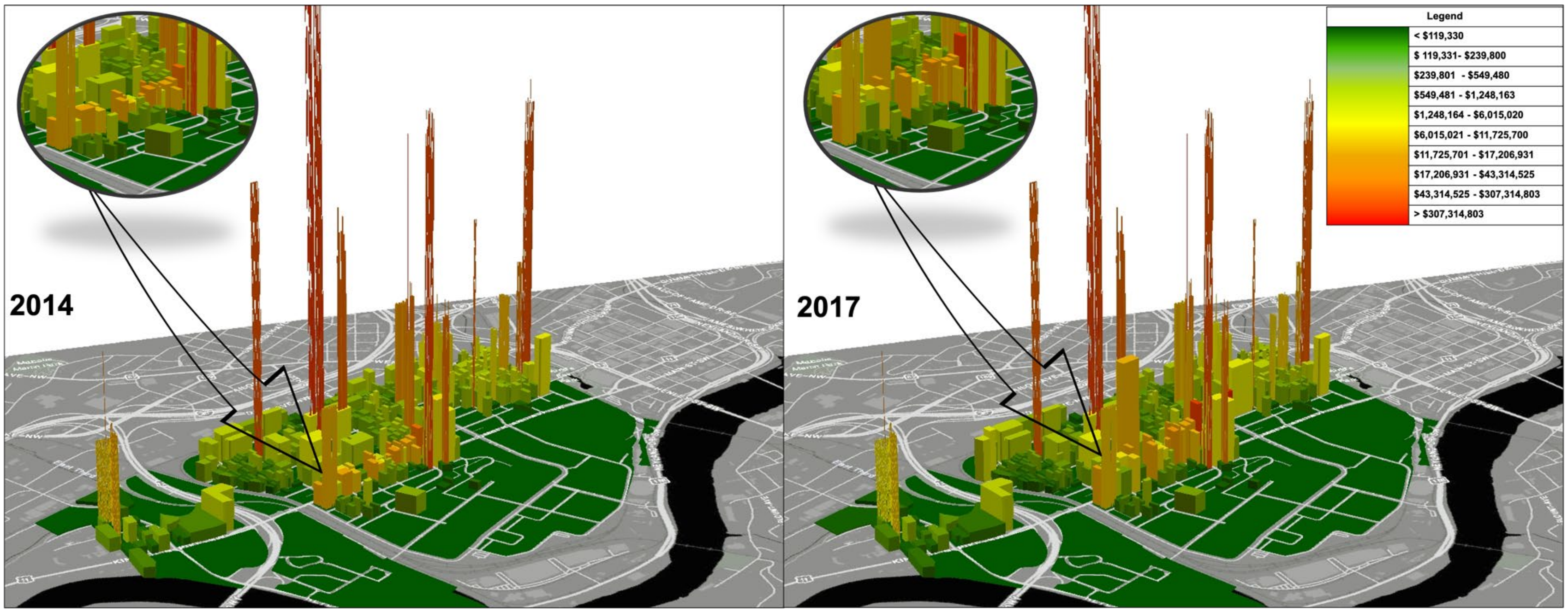


Figure 5-19 Value per Acre half a mile around Cumberland Avenue before (2014) and after (2017) the reconfiguration.

The *DID* model demonstrated a more comprehensive analysis of the effects of road reconfiguration projects on land value while aiming to control for other factors (e.g., macroeconomic factors affecting land value in Knoxville). According to the Knox County property appraisal data, the average value per acre of land adjacent to the Cumberland Avenue corridor before the road reconfiguration was $583,006. After the completion of the road reconfiguration project, the average value of land was estimated to be $793,935. Therefore, an observed growth of $210,929 (36 percent of the pre-road reconfiguration value) occurred following the project completion. Similarly, parcels a half-mile around Cumberland Avenue witnessed growth from an average of $540,821 per acre to $766,907 per acre during the same period. At the same time, the average value per acre of land throughout Knoxville increased from $91,749 to $98,294 (approximately a 7 percent increase). The results presented in Table 5-8 demonstrate that the Cumberland Avenue corridor and the parcels half a mile around Cumberland Avenue had five times higher growth than the average growth in the City of Knoxville. The results' statistical significance was checked and presented in Table 5-11 and further discussed in the latter part of this section.

It should be noted that a large portion of land facing Cumberland Avenue, and particularly land in the half-mile buffer surrounding the street, is owned by the University of Tennessee. Those parcels are tax-exempt and therefore not appraised, so this analysis does not capture the value change in those properties. If those were marketable parcels, then the values presented here would likely change positively as well.

Table 5-8 Coefficient for Difference-in-Differences Analysis. (Cumberland Avenue)

	Treated corridor	Half-mile around the treated corridor
Pre-road reconfiguration value per acre of land *	$583,006	$540,821
Post road reconfiguration value per acre of land *	$793,935	$766,907
Absolute growth	$210,929	$226,085
Growth percent	36	41
Average growth percent for COK (during the same period)	7	
The ratio of corridor growth against the city of Knoxville	5	5

**Values provided are the average value per acre of land.*

** City of Knoxville (COK)*

5.4.2 Central Street

While the Cumberland Avenue Road reconfiguration project was a massive redevelopment, the Central Street reconfiguration project was a more incremental effort to bring economic growth and safety with minimal cost by simply re-striping and transforming a 4-lane corridor into a 3-lane corridor with new bike lanes in both directions. The Central Street project was envisioned to improve the multimodal function of the Street, making it friendly for pedestrians, bicyclists, transit users, and motor vehicles. Such an improvement was expected to improve the corridor's desirability and ultimately boost land value around the corridor. A visual comparison of the change in average value per acre for parcels on Central Street, a half-mile around the treated section, and the City of Knoxville is presented in Figure 5-20.

Figure 5-20 presents the before and after change in land value at Central Street and surrounding parcels compared to the City of Knoxville. The y-axis represents the average price per acre of land, and the x-axis represents the year divided into before, during, and after sections. The different shades of blue stacks represent the average value per acre of land at Central Street, half a mile around Central Street and Knoxville. Figure 5-20 shows that the overall growth in land value is gradual over the City of Knoxville. The first atypical growth in land value along Central Street can be observed in 2011 and 2012 average value per acre results. The exact timeframe also corresponds with the submission of a formal proposal for the streetscape project. A similar increase in land value can also be observed after the completion of the road reconfiguration in 2019. Figure 5-20 shows that the road reconfiguration positively impacted the value of land parcels around the road reconfiguration portion of Central Street. An additional before and after illustrative representation of parcels a half-mile around the Central Street treated corridor is presented in Figure 5-21.

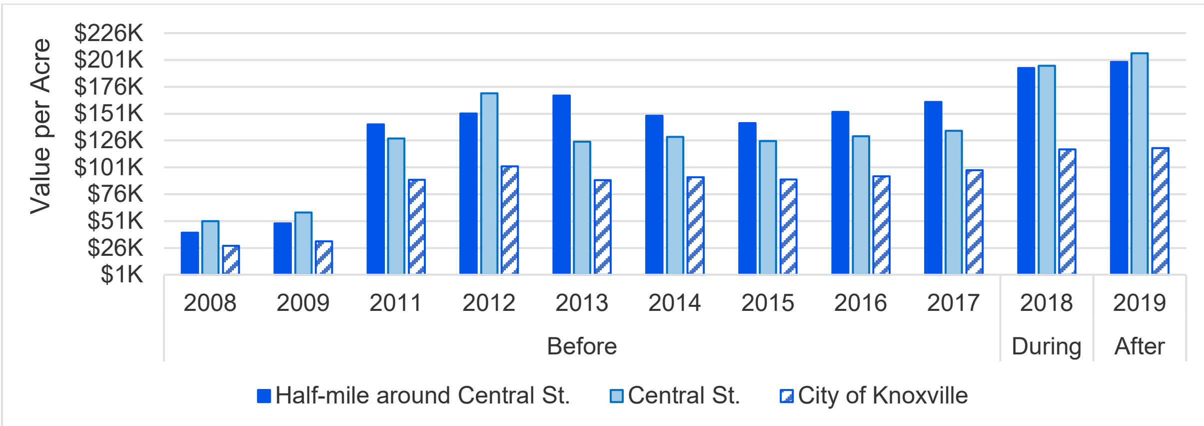


Figure 5-20 Average price of land per acre at treatment and control corridor over the year.

The *DID* analysis presented below in Table 5-9 quantifies the change in the land value at and around North Central Street before and after the road reconfiguration project compared to Knoxville as a whole. The statistical significance of the DID is further provided in Table 5-11. In the baseline *DID* specifications for North Central Street, 2017 and 2019 were selected as pre-and post-treatment years. The parcels adjacent and up to a half-mile around the treated portion of Central Street (5th Avenue to Woodland Ave) were categorized as the treatment groups. All of the parcels from the City of Knoxville were considered a control group. The average value of an acre of land adjacent to Central Street before the road reconfiguration was $135,016, which increased to $207,338 after the project completion.

Similarly, half a mile around Central Street, the average value for an acre of land changed from $161,973 to $199,111 after the road reconfiguration completion. Both of the treatment groups witnessed an increase of 53 and 23 percent, respectively. During the same time frame, the City of Knoxville had an absolute growth of 21 percent. The results presented in Table 5-9 indicate that the road reconfiguration was solely responsible for increased land value along the treated corridor and reinforcement of economy of parcels half-mile around the treated corridor. As indicated by Table 5-9, the increase in land value was two times higher for parcels along the Central Street Corridor with a nearly similar increase for parcels within the half-mile buffer.

Table 5-9 Coefficient for Difference-in-Differences Analysis. (Central Street)

	Treated corridor	Half-mile around the treated corridor
Pre-road reconfiguration value per acre of land *	$135,016	$161,973
Post road reconfiguration value per acre of land *	$207,338	$199,111
Absolute growth	$72,322	$37,137
Growth percent	53	23
Average growth percent for COK (during the same period)	21	
The ratio of corridor growth against the city of Knoxville	2	1

**Values provided are the average value per acre of land.*

** City of Knoxville (COK)*

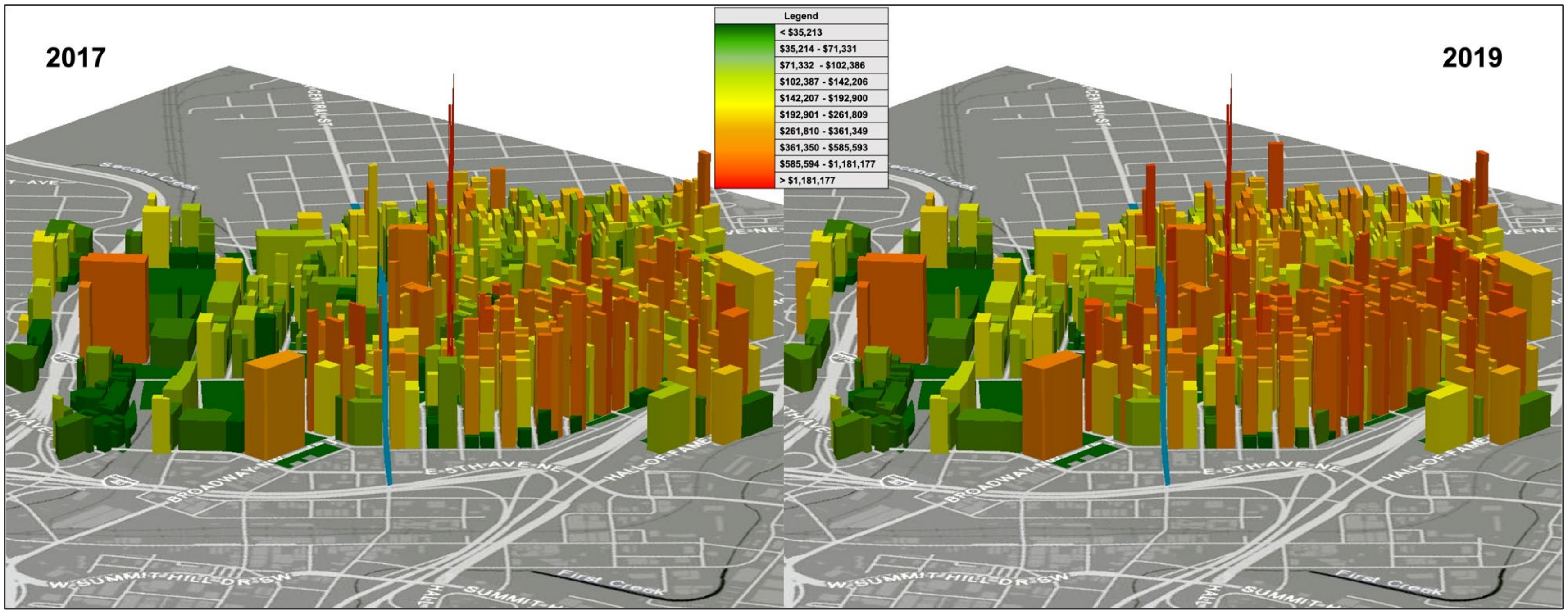


Figure 5-21 Value per Acre half-a-mile around North Central Street before (2017) and after (2019) the reconfiguration. Blue line indicates Central corridor.

5.4.3 North Broadway

The stretch of road reconfigured on Broadway was conducted between Central Street and Jackson Avenue, spanning 0.7 miles. The reconfiguration project converted the four-lane street to a three-lane street, utilizing the additional space for a center turn lane and bike lane on both sides of the corridor. The project's total cost was kept relatively low by aligning the timing of the reconfiguration with the corridor resurfacing project that was already planned. Such a scenario provided an opportunity to include a bike lane on the roadway. The resurfacing, with the addition of bike lanes, was expected to attract more riders and improve the economic activity of the corridor. Figure 5-23 reflects an overall growth in land value around the Broadway corridor before and after the project.

The general trend in the price of land along and around Broadway shows a similar story of rising after the great recession of 2007 to 2011. A general trend in growth in property value around the North Broadway Corridor is presented in Figure 5-22. There was a fluctuation in property value along Broadway from 2011 to 2016. The next upsurge in property value was observed after the reappraisal in 2017. After the reappraisal, the property values in the vicinity of Broadway increased, while the average value of land leveled out for the entire city of Knoxville. The difference in differences analysis was calculated to specifically quantify the difference in change before and after the road reconfiguration.

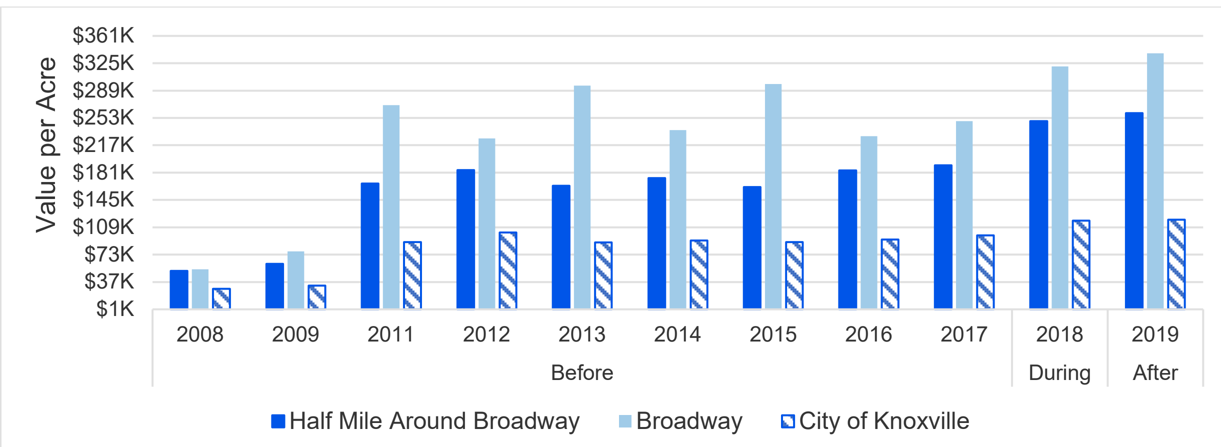


Figure 5-22 Average value per acre for Broadway (treated corridor), half-mile around the treated corridor, and city of Knoxville.

For the *DID* analysis, similar to the previous two cases, parcels adjacent to the Broadway corridor along the road reconfiguration sections are considered the first treatment group. The parcels half a mile around Broadway are regarded as the second treatment group. The average value per acre of land through the City of Knoxville during the same period was a control group. Before the road reconfiguration project, the average value per acre of land adjacent and half a mile around Broadway were $228,858 and $190,830, respectively. From 2017 until 2019, the average value per acre of land increased by 36 percent for both the parcels adjacent to the corridor and for the parcels a half-mile around the corridor.

Table 5-10. Coefficient for Difference-in-Differences Analysis (Broadway).

	Treated corridor	Half-mile around the treated corridor
Pre-road reconfiguration value per acre of land *	$248,763	$190,830
Post road reconfiguration value per acre of land *	$337,997	$259,173
Absolute growth	$89,233	$68,343
Growth percent	36	36
Average growth percent for COK (during the same period)	21	
The ratio of corridor growth against the city of Knoxville	2	2

******Values provided are the average value per acre of land.*

* *City of Knoxville (COK)*

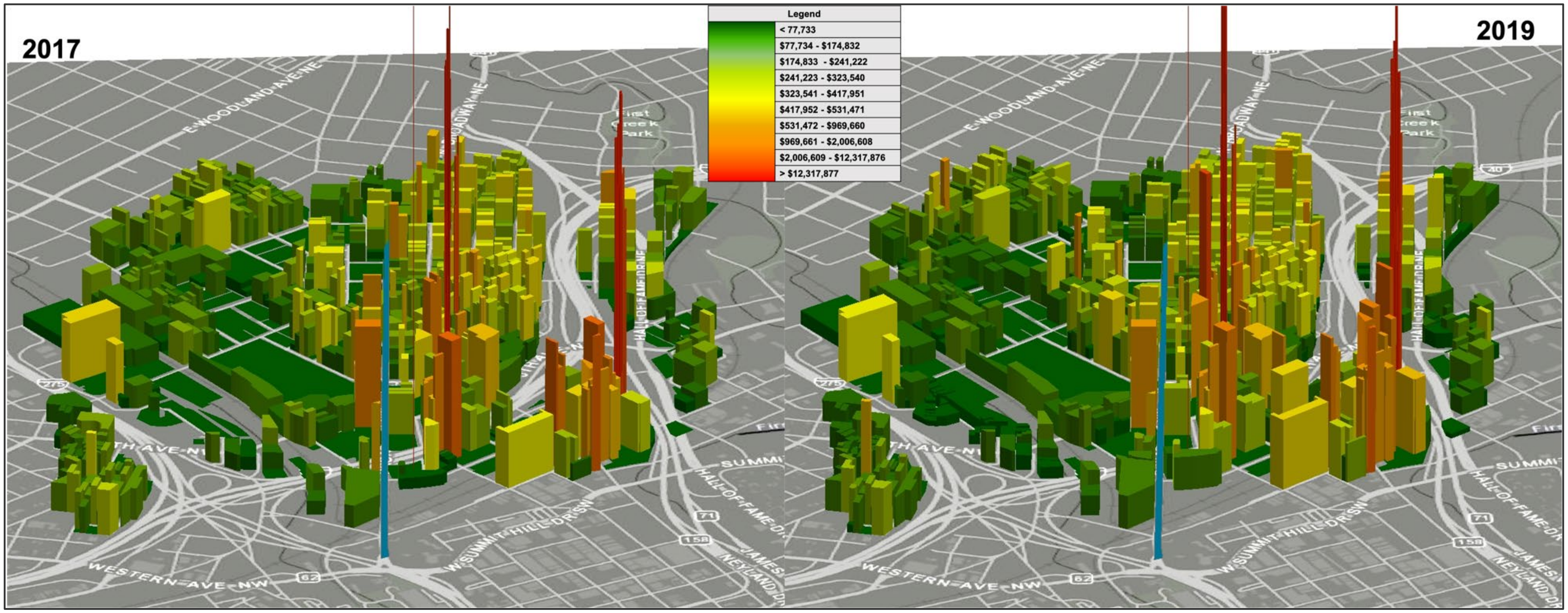


Figure 5-23 Value per Acre half a mile around Broadway before (2017) and after (2019) the reconfiguration. Blue line indicates Broadway corridor.

5.4.4 Statistical tests

The *DID model* results described previously were further checked for statical significance using a regression model. Table 5-11 presents the coefficients and results for the regression analysis. The higher coefficient of the *DID* estimate for the parcels along the treated corridor signifies a higher impact from the road reconfiguration. The *p*-value less than 0.05 signifies the result obtained from the model were statistically significant.

Table 5-11 Significance of results from the *DID* regression model.

Coefficient from DID	Estimate	Std. Error	T- Value	Pr(>|t|)	F- Stat
DID for parcels along the Cumberland Avenue	$913,301	$149,396	6.113	5.65E-06	37.370
DID for parcels around half a mile of Cumberland Avenue	$548,792	$106,092	5.173	4.63E-05	26.760
DID for parcels along the Central street	$101,313	$26,245	3.860	0.001	14.900
DID for parcels around half miles of Central street	$91,025	$31,608	2.880	0.009	8.293
DID for parcels along Broadway	$185,228	$65,140	2.845	0.010	8.095
DID for parcels around half a mile of Broadway	$139,611	$37,408	3.732	0.001	13.930

Table 5-11 indicates that the difference in the increase in land value for all the corridors was statistically significant, with a *p*-value less than 0.05. This indicates that the increase in land value for the parcels along the treated corridor and the parcels half a mile around the respective corridor is due to the effects of the reconfiguration project. It should be noted that the level of significance of the results is higher for Cumberland Avenue but just above the 0.05 p-value limit for Central Street and Broadway due to a lack of post-intervention data. In this analysis, we had the property appraisal data until 2019 whereas all the reconfiguration projects were completed in 2018. Based on the results obtained for the *DID* analysis of Cumberland Avenue, it is evident that a more precise model summary can be extracted if provided with a few more years of post-reconfiguration data. Furthermore, it can be stated that the additional reconfiguration measures like bike lanes and pedestrian infrastructure can be linked to a better economic performance of the surrounding area, based on the results from the statistical analysis.

Chapter 6 CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

> *"To plan is human. To implement is divine." (Kayden, 2014)*

The literature reviewed for the purposes of this study has presented the advantages and disadvantages of the application of road reconfigurations. Road reconfigurations can take different forms, but the typical four-lane to three-lane conversion remains the most common. Other innovative designs have also emerged to match the existing conditions and context of the study area. Different studies have used various methods and performance measures to evaluate individual road reconfiguration projects. The evaluations are conducted based on before and after studies, simulations, and statistical models to assess the proposed projects in addition to the standard performance measures related to safety and operation. The safety, traffic operations, and economic impacts of such projects were primarily investigated.

The study results indicated that road reconfigurations have an overall positive impact on numerous corridor factors. Some factors did not experience significant positive changes, but the metrics indicated no worsening of performance. Based on the selected case studies, the post-reconfiguration effects are directly related to the intensity of the road reconfiguration project. Modestly scoped projects result in modest impacts on the corridor. In one case study (Cumberland Ave), traffic volume decreased along the treated corridor after the reconfiguration. Similarly, the results indicated that the traffic volume increased in the streets parallel to the treated road. Hence, proper planning and consideration regarding the capacity of the parallel street are also required for a successful reconfiguration project. On another corridor (Broadway Ave), the data collected along the treated corridor showed that the reconfiguration did not drastically affect the average 85th percentile speed. The average 85th percentile speed was already below the speed limit before the treatment and remained below it post-treatment as well.

With regards to safety, there were fewer crashes after implementing the road reconfiguration compared to before. This study found a significant reduction (approximately 50% and 55%) in the total number of crashes involving vulnerable road users after the reconfiguration for two of the selected case studies. The safety analysis results showed a statistically significant decrease in crashes on both Cumberland Avenue and Central Street after receiving road reconfiguration treatment. Broadway experienced a decline in crashes that were not statistically significant. However, when comparing the percent reduction in crashes on each corridor to Knoxville during the same periods, only Cumberland experienced a reduction in crashes that significantly differed from the percent change in crashes in Knoxville during the same time frame. In other words, Cumberland was the only treatment corridor that substantially improved safety performance that was statistically significantly better than Knoxville as a whole. Nonetheless, Central Street also experienced a significant reduction in crashes after the road reconfiguration, implying that some benefit comes from low-cost and straightforward reconfiguration treatment. It should be noted that the analyzed corridors were all developed relatively recently, and the duration of observation after completion of the projects was short-term. Confounding factors such as traffic disruptions from COVID-19 and adjacent major construction projects obscures some aspects of this before and after analysis. Nonetheless, the results indicate that safety either improved or was not made any worse by the implementation of reconfiguration projects.

Finally, this study further shows that the difference-in-differences method can be applied to understand an intervention's spatial effects. However, special consideration must be given to spatial relationships by selecting appropriate control groups. The additional method to normalize the assessed value of a property by its area provided meaningful information in the comparison to capture the many intangible impacts of a reconfiguration project. This analysis revealed that, although property values throughout the city increased during the study period, properties adjacent and surrounding the road reconfiguration project experienced a more significant increase in land value. This study indicated that the block-facing land parcels adjacent to the reconfigured Cumberland Avenue, Central Street, and Broadway corridors experienced four-times, four-times, and three-times higher growth than the average growth in Knoxville the same period, respectively. Similarly, the parcels located half a mile around the treated corridors experienced two- and three-times higher land value growth than Knoxville's average growth. The analysis provides direct, robust evidence for the positive impact of road reconfiguration projects on nearby property values while highlighting the importance of using more aggressive reconfigurations for optimum results.

6.2 RECOMMENDATIONS

This chapter concludes the report with recommendations for planners, researchers, and respective agencies to design road reconfiguration projects and effectively evaluate such projects based on the crash, traffic, and land value data. These recommendations are based on the analysis of three different road reconfiguration projects in Knoxville, in addition to the review and inventory of other road reconfiguration projects. The study recommends that TDOT maintain a statewide inventory of completed, planned, and potential candidate corridors for reconfiguration. TDOT should also develop standard guidelines to evaluate specific major characteristics for future street reconfiguration projects and maintain consistency across projects throughout the state. Such characteristics can range from economic and safety analysis to social changes depending upon the location and intensity of the project and the readiness and availability of data. The inventory of reconfiguration projects developed in this report for four cities in Tennessee can be adopted and adapted.

Various statistical alternatives for safety and economic impact matrices were explored for evaluating a road reconfiguration project. It is recommended that the specific choice of road reconfiguration type should depend on the site's characteristics being considered for treatment. For example, if a site requires extensive improvement in safety, traffic, and economic performance, it can be expected with heavier treatment instead of lighter corridor treatment. However, lighter corridor treatments can be implemented faster and may be more cost-effective to achieve similar results. Modest results achieved more quickly and more often may result in more significant overall benefits.

The following points are recommended for future evaluations. A safety analysis of treated corridors could be strengthened by investigating the specific effects of the reconfiguration on the safety of vulnerable road users. This could be carried out using a similar statistical analysis to that which was utilized for this study on the change in the number or proportion of crashes involving vulnerable road users on the treated corridor. Rather than focusing on the total crash count involving vulnerable road users, it may also be beneficial to assess the degree to which the crash severity of VRU-involved crashes was affected by the road reconfiguration project. An additional focus on VRU crash severity would be beneficial due to the possibility of newly implemented road reconfigurations attracting more VRUs to a corridor, particularly if dedicated infrastructure has been added, possibly resulting in a higher crash count.

While analyzing and presenting the impacts of road reconfigurations to various street types, it is essential to look at changes both to number (raw counts) and percentage (or proportion) to understand the true impact and relevance of the study findings. We recommend developing a cross-sectional research design framework to compare the traffic volumes and speeds at the treated corridor and the outside the project neighborhood. In some cases, it would be beneficial to analyze the number of vehicles and their speed that falls above the 85^{th} percentile limit rather than exploring the average 85^{th} percentile speed.

While analyzing the economic impact on a corridor, it is essential to look at each location and mean values across large data-collection sites. While many economic factors drive property values, it is well documented that transportation and built environment improvements influence property values. Many times, increases in mobility and accessibility increase property values and should not be double-counted as a benefit within transportation systems and a benefit to property values. In this case, increases in land value are not likely affected solely by increases in mobility since all reconfiguration projects assessed here are limited in geographic scope. Value per acre analysis normalizes the land value according to a fixed amount of land available for economic productivity (rather than solely focusing on agglomeration through large-scale projects). We recommend using a graphical representation that reflects the before and after changes with normalized data, which better emphasizes which parcels are being redeveloped, which are increasing in value, and which are collectively growing economic productivity by using land value as a proxy. Based on this analysis, a given treated corridor and its surrounding area would substantially benefit from a road reconfiguration project accommodating different modes of transportation within its existing cross-section.

6.3 ACKNOWLEDGMENT

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APPENDIX A. INVENTORY OF ROAD RECONFIGURATIONS IN TENNESSEE

Nashville, Tennessee

1. 51st Avenue North (2-4)
2. Church Street (5-7)
3. Commerce Street(8-10)

1

Nashville, TN

51st Ave North

Context

- In July 2016, council person Mary Carolyn Roberts announced the Road Diet Project for 51st Avenue from Centennial Boulevard and Charlotte.
- The project built on the paving and bike lane stripping project from 2014 to transform the corridor into a complete street enhancing and creating sense of place for growing neighborhood.
- 51st Avenue historically was very industrial corridor which has transitioned itself into a mixed residential and commercial area. Currently, 51st avenue is home to numerous Nashville hot spots like Fifty First kitchen & Bar House, The Mill Boutique and many more.
- The portion of development stretched from Centennial boulevard to Charlotte Avenue, a 0.7 mile stretch which shared the concept plan created by Metro Nashville Public Works, Metro Water and RPM.

Objectives

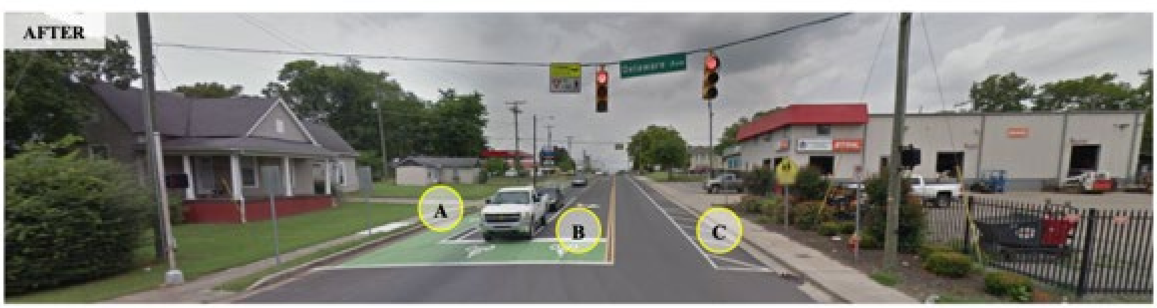
- Installation of traffic calming measures maintaining safety for all road users.
- Installation of bike lane through the corridor and contribute towards bike connectivity through the city .
- Drainage improvement during the streetscape project

Problems

- Unpredictable riding behavior by bike user leading towards incident.
- Conflicts between through and turning vehicle at higher speed.
- Inadequacy of parking along the corridor.

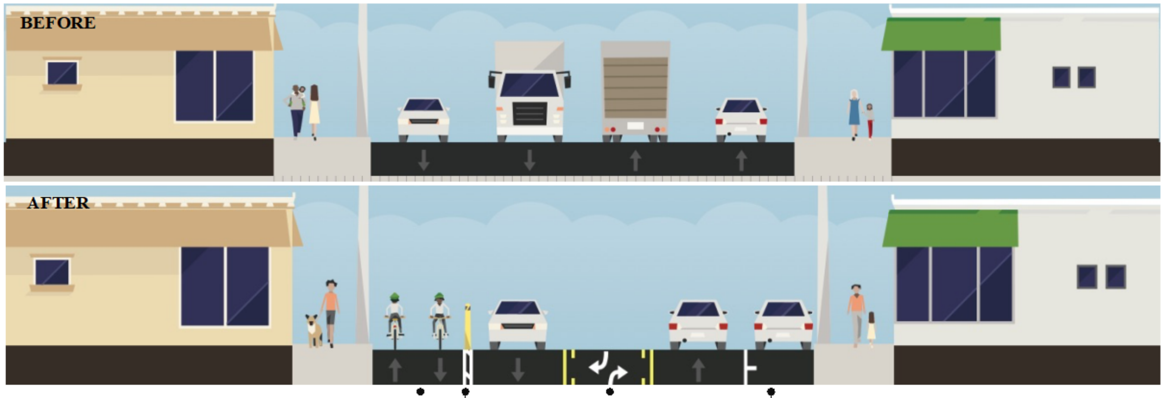
Interventions

A. Buffered protected two-way cycle track.
B. Two-way left turning lane.
C. Parking on one side of street.



Nashville, TN

51st Ave North

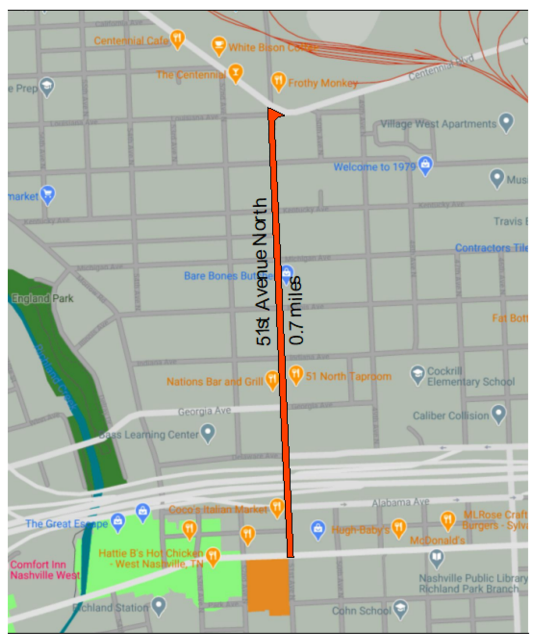


1. Two-Way Bike Track has been the mark of this project.

2. Protected bike lane delineates space on the road for bike and prevents cars from infringing on that space.

3. Center turn lane has elevated congestion and prevented accidents for left turning vehicles.

4. Parking lane along the corridor is highly appreciated by the local business owners.



Nashville, TN

51st Ave North

Results	Challenges
➢ Accelerated economic development. ➢ Improve walkability. ➢ Better drainage system. ➢ Improved land value.	➢ Transition from old to new road features. ➢ Industrial to commercial/private property.

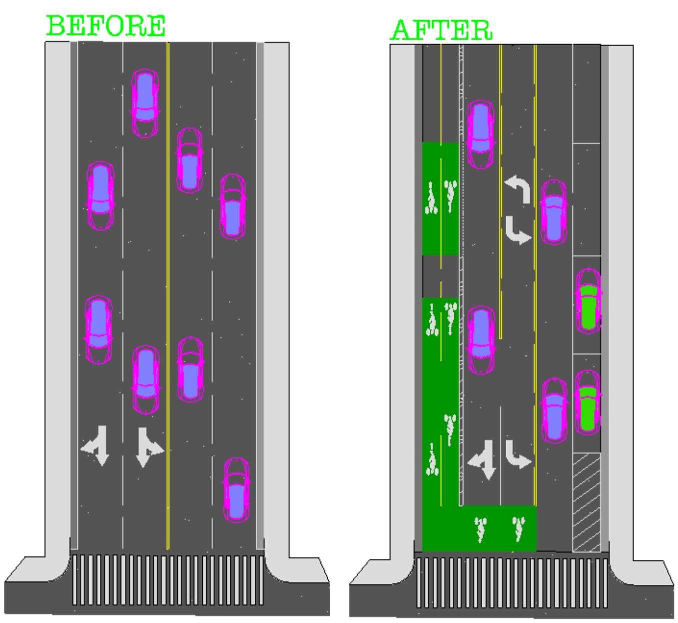
Takeaways

➢ **Safe and attractive for all users**

Reduced crossing length as well as the reduced vehicular speed was achieved. Addition of center turn lane allowed the left turning vehicle to exit the traffic stream while waiting for the gap to complete their turn which made up space for other users.

➢ **Building neighborhood vitality**

Addition of on street parking and bike lane transformed the image of the corridor. New business were introduced.



Street Classification:
Arterial

Right of Way:
60 feet

Length:
0.7 Miles

Construction Period:
3 years

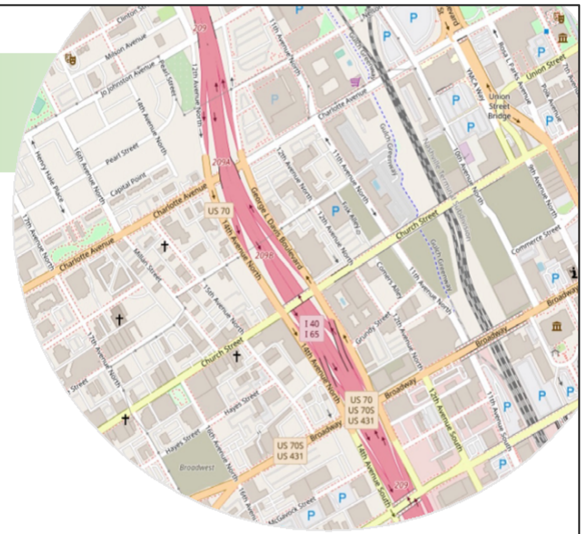
Speed:

Before **After**

Responsible Agency:
Tennessee Department of Transportation

Nashville, TN

Church Street



Context

- Church street serves as a major corridor for daily commute to and from downtown to the city.
- Nashville's first bike box was installed at Church Street at intersection of 9th Avenue north.
- The Church street corridor was chosen as pilot for bike box and road reconfiguration being gateway into the city bike mobility. It is important section of existing bike infrastructure and downtown connectivity.
- The extra space after reconfiguration was used to install buffered bicycle lane on both sides of the street. Removing the outer lane and narrowing travel lane made walking and biking more comfortable.

Objectives

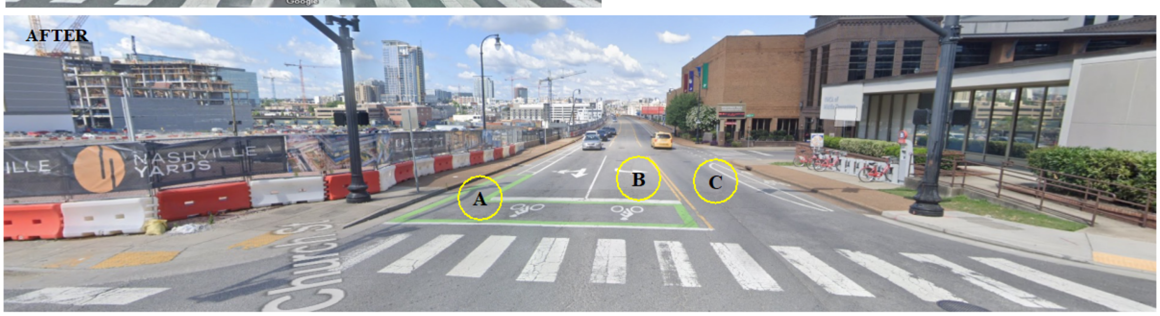
- Traffic calming on a wide and straight section of corridor.
- Proper utilization of space occupied by underused turning lanes.
- Extend the range of bike connectivity through the city.

Problems

- High speed of vehicle travelling to and from downtown.
- Lack of extra space on the corridor to add more features..

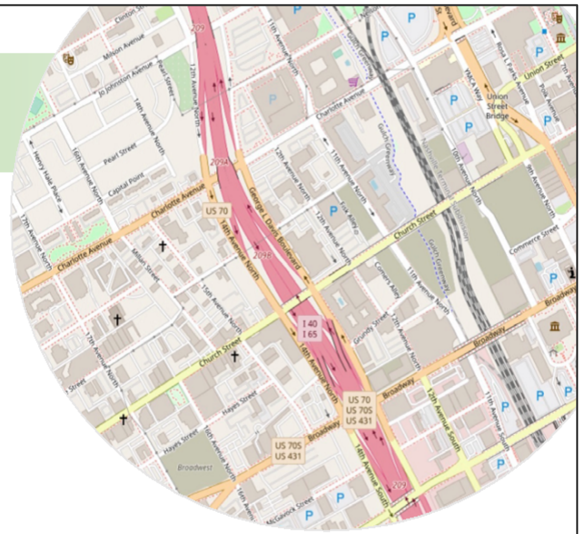
Interventions

A. Single lane buffered bike lane on both directions.
B. Center turn lane for left turning vehicle.
C. Reduced width of travel lane.



Nashville, TN

Church Street



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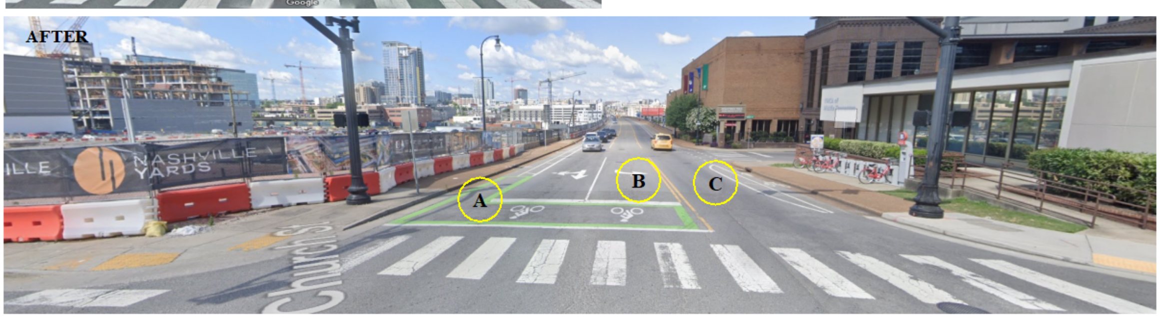


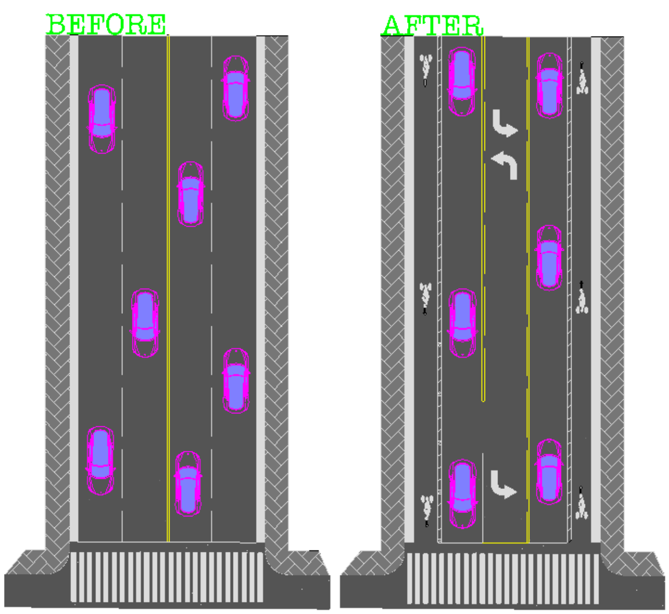
Nashville, TN

Church Street

Result	Challenges
➢ Reduced travel lane and slower traffic through the corridor ➢ Accommodation of bike and extension of bike connectivity through city. ➢ Comfortable walking and biking scenario.	➢ Complains from people since it was installed without community input. ➢ Daily commute traffic was slowed down which was not appreciated by many travelers.

Takeaways

- **Utilization of left turning lane.**
  One of the unique features of transformed corridor has been the Vanderbilt Medical Center effective use of center turn lane for emergency vehicles, as necessary.
- **People have different opinion.**
  After the completion of the project motorist through the corridor have complained about their trips taking longer than usual.
- **More bike through the corridor.**
  Observationally the amount of bike use through the corridor have gone up in numbers. Same goes with the AADT after the project which can be related to the development of downtown corridor.



Street Classification:
Arterial

Right of Way:
71 feet

Length:
0.7 Miles

Construction Period:
*** years**

Speed:

Before **After**

Responsible Agency:
Tennessee Department of Transportation

Nashville, TN

Commerce Street

Context

- Commerce street road diet project installed first protected bike lane in Downtown Nashville.
- The project was delayed for nearly over a year due to impedance from the existing business concern over bike lane changing their day-to-day workflow. Business owner were reluctant to move their loading zone.
- Downtown Nashville was expected to grow by 40,000 or more people, with many new buildings planned to be built. Unless properly planned, all the projected growth and created new jobs was expected to make downtown inaccessible with thousands of cars clogging the street.

Objectives

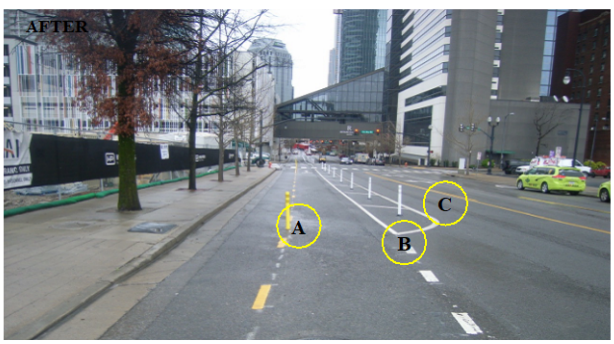
- Decrease the number of traffic and making it possible to get around downtown without driving.
- Installing a low street and safter bike way.
- Safety of all road users.

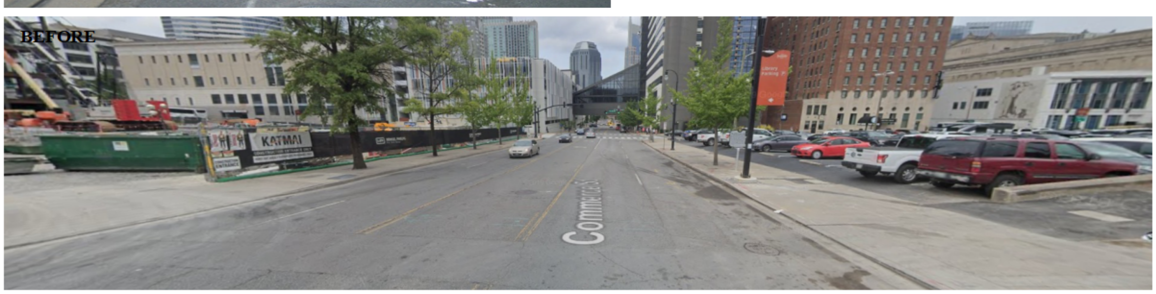
Problems

- Business owner are reluctant to giveaway store front parking and loading zone for bike lane.
- Inclusion of bike lane and the parking with smooth flow of traffic in the given cross section.

Interventions

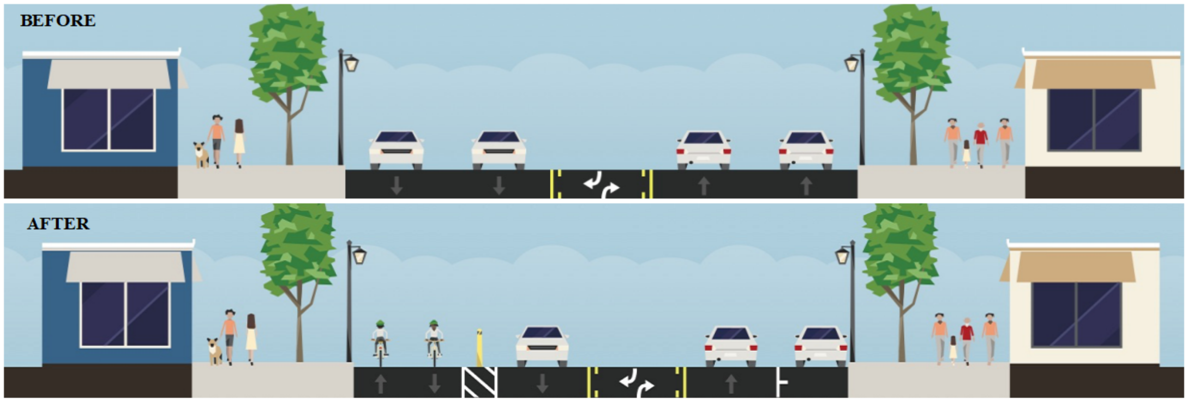
A. Two-way bike lane on one side of street.
B. Buffered separation for travel lane and bike.
C. Reduced travel lanes.



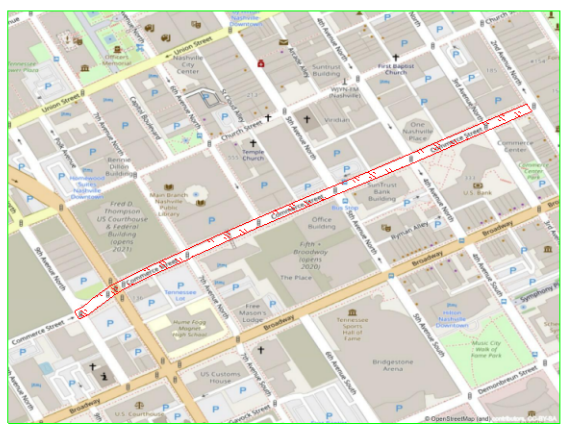


Nashville, TN

Commerce Street



1. Two-Way Bike Track on one side of the corridor has been the mark of this project.
2. Protected bike lane delineates space on the road for bike and prevents cars from infringing on that space.
3. Width of travel lane were reduced to control traffic speed providing the feeling of safety for vulnerable road users.



Nashville, TN

Commerce Street

Result	Challenges
➢ Slower traffic through the corridor. ➢ Accommodation of bike and extension of bike connectivity through the city. ➢ Development of comfortable walking and biking scenario.	➢ Organization of loading zones from front to back of the store. ➢ Acceptance of change in parking space by local business owners.

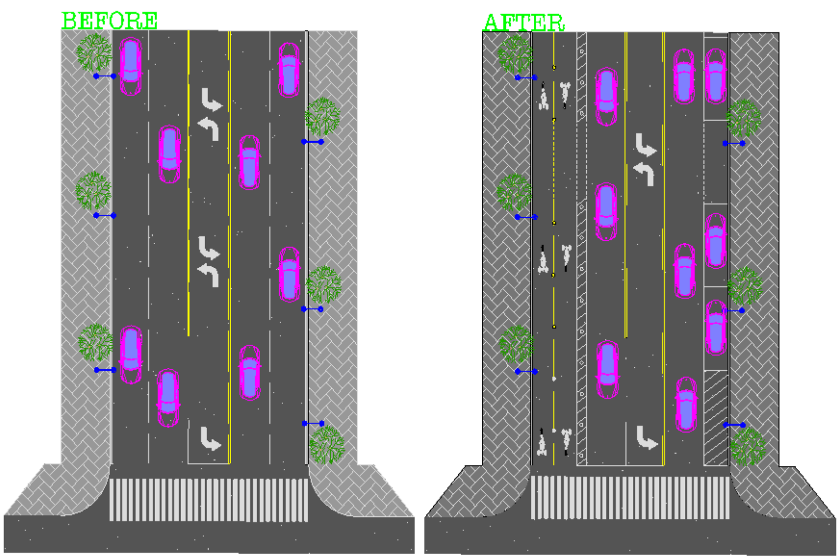
Takeaways

➢ **Buffered bike lane for safer ride.**

Protected bike lane has helped reduce downtown car traffic and resulted in fewer bike related crashes.

➢ **Accommodation of both bike and parking lane.**

Delivery and pickups can be managed successfully even with street curbs occupied with bike and parking lane.



Street Classification:
Arterial

Right of Way:
91 feet

Length:
0.5 miles

Construction Period:
2 months

Speed:

Before **After**

Responsible Agency:
Tennessee Department of Transportation

Knoxville, Tennessee

Knoxville, TN

Cumberland Avenue

Context

- The Cumberland Avenue was a four-lane undivided street often congested with expected turning vehicle, unregulated and frequent parking vehicles and delivery trucks.

- The project took a semi-suburban, auto oriented pass-through corridor and made it into an urban multi-modal corridor incorporating pedestrian, bicyclist, transit, and cars while creating unique urban district.

- The reconstruction reduced the corridor from a 4 lane to 3 lane street. One of the three lanes is dedicated turning lane.

- The corridor have had the most pedestrian/bike related traffic crashes per mile in the city of Knoxville. In the 18 months after intervention, crashes were down by 90 percent.

Objectives

- Traffic calming and improve safety along the corridor.
- Economic and aesthetic development along the corridor.
- Improve pedestrian and bicycle connectivity.
- Removal of curb cutting.

Problems

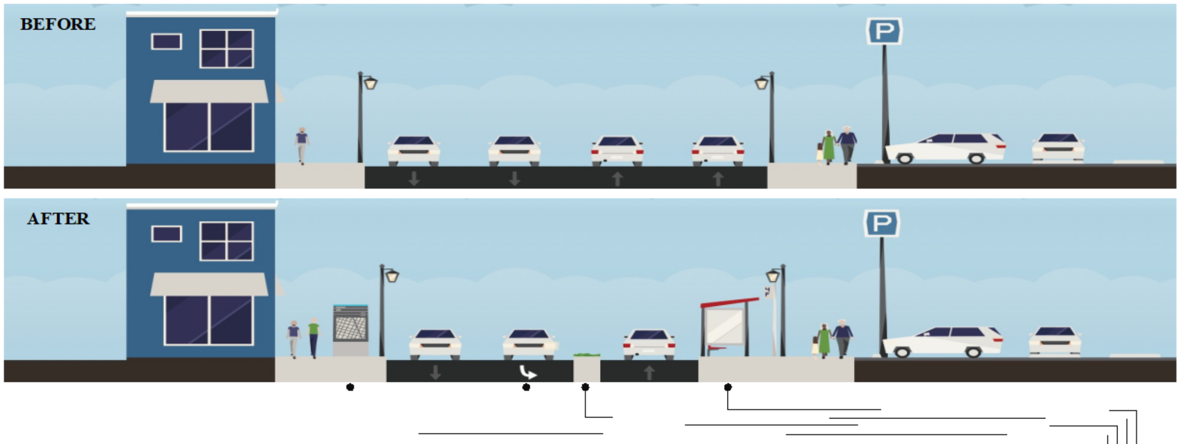
- Higher travel speed.
- Lack of proper transit stops.
- Lack of proper pedestrian infrastructure.

Interventions

A. ADA- accessible transit stops
B. Kiosks and waste receptacles.
C. Median divided travel lanes.
D. Street trees, plants and furniture space.
E. Wider sidewalks.

Knoxville, TN

Cumberland Avenue



1. kiosks and waster receptacles gave the street new look.

2. Widened median and turn at signalized intersection allowed navigate left turn without disturbing through traffic.

3. Physical median separation between two lanes helped in reducing speed and provided space for landscaping.

4. Wider sidewalks with transit shelter and seating arrangement made the corridor pedestrian friendly.

Knoxville, TN

Cumberland Avenue

Result	Challenges
➢ Number of pedestrians went up and pedestrian related crashes went down. ➢ Economic growth of the corridor. ➢ Corridor transformed into a transit friendly environment.	➢ Convincing business owners and stakeholders regarding losing travel lane. ➢ Maintaining convenient traffic flow during construction.

Takeaways

➢ **Safe and attractive for all users**

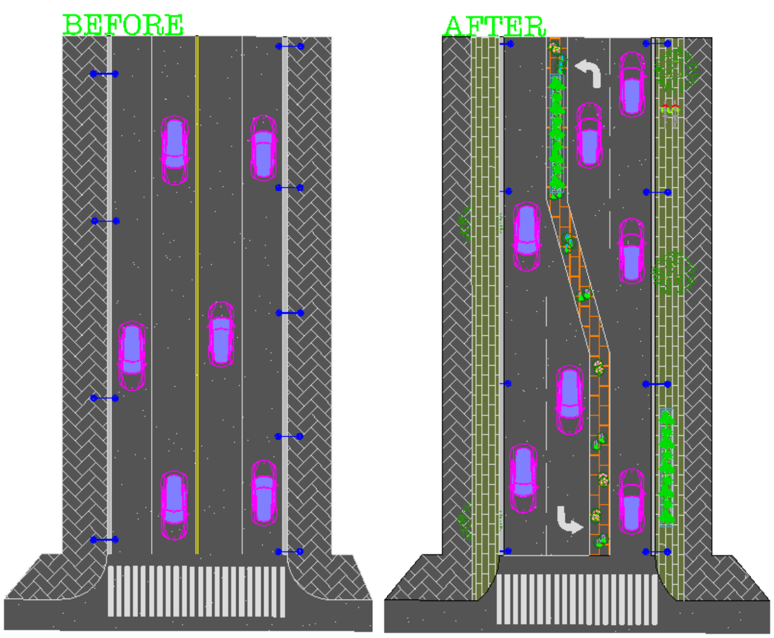
The Cumberland Avenue Streetscape project had created a safe environment for pedestrians, bicyclist, and motorist by decreasing speed to an 85th percentile of 26 mph in the project corridor.

➢ **Lower Traffic**

The annual average traffic along the Cumberland Avenue Corridor has decreased in volume after the intervention.

➢ **Increased in property assessed value.**

Property along and around the treated corridor were assessed at higher rated compared to average rate throughout the city.



Street Classification:
Arterial

Right of Way:
65 feet

Length:
0.6 Miles

Construction Period:
18 months

Speed:

Before **After**

Responsible Agency:
City of Knoxville

Knoxville, TN

Broadway

Context

- City of Knoxville and Regional Transportation Planning Organization in collaboration with TDOT extended a bridge replacement project to convert 4 lane street into 2 lane with center turn lane and bike lane street.
- The plan was to connect downtown with world Fair Park, which encompasses the larger portion of the cycling traffic for the city.
- The section of street was identified as one of the top 25 priorities in the City's Bicycle Facilities Plan completing a missing bike link between Fort Sanders, the University of Tennessee and the City's 18-mile downtown greenway system.
- The City expected to make the section safer by reducing the pedestrian related crashes.

Objectives

- Traffic calming and improve safety along the corridor.
- Economic and aesthetic development along the corridor.
- Improve pedestrian and bicycle connectivity.

Problems

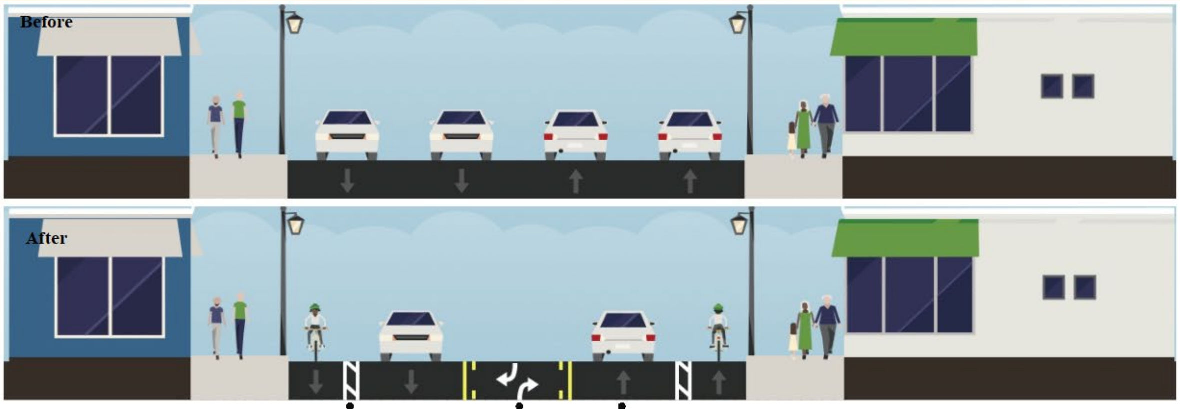
- Pedestrian crossing.
- Confusion in lane merge at different section.

Interventions

A. Bike lane on both directions.
B. Reduced travel lane.
C. Addition of center turn lane.

Knoxville, TN

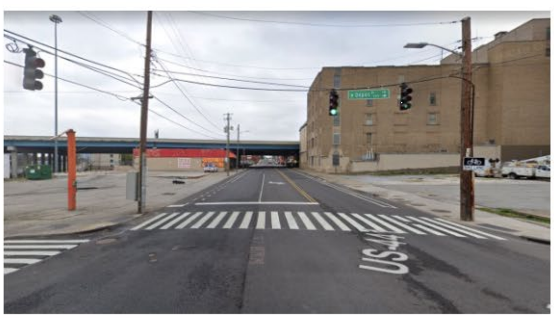
Broadway

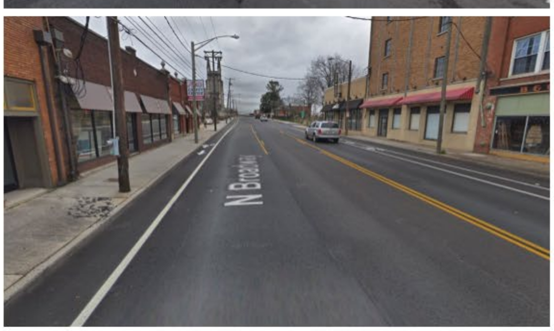


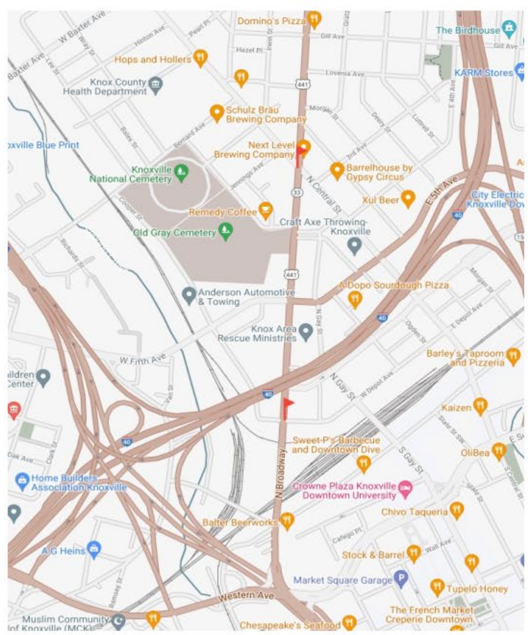
1. Bike lane on both direction added on the bike connectivity.

2. Center turn lane.

3. Reduced travel lane help in traffic







Knoxville, TN

Broadway

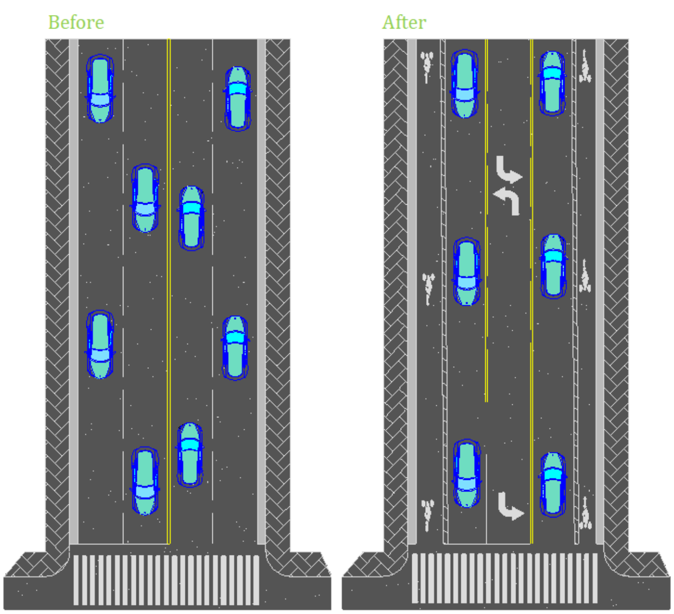
Result	Challenges
➢ Bike lane connectivity between two prime location in city. ➢ Slower vehicles. ➢ Safer and attractive street section.	➢ Business losing on street parking.

Takeaways

- **Safe and attractive for all users**

  Reduced vehicular speed has been achieved by converting an existing four-lane undivided highway to a two through lanes and a center turn lane. This conversion also allowed the left turning vehicle to exit the traffic stream while waiting for the gap to complete their turn which made up space for other users.

- **Addition of bike lane helped reduce vehicle speed**



Street Classification:
Arterial

Right of Way:
60 feet

Length:
0.7 Miles

Construction Period:
3 years

Speed:

Before **After**

Responsible Agency:
Tennessee Department of Transportation

Knoxville, TN

Sevier Avenue

Context

- Sevier Avenue road intervention project has been one of the important projects in the city of Knoxville being central to multiple developing and planned projects.
- Sevier avenue project added two buffer protected bike lane each direction eliminating center turn lane.
- 2.5-foot-wide painted buffer is provided between bike lane and the travel lane with an intention to provide a more comfortable and safer route for the bicyclist.
- The project has gone hand in hand with larger Knoxville South Waterfront Vision Plan by better connecting major location.

Objectives

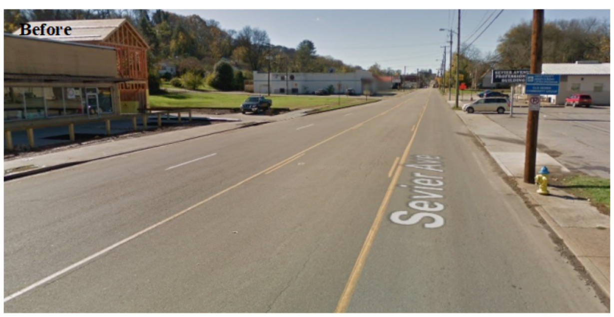
- Creating a base for further development.
- Economic and aesthetic development of the corridor.
- Establish a place for bike so it won't be taken in further development.

Problems

- Higher travel speed.
- Lack of bicycle connectivity outside the corridor.

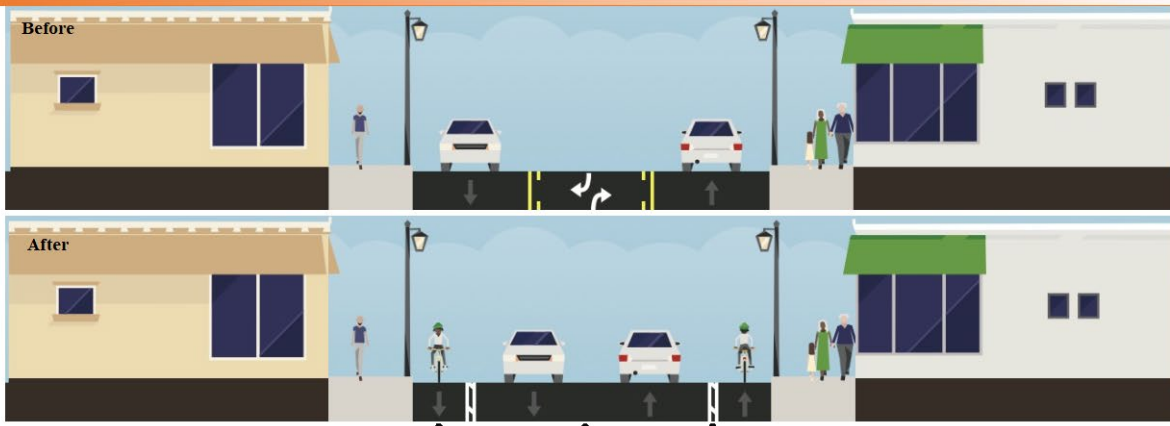
Interventions

A. Central turn lane was removed.
B. Two-way bike lane were introduced.
C. Buffer was provided between bike lane travel lane for rider's safety.



Knoxville, TN

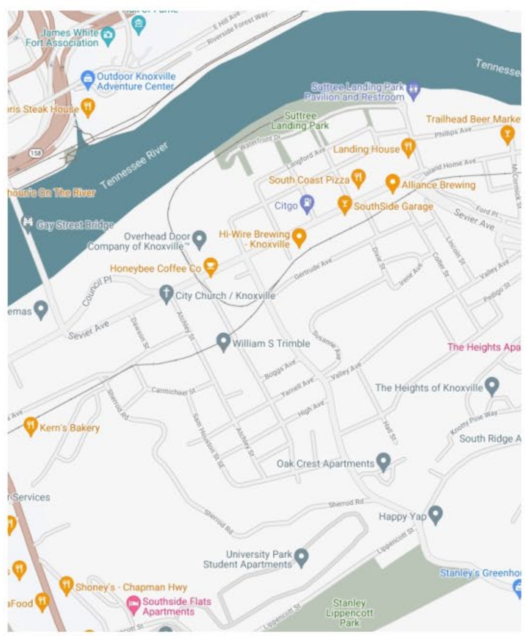
Sevier Avenue



1. Two-way bike lane established the space for bicyclist in the street.

2. Removed center turn lane to accommodate bike lane has helped in reducing the through traffic speed.

3. Buffer is provided for rider's safety.



Knoxville, TN

Sevier Avenue

Result	Challenges
➢ Aesthetic of the corridor id more pedestrian friendly. ➢ The project has helped to drive business along the corridor. ➢ Speed of vehicles has decreased.	➢ Defending the loss of left turn lanes for bike lane. ➢ Assurance of street parking at certain section. ➢ Establishing bike connectivity in ad out the treated corridor.

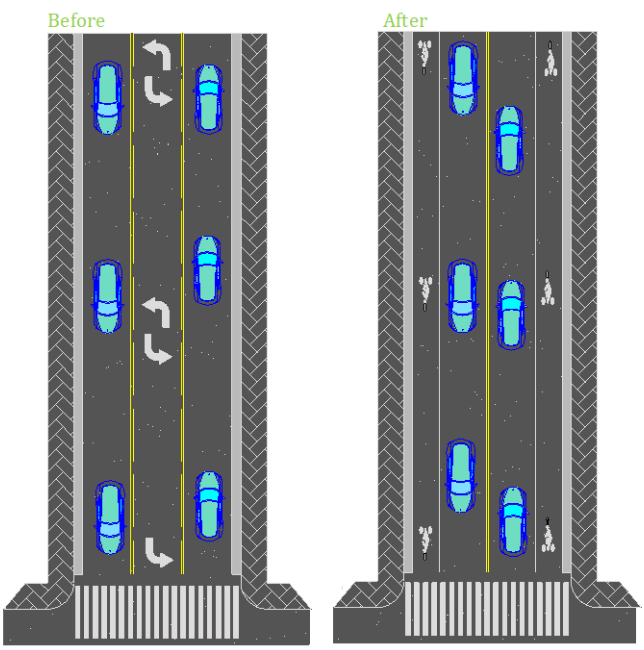
Takeaways

- **Safe and attractive for all users**

  Reduced crossing length and the reduced vehicular speed achieved by converting an existing four-lane undivided highway to a two through lanes and a center turn lane. This conversion allowed the left turning vehicle to exit the traffic stream while waiting for the gap to complete their turn which made up space for other users.

- **Bike lane for future development.**

  The project was the center for few planned development project and secured bike lane for the future use,



Street Classification:
Collector

Right of Way:
61 feet

Length:
0.8 Miles

Construction Period:
12 Months

Speed:

Before **After**

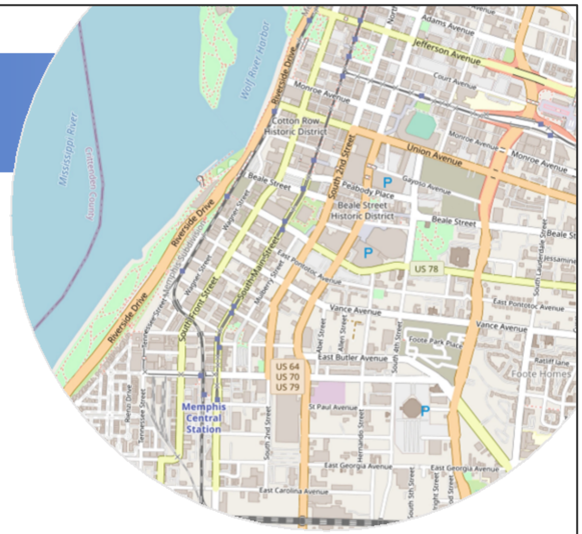
Responsible Agency:
City of Knoxville

Memphis, Tennessee

1. **Riverside Drive** (22-24)
2. **South Manassas Street** (25-27)
3. **Madison Street** (28-30)
4. **Hampline Street** (31 -33)

Memphis, TN

Riverside Drive



Context

- Riverside drive functioned much like a highway moving four lane traffic speedily through downtown creating a high-speed barrier that discourages pedestrian and cyclist activities and easy river access.
- Instead of re opening all four lanes to auto traffic after Riverside's annual closure for the Memphis in May Festival, the city opted to pilot project for 12 months.
- The pilot road intervention project helped people envision the re-purposing of available travel lane which converted a four-lane vehicular traffic to two lane devoting additional space to bike and pedestrian activities.

Objectives

- Improve aesthetics.
- Safter environment for bike and pedestrians.
- Improve walkability.
- Support active and healthy activities .

Problems

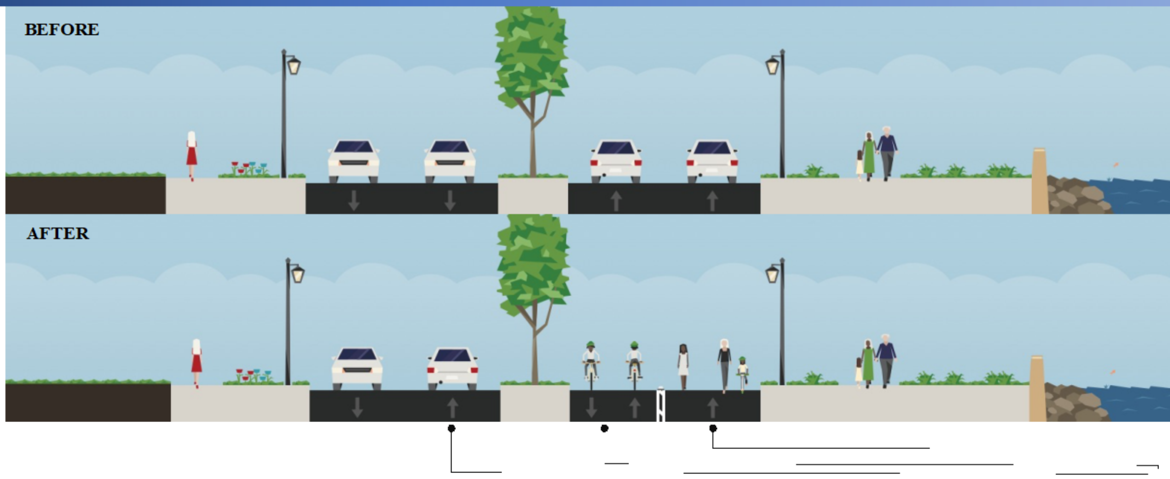
- Convincing authorities reading the pilot project with reduced lane.
- Limited curb width made it impossible of any new constructions and interventions.

Interventions

A. Pedestrian walkway
B. Two-way bike lane.
C. Reduced travel lane.

Memphis, TN

Riverside Drive



1. Replaced two-way travel lane to one way each direction

2. Replace a travel lane into space for pedestrian and cyclist with two-way cycle track.

3. Allocated the extra travel line for pedestrian path expanding the purpose of street.

Memphis, TN

Riverside Drive

Result	Challenges
➢ Safer bike lane encouraged riders. ➢ Wider sidewalks invited many people to the street. ➢ Shorter and safter street crosswalks. ➢ Incorporation of people's opinion in larger scale.	➢ Convincing travelers about loss of left turn lanes. ➢ Assurance of street parking for the visitors of park.

Takeaways

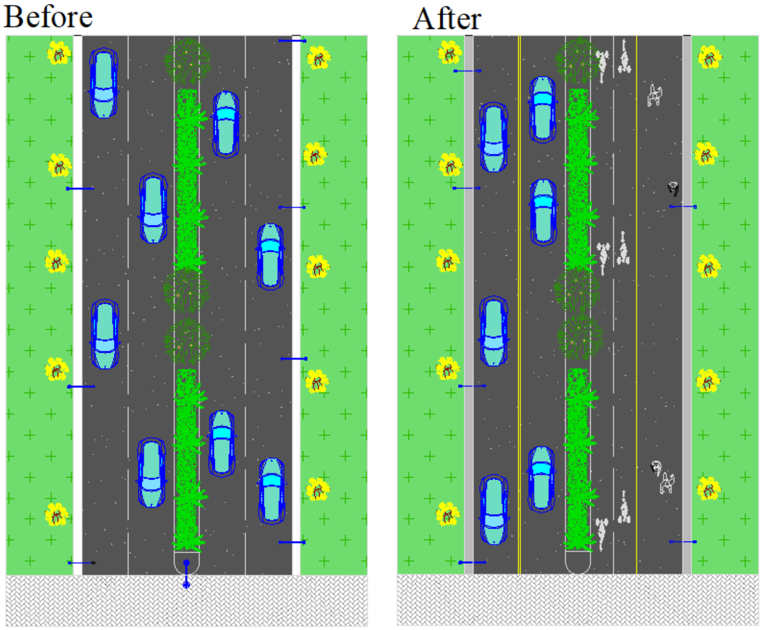
➢ **Maintained capacity with reduced speed.**

Traffic volume remained same during the pilot period. Traffic speed reduced slightly compared to the measured before the pilot project. But most of the traffic remained well above posted limit.

➢ **Multimodal use of street made it safer.**

Reported crash incident were higher during the pilot period, but the type of the crash and the severity was greatly reduced. Bicycle use through corridor dramatically increased as a result of available on street parking and separated bicycle lane, but the pedestrian use of the space was limited and underused.

Before After



Riverside Drive

Street Classification:
Arterial

Right of Way:
70 Feet

Length:
1.2 Miles

Construction Period:
12 Months

Speed:

Before **After**

Responsible Agency:
City of Memphis

Memphis, TN

South Manassas Street

Context

- The intervention project was the partnership between City Hall and the Memphis Medical Collaborative to create a safer street for all user by encouraging active transportation.
- The project reduced the roadway from five lanes to three lanes with added dedicated buffered bike lanes to connect existing and future bicycle routes in city.
- Added pedestrian bumps outs and newly designed crosswalks provided additional visual cues to reduce vehicle speed, reduce time and distance to cross the street.
- The Memphis medical district is also an area adjacent to downtown which seeks to create safer multimodal roadway that gives pedestrian and cyclist equal access.

Objectives

- Improve aesthetics.
- Safter environment for bike and pedestrians.
- Improve walkability.
- Support active and healthy activities .
- Encourage mix use and multifamily residential development.

Problems

- Defending loss of travel lane to local business owners.

Interventions

A. Bike lane
B. On street Parking
C. Pedestrian bump outs
D. Concrete traffic domes.

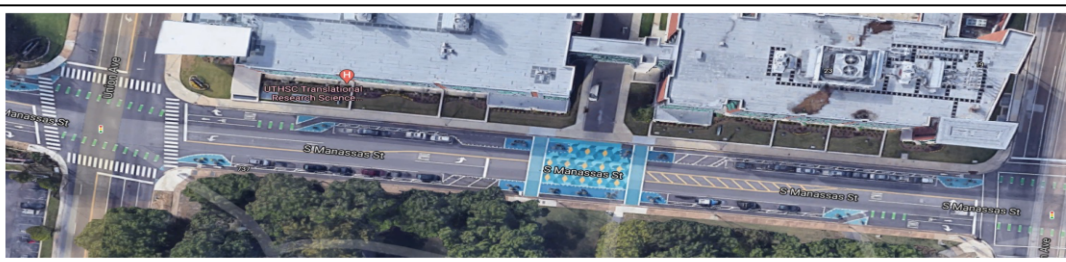
Memphis, TN

Manassas Drive

1. Replaced two-way travel lane to one way each direction to accommodate other infrastructure.

2. Protected bike lane created safer space for bike riders while encouraging other to join.

3. Pedestrians were provided right of the way at different intersection and crossing encouraged people to choose active mode of transportation.



Memphis, TN

Manassas Drive

Results	Challenges
➢ Slower vehicle speed. ➢ Highly aesthetic and walkable street. ➢ Increased foot and bike traffic. ➢ Established and extend bike connectivity.	➢ Some argue street art is distracting for drivers. ➢ Local business owner were worried about losing parking and loading zone.

Takeaways

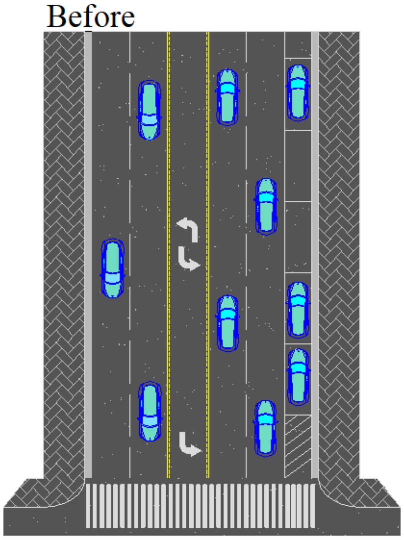
- **Unorthodox design idea can be effective.**

  With innovative prospect unique, economically viable and aesthetically pleasant ideas can be very effective. Project implemented street arts as well as use of bright blue color attracted interest of many people.

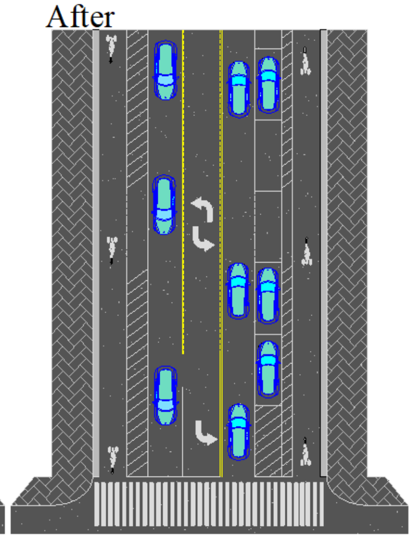
- Infrastructure developed with connectivity to existing infrastructure.

  Seamless connection for bike lane between downtown and Medical District and Midtown, Memphis is behind the success story and acceptance of such intervention project. .

Before



After



Manassas Street

Street Classification:
Arterial

Right of Way:
80 Feet

Length:
0.7 Miles

Construction Period:
9 Months

Speed:

Before

After

Responsible Agency:
MMDC and the city of Memphis

Memphis, TN

Madison Street

Features

- The road diet at Madison altered the two automobile lanes in each direction to a one automobile, one bike and parking/loading zone in each direction along with a center turn lane.
- The road diet transformed a dull speeding corridor into a vibrant, lively public space and mostly walkable and bikeable space.
- Several properties along the corridor have seen drastic improvements, a handful of new business have opened and quite a few more started constructing.
- The road diet project was planned to increase operating capacity from 35 to 40 percent and design capacity by 45 to 50 percent.

Objectives

- Improve aesthetics.
- Safer street for everyone.
- Enhance economic viability.
- Preserve parking and loading zones.

Problems

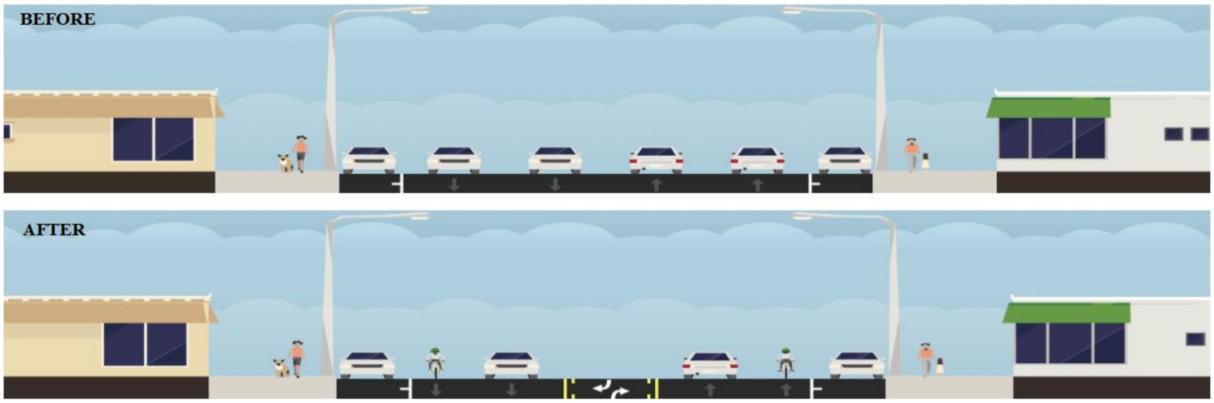
- Taking way travel lane.
- Convincing merchants benefits of bike lane.

Interventions

A. Reduced travel lane,
B. New bike lane
C. On street parking.
D. Center turn lane.

Memphis, TN

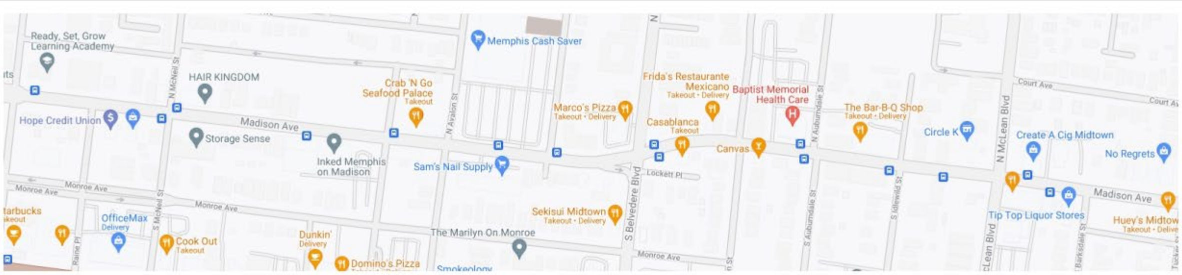
Madison Drive



1. Replacing a travel lane into two-way cycle track.

2. Introduction of center turn lane.

3. Replacing two-way travel lane to one way each direction.



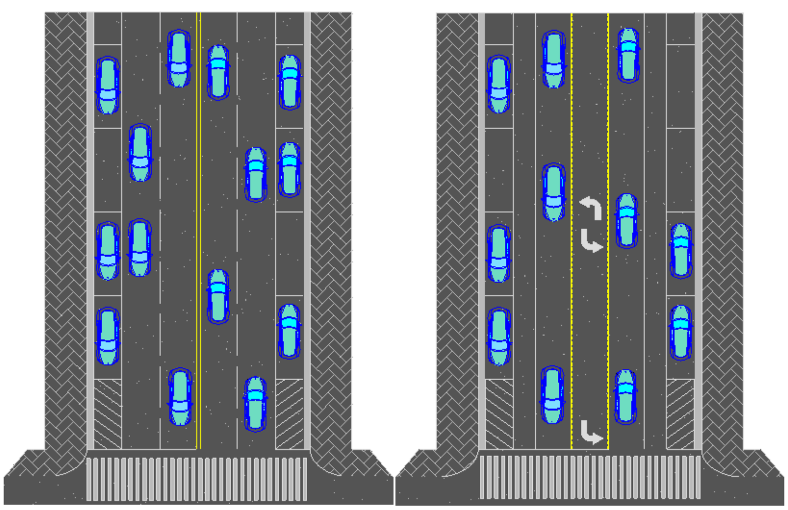
Memphis, TN

Madison Drive

Result	Challenges
➢ Increase in ridership. ➢ Safer street. ➢ Extended bike network. ➢ Improve in business and property value.	➢ Convincing merchants along the street regarding the benefits of bike lane. ➢ Taking away travel lane on each direction.

Takeaways

The calm environment created more interest in restaurants and business along the corridor.
Bike lane encouraged and enhanced the economic viability of Madison Avenue.
The capacity did increase after the road diet, but the increase was insignificant due to the center turn lane alleviated the backing traffic pressure.



Madison Street

Street Classification:
Arterial

Right of Way:
74 Feet

Length:
1.6 Miles

Construction Period:
9 Months

Speed:

Before **After**

Responsible Agency:
City of Memphis

Memphis, TN

Hampline Street

Features

- The hampline park to park connector provides a major connection in the growing Memphis greenway and bikeway network and is one of the key gaps connecting a major regional park with downtown.
- The 2-mile-long corridor provides a high-level bicycle connection through an economically distressed neighborhoods along with different public arts murals and sculptures.
- The project features the Memphis's first bicycle specific traffic signal.
- The street segment also features raised median separating a two-way cycle track from motor vehicles, enhanced on street pedestrian crossing.
- The project was upgraded for compliance with Americans with Disability Act.

Objectives

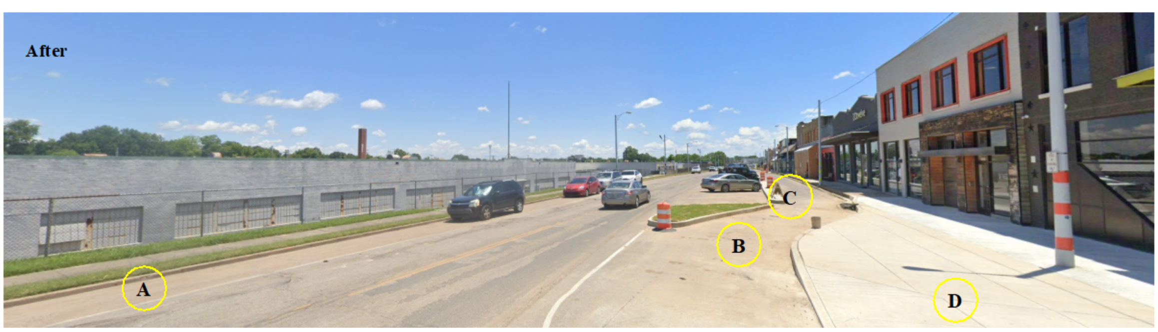
- Improve aesthetics.
- Safer street for everyone.
- Commercial appeal.
- Park to Park bike connectivity.

Problems

- Convincing merchants benefits of bike lane.
- Inconvenience for costumers to pickup their products.

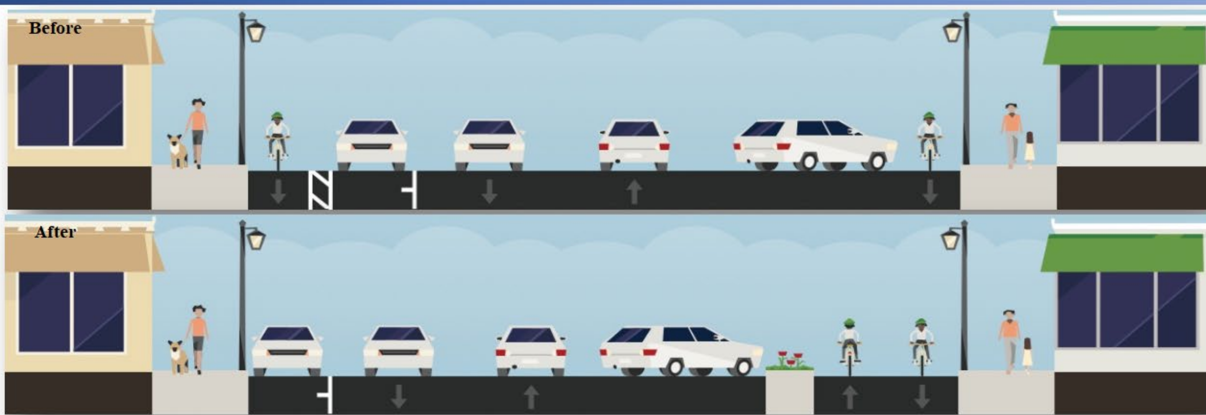
Interventions

A. On street parking on one side of street.
B. Angular parking on the street side with business.
C. Buffer separated two-way bike lane.
D. Improved streets and pedestrian facilities.



Memphis, TN

Hampline Street



1. Removed far end bike lane replaced with on street parking.

2. Buffer between two-way bike lane and parking.

2. One way cycle lane was expanded into two lane.

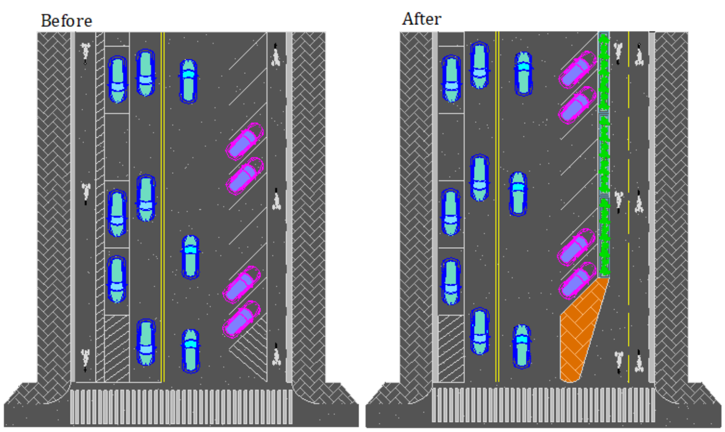
3. Extra space were allocated for pedestrian..

Memphis, TN

Hampline Street

Result	Challenges
➢ Connected greenway. ➢ Increased in amount of ridership. ➢ Slower and safer traffic.	➢ Convincing merchants along the street regarding the benefits of bike lane. ➢ Taking away travel lane on each direction.

Takeaways



Hampline Street

Street Classification:
Collectors

Right of Way:
75 Feet

Length:
1.7 Miles

Construction Period:
9 Months

Speed:

Before **After**

Responsible Agency:
City of Memphis / Public funded

Chattanooga, Tennessee

Chattanooga, TN

Broad Street

Context

- The road diet transformed a six-lane street with a median to a four lane with one curb protected bike lane in each direction with an expectation of increase in sidewalk and street activities as well as improve downtown retail business.
- New separated and buffered bike lane in what formerly the parking lane, between the sidewalk and on street parking.
- Even with the reduction in travel lane the capacity of the street did not decrease.
- This was the first protected bike lane in the city with intense initial investment hoping to guide Chattanooga towards complete street.

Objectives

- Improve aesthetics.
- Safer street for everyone.
- Improve business along the corridor.

Problems

- Business owner were concerned over the lack of delivery and pickup truck parking space.
- Protected bike induced confusion among drivers.

Interventions

A. Buffer protected bike lane on each direction.
B. On street parking space allocated on both side of street.
C. Reduced travel lane.

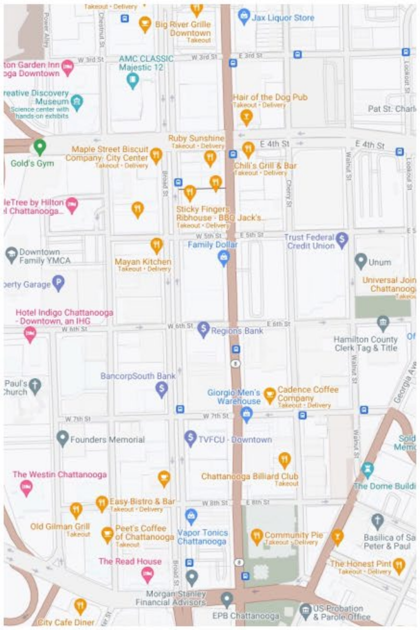
Chattanooga, TN

Broad Street

1. Reduced travel lane provided space for bike lane without reducing the capacity of street.

2. On street parking ask as space for parking as well as acted as extra buffer for pedestrians and bike lane.

3. Buffered bike lane adjacent to pedestrian facility boosted the confidence and encouraged people to ride bikes.



Chattanooga, TN

Broad Street

Result	Challenges
➢ Capacity remained same even after lane reduction. ➢ Increased cycling and foot traffic in downtown. ➢ Reduced travel lane decreased travel speed.	➢ Business concerned over loosing their business. ➢ Bike lane been a source of confusion among drivers. ➢ Managing delivery trucks parking.

Takeaways

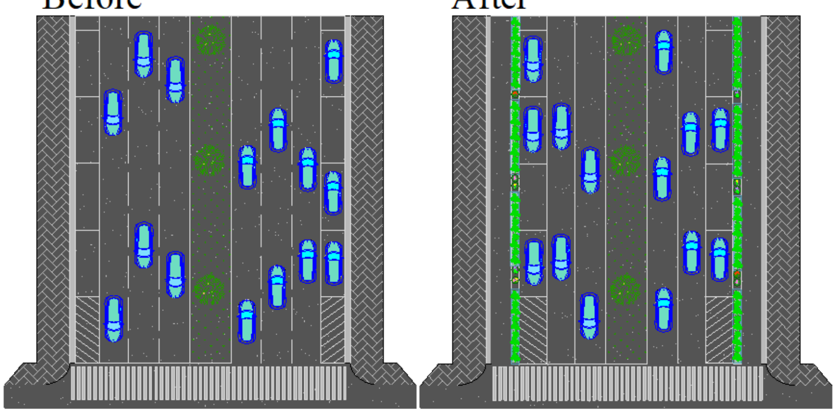
- **Safe and attractive for all users**

  Reduced travel lane help lower vehicle travel speed and need added curb and parking protected bike lane pedestrian pathway created an environment for suitable for all users. The

- **Building neighborhood vitality**

  Street developed a calming environment and helped to promote active mode of transportation with out affecting the before vehicle capacity.

Before After



Broad Street

Street Classification:
Arterial

Right of Way:
102Feet

Length:
0.6 Miles

Construction Period:
9 Months

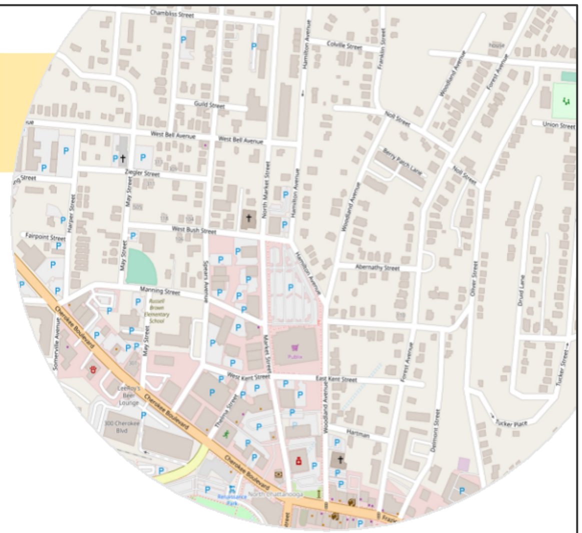
Speed:

Before **After**

Responsible Agency:
City of Chattanooga

Chattanooga, TN

N Market Street / Dallas Road



Context

- The 1.2 miles corridor from Cherokee Blvd to Mississippi Avenue has 3 different configuration of road intervention depending upon the neighborhood need and available right of the way.
- Mostly 4 lane undivided corridor was transformed into one travel and bike lane each direction with center turn lane and on street parking on one side.
- North market street section of the project was accomplished as a part of resurfacing.
- Reduction of T-bone crashes from people pulling out of parking lot was expected benefits.

Objectives

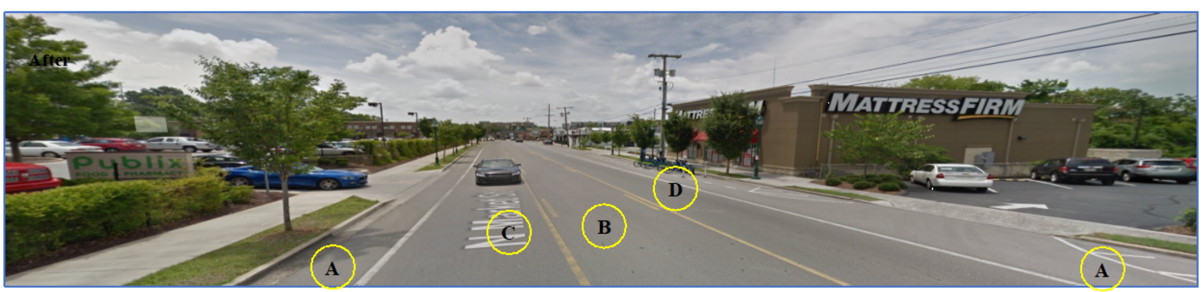
- Traffic calming.
- Enhance local economy.
- Reduce T-bone crashes (Safer street).

Problems

- Different right of the way required different design.
- Taking away travel lane for center turn lane.

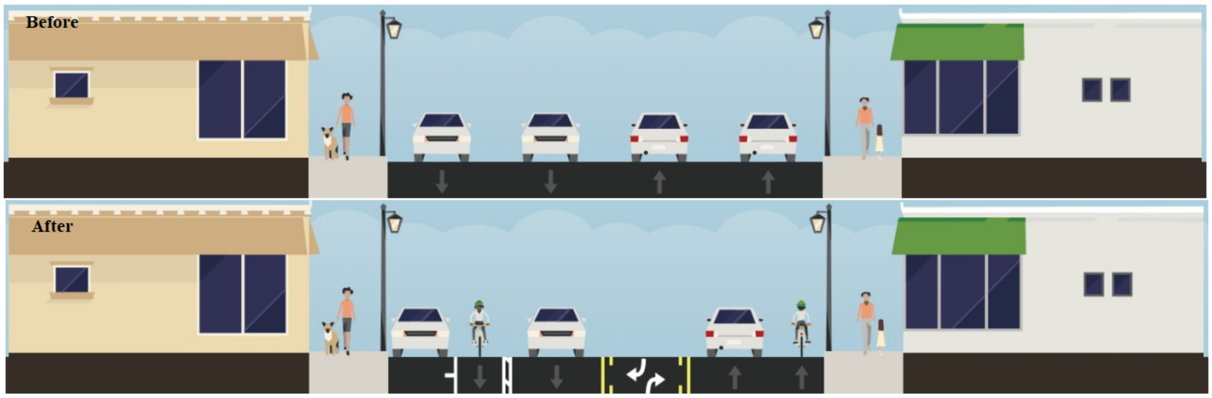
Interventions

A. Bike lane.
B. Center turn lane.
C. Reduced travel lane.
D. Bike stand.

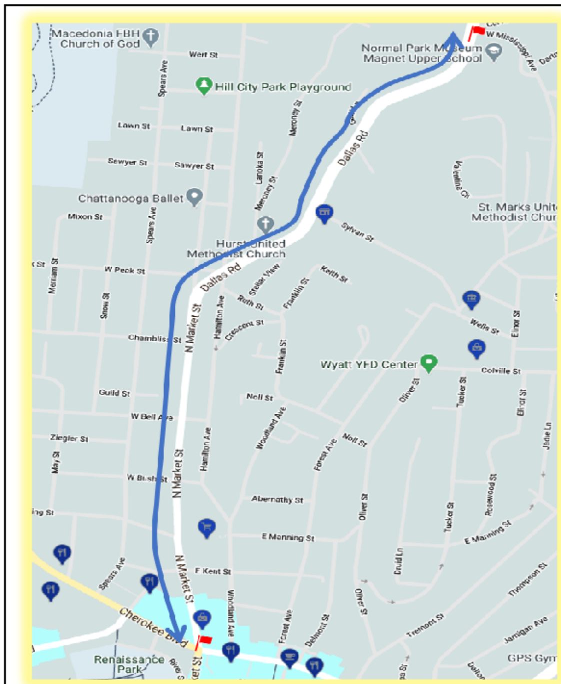


Chattanooga, TN

N Market Street / Dallas Road



1. Replaced two-way travel lane to one way each direction (at different sections)
2. Replaced a travel lane into two-way cycle track and a center turn lane.
3. Allocating the extra space to pedestrian path.



Chattanooga, TN

N Market Street / Dallas Road

Result	Challenges
➢ Reduced in travel speed along the corridor ➢ Reduced parking existing T-bone crashes. ➢ Introduction of different new business along the corridor.	➢ Confusion in bike lane transition through different section due to different configuration. ➢ Steep slope along the corridor discourages the bike lane use. ➢ Convincing locals regarding travel lane reduction.

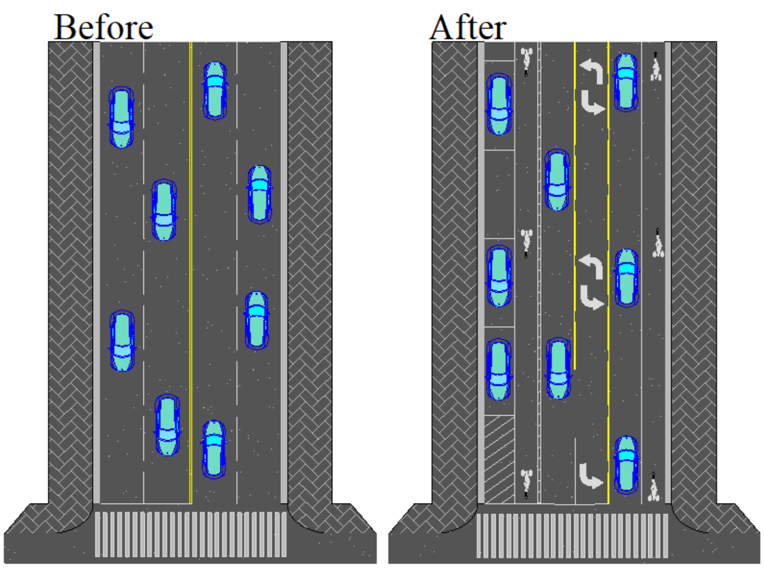
Takeaways

➢ **Safe and attractive for all users**

Road reconfiguration made it safe for vehicle entering and existing parking. Similarly, addition of bike lane and extended pedestrian pathway enhanced foot traffic in local business.

➢ **Building neighborhood vitality**

Addition of on street parking and bike lane transformed the image of the corridor. New business were introduced. Owners were enthusiast about increased foot traffic.



N Market Street/ Dallas Road

Street Classification:
Arterial

Right of Way:
Varying

Length:
1.2 Miles

Construction Period:
X Months

Speed:

Before After

Responsible Agency:
Chattanooga DOT

Chattanooga, TN

Station Street

Context

- Station street, formally an alleyway, was renovated to become pedestrian friendly space provided with patio assess to restaurants.
- Backdoor service alley has been transformed into a commercial corridor with restaurants, music venues, bars, and comedy station.
- Originally stormwater management project transformed mostly avoided section into a successful complete street resolving all existing issues.
- Station street has been the 11th street nationwide to allow on street alcohol consumption.

Objectives

- Strome water management.
- Economic development.
- Corridor transformation.
- Mixed used street transformation.

Problems

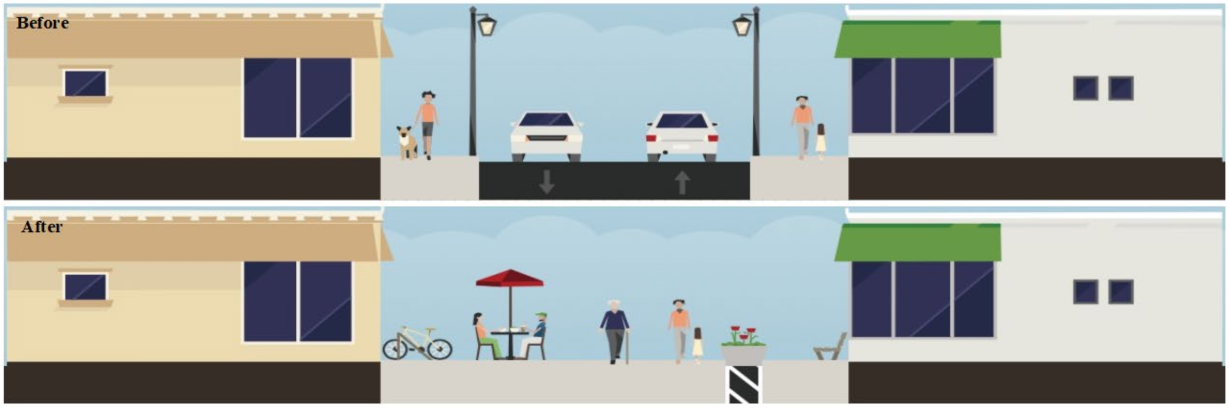
- Designing a one of its kind street encountered different unknowns.

Interventions

A. Multi model space.
B. Furnitures in front of stores.
C. Plant.
D. Strome water drainage.

Chattanooga, TN

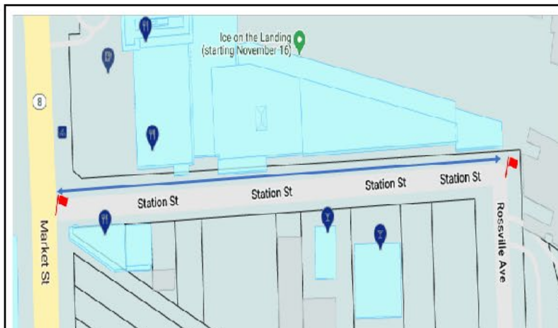
Station Street



1. Replaced two-way travel lane to one way each direction with a mixed traffic environment.

2. Infrastructure such as cycle racks, benches and patio enhanced the desirability for all user types.

3. Pedestrian were provided with the right of the way.



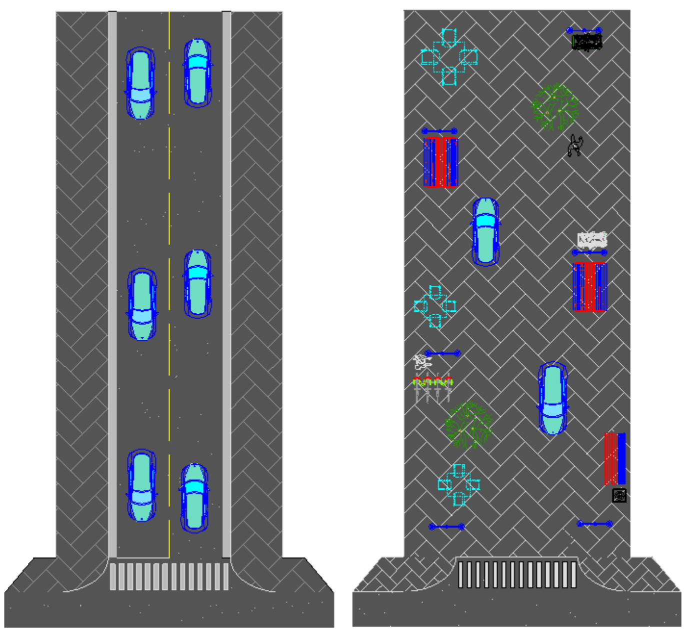
Chattanooga, TN

Station Street

Result	Challenges
➢ Economic Development of a back alley. ➢ Usually avoided street transformed into go to location. ➢ Strome water issue resolved.	➢ Extra design, planning and work than the original plan. ➢ Different unknows during and after construction being one of its kind design.

Takeaways

- **Safe and attractive for all users.**
- **Road transformation for neighborhood vitality.**



Station Street

Street Classification:
Alley Way

Right of Way:
Varying

Length:
0.1 Miles

Construction Period:
X Months

Speed:

Before **After**

Responsible Agency:
Chattanooga DOT and Local businesses