Route 12 & 31 Intersection Design: Fitchburg, Massachusetts

A Major Qualifying Project Submitted to the Faculty of Worcester Polytechnic Institute in Partial Fulfillment of the requirements for the Bachelor of Science Degree

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Abstract

An intersection located in Fitchburg, Massachusetts has experienced a high number of crashes recently. To address the current and foreseeable issues, a short-term and long-term design was provided to the Montachusett Regional Planning Commission. A geometric improvement on Westminster Street was selected as the short-term recommendation along with the addition of a traffic signal to the intersection as the long-term recommendation. ATR counts, manual turning movement counts, and speed studies were conducted. In addition, a level-of-service analysis and a signal warrant analysis were done. The team met with multiple agencies including Montachusett Regional Planning Commission, MassDOT, and the Public Works Department for Fitchburg to gain additional insight on the intersection.

Executive Summary

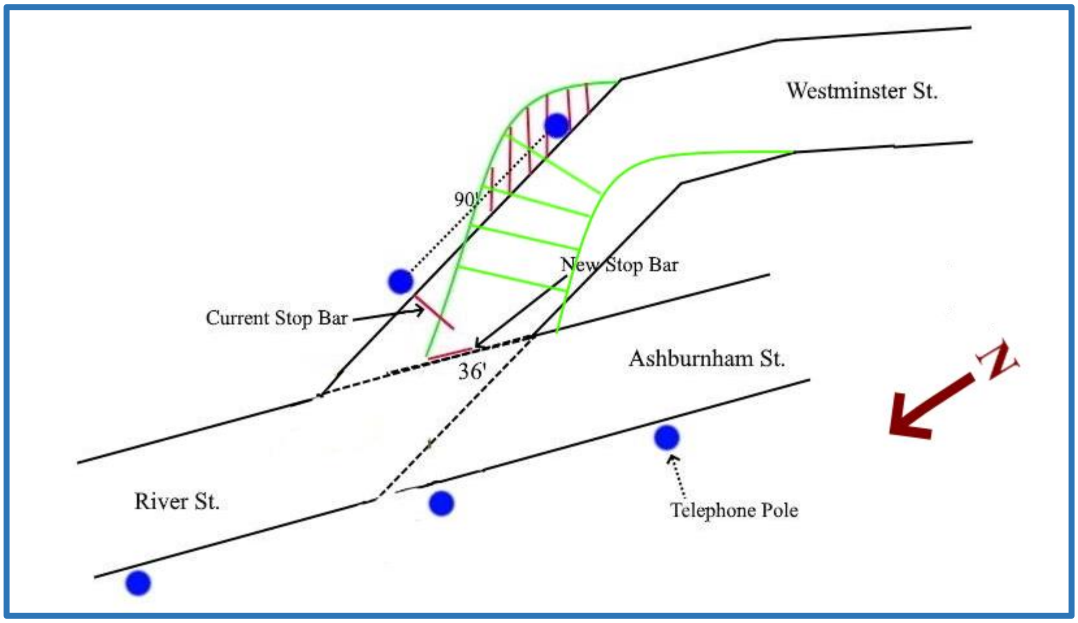
A problematic intersection located in Fitchburg, Massachusetts between Route 12 (Ashburnham and River Street) and Route 31 (Westminster Street) has previously been investigated by the Montachusett Regional Planning Commission and the Massachusetts Department of Transportation. This is a three-way intersection with a one-way controlled stop. There is limited sight distance as well as high vehicle speeds resulting in a large number of rear-end crashes on Route 31 (Westminster Street). The goal for this Master Qualifying Project (MQP) was to improve the functionality of the intersection while prioritizing the safety of everyday residents. To successfully meet the project goal, the following objectives were met:

1) Understand Intersection Improvement Methods
2) Collect & Analyze Data
3) Develop Intersection Redesign Alternatives
4) Apply Evaluation Criteria to Design Recommendations

The team was able to develop four different preliminary designs which were evaluated using the transportation evaluation criteria, established by MassDOT, that the Montachusett Regional Planning Commission uses to evaluate various projects. Other criteria include level-of-service analysis, and engineering and public opinion to evaluate the following designs: an island, a Route 31 bump out, a Route 31 bump out with a signal, and a signal by itself. The bump out options aim to improve the alignment of the intersection by changing the angle at which the minor street connects into the major streets. It currently connects at an obtuse angle where the goal of the alignment is to create a perpendicular angle.

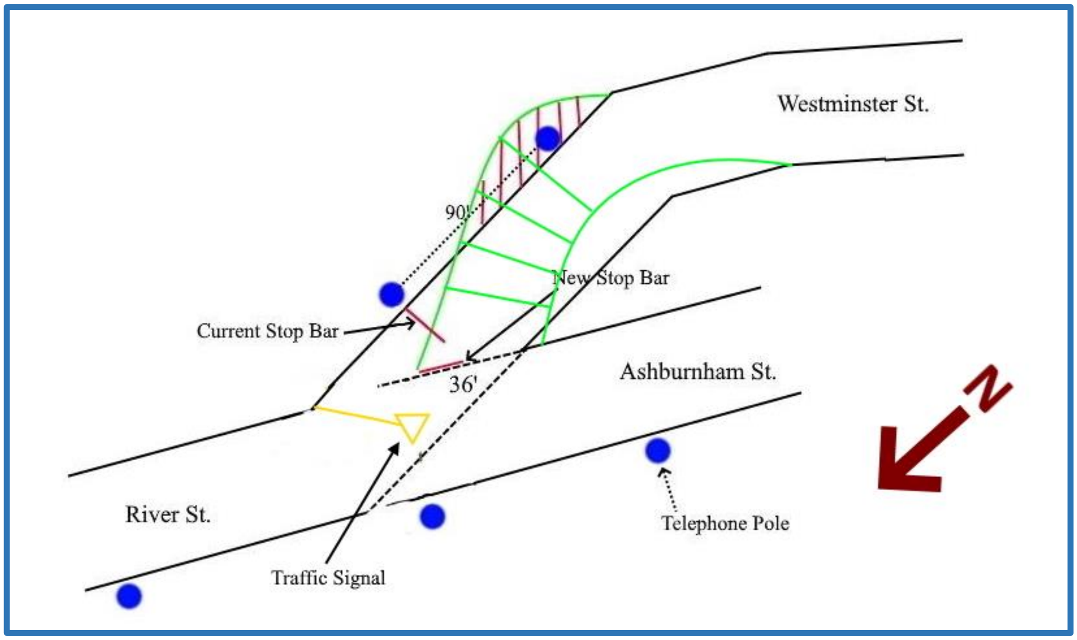
The final design recommendation was to implement the Route 31 Bump Out for the short term supplemented with a signal as a long-term solution. The figure below shows both the short-term solution, the Route 21 Bump Out, and the long-term solution, the signal. This solution heavily prioritizes the safety of individuals as it will reduce the high number of crashes that currently occur at the intersection. This signal is to be installed in approximately 10+ years as this is the estimated amount of time until the intersection will receive a failing level-of-service based on the team’s analysis. The team’s analysis concluded that a signal is currently warranted at the intersection however it will require years of paperwork, funding, and approval.

Short-Term Recommendation



Route 31 Bump Out Design w/ Moving Utility Pole

Long-Term Recommendation



Route 31 Bump Out Design w/ Moving Utility Pole and Signalization

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Capstone Design Statement

Worcester Polytechnic Institute requires that all capstone design projects meet ABET (Accreditation Board for Engineering and Technology) standards. At WPI the Major Qualifying Projects (MQP) provide assurance that the students demonstrate design knowledge related to their given major. This MQP involved a design investigation of a three-way intersection located in Fitchburg Massachusetts. This intersection consists of two Massachusetts state routes, Route 12 (Ashburnham and River Street) and Route 31 (Westminster Street). Route 31 (Westminster Street) is currently a stop-controlled approach while Route 12 (Ashburnham and River Street) has continuous traffic in both directions. The team collected data in order to do various analyses of the intersection including a level-of-service analysis, signal warrant analysis, and a crash analysis. The team was able to come up with four preliminary designs based upon the data collected. These designs were evaluated based upon different criteria such as community opinion, engineering opinion, level-of-service, and TEC (Transportation Evaluation Criteria) scoring sheets. The following constraints were used based upon the following categories: *Health & Safety*, *Economical*, *Environmental*, *Social*, *Political and Ethical Effects*, *Constructability*, *Sustainability*.

Health & Safety: The health & safety parameter evaluates the overall intersection in regard to the priority of the crash location. The region consists of Montachusett Regional Planning Commission's region which is generally central Massachusetts. This project accounted for crash rate, crash severity, and pedestrian safety by selecting a final recommendation that would decrease these constraints the most. Each design was scored in order to select the final recommendation and the health and safety of the community was considered in all four scoring elements. The Transportation Evaluation Criteria scoring awarded points to designs that will decrease crash rate and severity. Subject matter experts also selected a design they think would fit the intersection considering the health and safety of the area along with other characteristics. Next, the public opinion was considered in order to account for their opinion regarding if each design would improve the intersection with the end goal of improving health and safety of the area. These were taken into account by awarding points to each design based upon the feedback from the public and experts. Lastly, the level of service analysis determined how safe the intersection will be in the future. If the analysis indicated an increase in level of service, the design was awarded a point. The design with the most points was selected as one of our final recommendations. Specifically, our recommendation includes a geometric change which is aimed to fix the sight distance issue at the intersection.

Economic Effects: This parameter was considered during the Transportation Evaluation Criteria (TEC) scores in the fourth objective to evaluate each design. The more the project focuses on local businesses in the area through general access, noise and aesthetics, traffic flow, and freight access, the more points in the project are awarded. Another consideration for the score is access to emergency facilities is also considered for the land use and economic development parameter. This project prioritized recommending designs that have the largest combined evaluation score. Additionally, cost was considered comparatively for each design to determine the most expensive one. For each design, different logistic options were included in order to understand how these details could add to or minimize the total cost. The economic effect of the project on local business was the main parameter scored as the total cost of the project was considered but not heavily weighed.

Environmental Effects: By creating a level of service analysis, the team was able to determine that the recommended design improvement would decrease the idling and buildup of traffic. The decrease of idling and traffic will result in better air quality of the area and decrease the amount of greenhouse gases being continually emitted. In addition, the Transportation Evaluation Criteria scoring of the design scoring awards points for projects that increase air quality and climate standards while decreasing greenhouse gases. These scores were added up and the design with the highest score was selected.

Social Effects: The goal of this project was to design improvements to benefit the community of Fitchburg, without negatively affecting the local businesses and residences nearby. The team determined the most economic and effective solution to improve the travel of the public.

Political Effects: Over the completion of the project, the team collaborated with local engineers, city and region officials, employees of MassDOT, and the City of Fitchburg. The team presented design improvements and feedback was then applied to better benefit the city.

Ethical Effects: The team represented WPI professionally. The team worked with proper conduct and complied to all of the American Society of Civil Engineers (ASCE) Code of Ethics. Following the Code of Ethics is essential in maintaining safety and welfare of the general public.

Constructability: This parameter reviews the process for each preliminary design in the pre-construction phase evaluating the efficiency of each design in order to prevent additional costs and delays within the construction process. In the subject matter expert discussion, the designs with a high constructability were specifically called out as beneficial. The designs that were called out for this reason were scored higher in the “Subject Matter Expert Opinion” section of design scoring. Therefore, designs with higher constructability were prioritized. Since the team provided a short- and long-term recommendation, it was essential that these were constructable together. This was a major influence in the recommendation to supplement the Route 31 Bump Out with a signal - the signal will be easily constructed after the geometric change.

Sustainability: The sustainability parameter evaluates each preliminary design and will be able to meet the needs of the general public. This was done by testing the level-of-service to see how long a design would be able fulfill the needs of the general public.

Professional Licensure Statement

Professional engineers are given a task to safeguard the health, safety and welfare of the public's wants and needs. The National Council of Examiners for Engineering and Surveying (NCEES) have developed a list of requirements in order to become a professional engineer (PE). The following requirements that must be satisfied are listed below:

1) Earn a four-year degree in engineering from an accredited engineering program
2) Pass the Fundamentals of Engineering (FE) exam
3) Complete four years of progressive engineering experience under a PE
4) Pass the Principles and Practices of Engineering (PE) exam

Individual states may have varying requirements in order to obtain a professional engineering license. Additional information can be found through the NCEES website for other criteria for specific states (Welcome to NCEES, 2021).

After passing the PE exam, a professional engineer is able to produce and stamp plans for projects. A professional engineering certification depicts the value of the engineer’s work experience and the value they can bring to a company. This license shows an employer that the PE has proper experience and ethical standards to lead a given project. On top of this, a Professional Engineer is able to make large scale decisions regarding a project, system, or mechanism. Not only does this ensure that future projects are structurally stable and safe, but that they benefit society with their products, services, or functions. With the need for Professional Engineers, society is able to trust that their future is in the hands of people who understand how their actions affect the health, safety, and welfare of those around them.

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1 Introduction

The Montachusett Regional Planning Commission (MRPC) identified a problematic intersection located in Fitchburg, Massachusetts between Route 12 (Ashburnham and River Street) and Route 31 (Westminster Street) that has experienced a high crash rate over the last three years. This three-way intersection has an ill-positioned stop sign on Route 31 (Westminster Street), which has contributed to the high number of crashes. According to the Massachusetts Department of Transportation (MassDOT), there have been approximately 49 recorded crashes at this location between the years 2017 and 2019, of which 28 were reported as rear-end crashes. The speed limit is 25 MPH on Route 12 (Ashburnham and River Street) in the southbound direction, 20 MPH in the northbound direction, and 25 MPH on Route 31 (Westminster Street) approaching the stop sign. A dangerous intersection sign is in the southbound direction on Route 12 (Ashburnham and River Street). Directional state route signs are present in all three directions at the intersection. A street view from Ashburnham Street facing River Street is depicted in *Figure 1*.

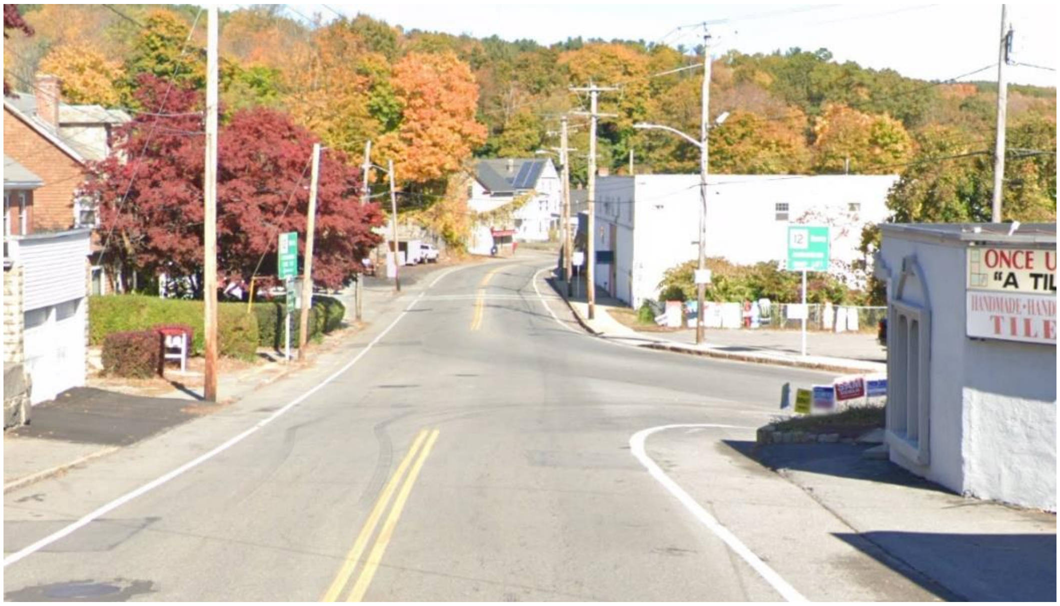


Figure 1: Street view of Route 12 (Ashburnham and River St.) and Route 31 (Westminster St.) in Fitchburg, Massachusetts.

The goal for this Master Qualifying Project (MQP) was to improve the functionality of the intersection while prioritizing the safety of everyday residents. To successfully meet the project goal, the following objectives were completed:

1) Understand Intersection Improvement Methods
2) Collect & Analyze Data
3) Develop Intersection Redesign Alternatives
4) Apply Evaluation Criteria to Design Recommendation(s)

2 Background

This chapter entails an overview of the problem and the general approaches taken by traffic engineers to improve or upgrade an intersection. These include roundabouts, signalization, and speed reducing methods. Public opinion is emphasized throughout this chapter as community opinion plays a major role in the decision-making process of a public project.

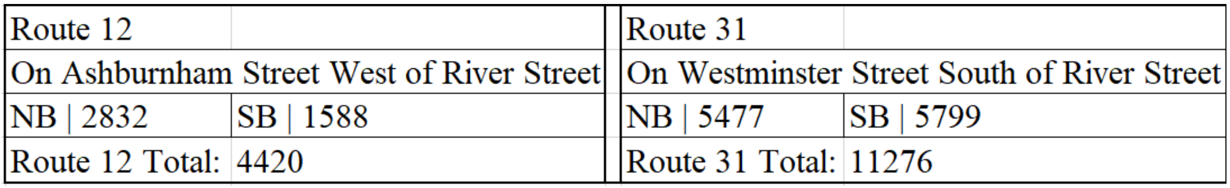
2.1 Route 12 & Route 31 Overview

The City of Fitchburg, Massachusetts is estimated to have a population of 40,000 covering an area of approximately 28 square miles. Route 12 (Ashburnham and River Street) (River and Ashburnham St.) and Route 31 (Westminster St.) are two state routes that intersect in Fitchburg at a three-way interaction. Route 12 (Ashburnham and River Street) and 31 both travel in the northbound/southbound directions. At this intersection Route 31 (Westminster Street) is also shared with state Route 2A. *Figure 2* provides a visual description of the intersection from an aerial view. Route 12 (Ashburnham and River Street) is highlighted in red, while Route 31 (Westminster Street) is highlighted in blue.

Figure 2: Aerial view of intersection between River and Ashburnham St. (Route 12) and Westminster Street (Route 31).

2.2 Pre-Existing Data

This intersection historically experienced a large number of crashes, specifically rear-end crashes. According to the Massachusetts Department of Transportation, (MassDOT) there have been approximately 49 recorded crashes at this location between the years 2017 and 2019. Of the 49, 28 were reported as rear-end crashes (MassDOT, 2020). Pre-existing traffic counts were found from MassDOT for each street and approach. *Table 1* indicates the annual average daily traffic collected from the year 2020.



Route 12	
On Ashburnham Street West of River Street	
NB | 2832	SB | 1588
Route 12 Total:	4420

Route 31	
On Westminster Street South of River Street	
NB | 5477	SB | 5799
Route 31 Total:	11276

Table 1: Annual Average Daily Traffic (MassDOT, 2020)

2.3 Three Way Intersections

Research was conducted to gain familiarity with three-way intersections to study the different features and unique aspects of a three-way intersection.

2.3.1 Advantages and Disadvantages of Three-Way Intersection

Three-way intersections are accompanied by a few advantages. First, they serve as a simple way to connect side streets to main roads. This integration can improve the overall usability of the highway system, allowing drivers to arrive at their destination in a shorter amount of time. Next, the cost of operating an unsignalized three-way intersection is relatively inexpensive. The lack of amenities and infrastructure result in little construction and operating cost.

However, these intersections have multiple disadvantages that coincide with the nature of the design. In the case of

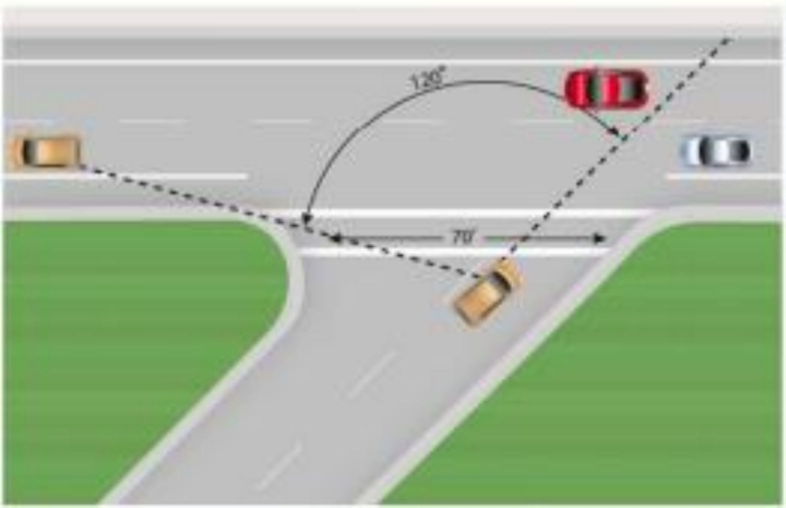


Figure 3: Example of a skewed intersection with the obtuse angle between vehicles marked.

skewed intersections, like the Route 12 (Ashburnham and River Street) and 31 intersection, as shown in *Figure 3*, the obtuse angle between approaching vehicles and the direction of the vehicle in question can create a dangerous situation (Broward Complete Streets Guidelines, pages 6-3 and 6-4).

According to the Broward Metropolitan Planning Organization, intersections that require drivers to “crane their neck” make them less likely to see oncoming traffic. This poses a serious safety problem, especially on high-speed roadways. Unsignalized three-way intersections pose another threat by putting the responsibility of quick decision making on the driver. Instead of following clear and organized signals, a driver must make the conscious decision to obey traffic laws and make the safest maneuver. More specifically, deciding what safe action to execute is subjective. Drivers rarely know the full situation of the road and can participate in unsafe movements.

2.3.2 Problems Likely to Occur

The majority of issues with these intersections are safety related. Referring back to *Figure 3*, the skewed intersection can result in T-bone or rear end collisions. Drivers are less likely to see an approaching car at these obtuse angles. This can lead to driver mistakes such as pulling onto a main road in front of an oncoming car they could not see.

Entering a major road too close to a vehicle ahead can result in a rear end collision, as well as T-bone collisions. This problem is not only a geometric design issue, but a driver response issue. According to the Broward Complete Streets Guidelines, drivers can have difficulty “assessing...all possible conflict” in an intersection (Page 6-4). The lack of suggestion at an unsignalized three-way intersection forces the driver to make unsafe choices. Additionally, high speed collisions are likely to occur. According to the Broward Complete Streets Guidelines, the street geometry can “encourage speeding” on the main road of a three-way Intersection. Especially if the driver pulling onto the main road has a stop sign, this can result in a high-speed collision. Overall, three-way intersections pose multiple safety threats to drivers due to lack of sight distance and driver responsibility.

2.4 Approaches to Intersection Improvement

Research was conducted on methods to improve the intersection.

2.4.1 Roundabouts

Roundabouts are a popular method to reduce the severity and number of crashes on a roadway as well as improve traffic flow. The constant movement through the design also reduces emissions as the start-and-stop aspect of driving is virtually eliminated. The opportunity for green space in the center as well as lower maintenance costs compared to a traffic signal help the space become more inviting and usable. Lastly, roundabouts provide improved safety for pedestrians and bicyclists compared to traditional intersections (Iowa Department of Transportation, paragraphs 1-7).

A roundabout can either be single or multi-lane. A single lane roundabout can have difficulties accommodating larger vehicles with their wide turn radii. However, multi-lane roundabouts can become more complex for pedestrians, bicyclists, and new drivers. Therefore, the decision between single and multi-lane roundabouts depends on the location's specific objectives (Broward Complete Streets Guidelines, pages 6-22 to 6-29).

2.4.2 Signalized Intersection

Signalized intersections provide a familiar and safe experience for drivers. There are many options for signals considering the needs of the specific location. Depending upon the amount of traffic, a signalized intersection can be a fixed, pretimed signal, or an actuated signal. Signals can fluctuate between fixed and actuated, based upon time of day, as well as vary from semi to fully actuated. This variation depends upon the ADT (Average Daily Traffic). Left turning signals can differ from permissive (yield to oncoming traffic) or protected, which grants left turns the right of way. A signalized intersection can have concurrent or non-concurrent phasing. Concurrent phasing allows for opposite flows of traffic to run at the same time; non-concurrent only has one direction of traffic flowing at once. (Accessible Pedestrian Signals, 2020).

2.4.3 Speed Calming Measures

Road features used to reduce the mean free-flow speed include the presence of on-street parking, presence of a sidewalk, city center areas, and lower network classes. Higher road classes, such as main and arterial areas, have wider widths, longer road segments, absence of sidewalks, and absence of on-street parking. This combination of characteristics increases the free-flow speed of the road (USDOT, 2018). Other studies have shown that vulnerable road users on the roads or crossing the roads significantly impact vehicle speed and road capacity. Similarly, the frequency of parking maneuvers along the roads significantly reduces other vehicles' speed (Silvano & Bang, 2015). The most influential road feature affecting a driver's speed is the number of lanes on a single roadway (Warner & Aberg, 2008).

2.5 Community Involvement

A unique aspect to this project was including the Fitchburg community in its decision-making process. Including local community perspective when considering redesign strategies is crucial to a project's long-term success (Community Places, 2014). Engaging the community will increase the likelihood of solutions being accepted because they would have had a say in the process. It can also create more effective solutions, with better insight to local issues, and reduced conflict. Overall, improved communication between the community and town officials creates an open dialogue allowing members of the community to express oneself and feel heard.

2.5.1 History of Fitchburg

The community of Fitchburg holds great pride in their city's history; many original buildings from its founding are well-kept and intact. The Town of Fitchburg was established in 1764. Since its founding, the town has reshaped and evolved many times over the years, lasting through major wars and societal change. Through the 1900s Fitchburg was living its golden years, with major commercial expansion, industries flourishing, and the population growing. By 1872, Fitchburg was declared a city (Garretson, n.d.). Residential neighborhoods were built along the slopes of the hills near the local town river. At the time with no automobiles, the city was established with pedestrians first in mind. This created a compact area with shops, residents, and work industries within walking distance of each other. Major roads were built parallel to the Nashua River and local railroads (Garretson, n.d.).

With the invention of the car, the upper middle class began to move out to more suburban homes. Neighborhoods began to lose their economic prosperity and stability, leaving the poorer population unable to move while their neighborhood started to decline. New car ownership also encouraged the growth of commercial strip mall streets and shopping centers. Local industries began to change ownership, selling out to national corporations. The industrial leadership, which led the city for decades changed to leadership that had limited interest in the city, except things directly connected to their own industries (Garretson, n.d.). Currently, Fitchburg has a strong interest in preserving town heritage in both the community and physical environment (Garretson, n.d.).

2.5.2 Fitchburg Strategic Plans

The City of Fitchburg adopted their Vision 2020 Comprehensive Master Plan in 1998 to maintain and enhance residents' quality of life and neighborhoods. The plan also addresses preservation of the city's historic character and heritage. The section "Transportation and Circulation" introduced six major goals with corresponding objectives. Related to the Route 12 (Ashburnham and River Street) and Route 31 (Westminster Street) intersection, the section aims to improve the circulation of cars, pedestrians, bicycles, and public transportation, including cross street circulation and intersections, with minimal negative impacts to residents. Part of Safety and Amenity, an included objective was to redesign problem areas and intersections where necessary (Vision2020, 1998). The selected intersection, at the time of Vision2020 was first adopted, had not experienced a large number of crashes yet. Only until the intersection experienced more crashes was it considered to be problematic.

2.5.3 Stakeholders

Public participation enables two-way communication between the decision-makers and their constituents in an open and transparent manner. This improves the accountability of the decision-making process, the project's long-term viability, and benefits the community (Al-Qadi, 2020). The decision-making process of community projects is becoming ever more complicated, especially with the increasing number of individuals/groups involved and their tendency to guard their own interests by influencing the implementation of projects. Therefore, it is important to coordinate with different stakeholders (or stakeholder groups), while building relationships with them.

A stakeholder, broadly, is an individual or group that is affected and/or can influence community organization decisions (Al-Qadi, 2020). In relation to the project, the community development department of Fitchburg, residents located at or near the intersection, and local businesses near the intersection would be considered stakeholders. Continual engagement with them throughout a project's lifecycle is an effective way of achieving and maintaining a strong relationship. In some contexts, planning decision-making, it has come to be viewed as a democratic right and to reflect the value in governance and decision-making frameworks that account for others (Li, Ng, and Skitmore, 2016). The implications of successful stakeholder engagement in a system going beyond public voice and representation and include co-production concepts that increase the potential for long-term support, successful implementation, and even cost-effectiveness. Empowering stakeholders so that they can influence how their services are designed and delivered increases the likelihood that a community's needs will be met. The quality of the stakeholder engagement process can strongly influence the quality of attained outcomes. If a decision is perceived as unfair by stakeholders, they may respond with reluctance to engage and to accept results (Li, Ng, and Skitmore, 2016). It is important for the stakeholders to feel heard.

2.5.4 Engagement Approaches

Proper communication is key to any successful engagement process. All communication materials used to engage the community should be clear and concise with a straightforward message with no term specific jargon. All materials should be fully accessible to all residents of the community, available in all proper formats and languages (Community Places, 2014). Using locally established community networks and local advertising will help maximize participation. Most common engagement approaches are already required "steps" by law in some way as a part of projects. Some mandatory examples include public hearings, written public comments, consultations with the community.

2.5.4.1 Group Approaches

Public hearings are commonly conducted in a formally structured, one-way communication manner (Innes & Booher 2004). Meetings are typically attended primarily, by avid proponents and opponents of an issue personally affecting them, by representatives of interest groups, and by a few diehard community board watchers. Discussion is strictly led by a pre-approved agenda; recognized speakers receive two to three minutes of floor time but must speak only on items listed in the agenda (Innes & Booher). In recent decades, public hearings have evolved to include open dialogue and discussions.

More collaborative group approaches such as focus groups, public forums, and consensus building have gradually been utilized over the years. These methods encourage active conversation where a back-and-forth exchange of information between official and resident can be facilitated (Community Places, 2014). Focus groups are designed to concentrate on a specific niche topic or issue. They are conducted in smaller groups compared to a forum, which allows participants or certain interest groups who otherwise feel excluded to speak out. A successful focus group includes a well-experienced facilitator(s). An ideal facilitator will lead discussions but allow for participants to engage as they want, while keeping people focused on the issue(s) at hand (Community Places, 2014).

Public forums target a wider audience, usually a group or organization who is affected by a local area issue. Forums are a diverse pool of community members, from different job occupations, pollical alignments, social status, etc. A larger gathering helps to create momentum and enthusiasm within the local area while encouraging more participation (Community Places, 2014). Consensus building or roundtable discussions are similar to focus groups. The key difference is that a roundtable has no leader in conversation. They'll involve a variety of participants with a variety of interests, but everyone is treated as equals. A level playing field encourages an open dialogue where the issues remain the focal point rather than personal attacks. And an open discussion may lead to new innovative solutions, where the end goal is a win-win solution (Al-Qadi 2020).

2.5.4.2 Individual Approaches

Survey questionnaires are used to identify the views and needs of a large number of people in a standardized format. Surveys should be short, concise, and easily understandable. They place focus on the individual and give participants opportunities to express their opinion in their own time and words. Surveys are useful for obtaining quantitative data and can be used over time. They are best used in conjunction with other engagement approaches because, by themselves, there is a limited scope (Community Places, 2014).

Interviewing stakeholders provides great insight into the local area. Taking time to speak with community members will first show the person they are being heard and their perspective matters (Wu, Jia, & Mackhaphonh, 2019). One-on-one engagement puts the interviewee at ease and encourages them to speak freely. Interviews are conducted with priority community members, people expected to be influenced the most. Interviews can be structured with set questions and timeframe; these are best used when looking for specific information. They can be unstructured, and conversation occurs organically; these can be used broader and allows for a variety of information to be collected. Semi-structured interviews include a small set of questions, but the interviewer does not have to follow them; these help keep the conversation stay focused while also letting the interviewee direct a part of the conversation (Wu, Jia, & Mackhaphonh, 2019).

3 Methodology

A problematic intersection located in Fitchburg, Massachusetts between Route 12 (Ashburnham and River Street) (River and Ashburnham Street) and Route 31 (Westminster Street) has previously been investigated by Montachusett Regional Planning Commission and the Massachusetts Department of Transportation. This is a three-way intersection with a one-way controlled stop. There is limited sight distance as well as high vehicle speeds resulting in a large number of rear-end crashes on Route 31 (Westminster Street). The goal for this Master Qualifying Project (MQP) was to improve the functionality of the intersection while prioritizing the safety of everyday residents. To successfully meet the project goal, the following objectives were met:

1) Understand Intersection Improvement Methods
2) Collect & Analyze Data
3) Develop Intersection Redesign Alternatives
4) Apply Evaluation Criteria to Design Recommendations

3.1 Objective 1: Understand Intersection Improvement Methods

Our first objective was to gain an understanding of all of the design options prior to data collection and analysis. This optimized data collection time and provided quality data necessary for preliminary designs. Understanding common intersection improvement solutions can be useful in the preliminary design process because the same solutions may be viable in this study.

Understanding the layout of the intersection and geometric configuration of the surrounding environment was a critical first step. Some geometrics collected prior to the data collection process were utility pole locations, neighboring properties, and basic measurements within the intersection.

The team used the Transportation Evaluation Criteria (TEC) based upon the Montachusett Regional Planning Commission’s provided TEC templates. This provided valuable information on how projects are typically rated. This criterion was used to verify that the selection process for the final design was ethical and accurate.

3.2 Objective 2: Collect & Analyze Data

The second objective was to collect and analyze data related to the intersection. Some tasks for data collection included collecting physical data from the intersection and surveying the public. Some analyses included finding the level-of-service and reviewing public opinion.

3.2.1 Traffic Counts

In fulfilling this objective, the team researched traffic counts and speed studies that occurred pre-COVID-19. Traffic studies showed that during the COVID –19 pandemic, in many cases, traffic counts had a tendency to be lower than expected volumes (Leavenworth, 2020).

The team conducted traffic counts as a collective group in October of 2020. The counts corresponded to typical counts based upon prior years, thus validating the data taken during COVID -19. Traffic counts consisted of using automatic traffic recorder (ATR) counts and manual counting boards provided by Montachusett Regional Planning Commission. Proper training on the setup of the ATR counts was conducted by an employee at MRPC. ATR counts were conducted Tuesday October 20th, Wednesday the 21st, and Thursday the 22nd. Due to some discrepancies in the ATR data, manual turning movement counts were conducted on Wednesday November 4th in order to determine peak hours of the intersection.

The manual turning movement counts occurred from 7:15 am – 9:15am and 2:00 – 6:00 pm. The manual traffic counts improved qualitative data, giving an indication of the flow of traffic, as well as problematic issues that may occur through visual observations. The ATR counts provided an abundance of quantitative data, giving specifics about the AADT (Average Annualized Daily Traffic) of vehicles factoring in time of day and day of the week. These traffic counts were critical in determining the level-of-service in each direction of travel.

Once the pre and mid COVID -19 data were collected, the first step in the analysis process was to determine the level-of-service of the intersection. Highway Capacity Software (HCS 2010), an older software provided by WPI, was used to conduct such analysis. The orientation of the intersection included

Westminster Street as the minor approach, while River Street and Ashburnham Street were designated as the major approaches. This analysis included specifics such as presence of turning lanes, signing, number of lanes, approach grades, and percent of heavy vehicles.

3.2.2 Signal Warrant Analysis

A signal warrant analysis consists of evaluating individual warrants. According to traffic engineers with MassDOT, the 8-hour vehicular volume warrant must be met in order for a signal to be justified at a minimum. This entails the intersection meets a minimum number of vehicles per hour for a span of eight consecutive hours. A signal may be considered for installation if the 8-Hour Vehicular Volume Warrant is passed, and if it is recommended based on an engineer's judgement. Additional warrants being met supplement the case for a signal to be installed (MUTCD, 2021). Below is a list of the following warrants analyzed for this intersection:

i. 8-Hour Vehicular Volume Warrant
ii. 4-Hour Vehicular Volume Warrant
iii. Peak Hour Warrant
iv. Pedestrian Volume Warrant
v. School Crossing Warrant
vi. Coordination Signal System
vii. Crash Experience
viii. Roadway Network
ix. Intersection Near a Highway- Rail Crossing

3.2.3 Crash Data

Pre-existing crash data at the Route 12 (Ashburnham and River Street) & Route 31 (Westminster Street) intersection in Fitchburg was collected through MassDOT crash reports. The data collected included the number of crashes in the years 2017- 2019, as well as the type of crash. Additionally, crash diagrams were created. The crash reports and diagrams played a critical role in determining the configuration of each preliminary design by identifying problems in the intersection that contributed to the crash. The crash data also gives reasoning to implement a new and more safe intersection.

3.2.4 Speed Studies

A critical component in determining the overall safety of the intersection was how fast the vehicles were traveling relative to the designated speed limits. The team researched any speed studies done prior to the start of the MQP in this location. The team also conducted speed studies in October of 2020. The ATR counts were used for the speed studies as they recorded the number of axles passing a certain point and their speed. The equipment and training for the ATR counts were provided by Montachusett Regional Planning Commission. The equipment collected data for three consecutive days, specifically October 20th, 2020 to October 23rd, 2020. All three approaches were accounted for over the span of the three days. The data collected from these speed studies helped determine if recommendations were necessary within the preliminary designs.

3.2.5 Implementing Community Engagement

The last step in the data collection process was to gather public opinion on pre-existing problems and possible solutions with the intersection. Opinion was collected through interviews with engaged residents, town officials, and other major stakeholders. Additionally, surveys were given to members of the community via online social media sites and email contacting.

Development of the community survey started in October 2020 and was approved by the WPI Institutional Review Board in December of the same year. Opinions were collected on a wide scale to include members of the community not directly connected to the intersection but who still interact with it. The survey was emailed to abutters, including Smart Mart, Once Upon A Tile, and K'vod Yisrael Church. Then the survey was posted to Fitchburg community Facebook page groups. People must ask to join these groups and must have a proper reason or connection to Fitchburg to be approved. The survey was posted in the groups; “Discussing Fitchburg Now,” Fabulous Fitchburg,” and “What’s Happening Fitchburg, MA.” Later with the survey results phone interviews were conducted as follow-ups to survey responses.

Two follow up interviews were conducted. An interview with one of the managers of Smart Mart was conducted on February 10th, 2021. Another interview with a Facebook user who commented on the survey post was conducted on February 11th. An additional contact was given to interview the Facebook user. This third interview with this new contact was conducted March 8th, 2021. The impacts to people's day-to-day life were highlighted by these interviews and surveys and such impacts can help evaluate the feasibility of the recommended design. Extended results from the survey may be found in the *Appendix D*.

3.3 Objective 3: Develop Intersection Redesign Alternatives

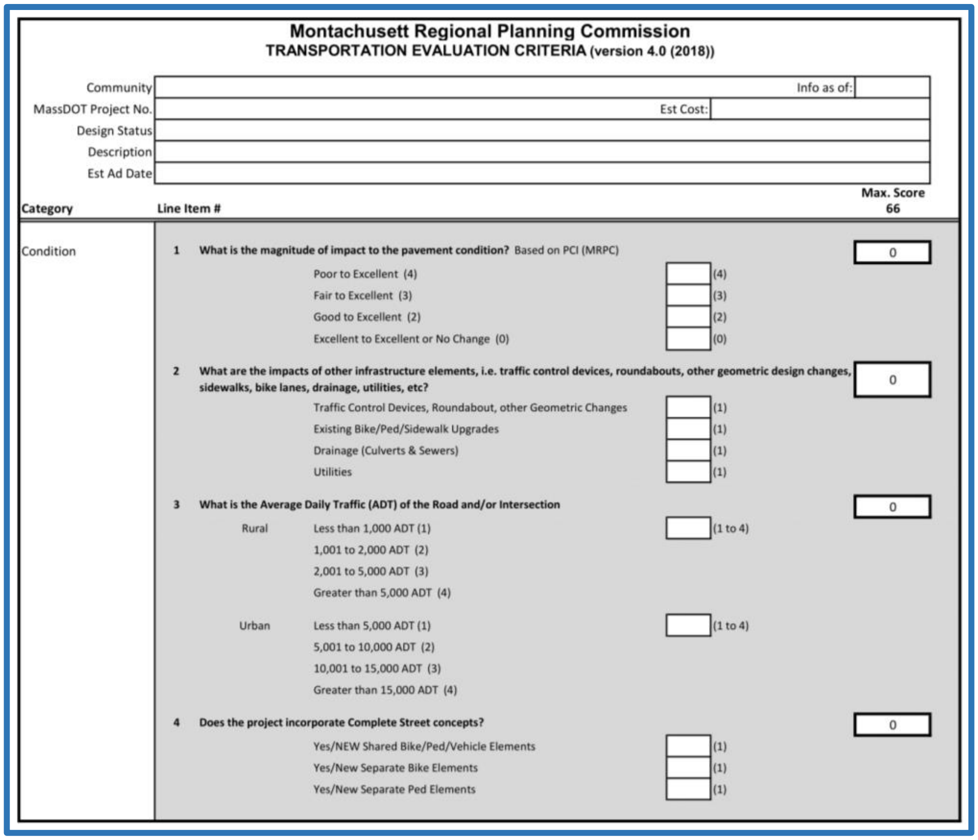
After analyzing the data collected from the previous objective, preliminary designs were created. The team focused on weighing the practicality of each design based upon the limited geometry, safety, efficiency, and longevity of the design. Four different designs were created. The team was able to contact engineers from MassDOT well as the Commissioner of Public Works for Fitchburg. This allowed for outside perspectives to weigh in on each design. When discussing the designs, the conversation focused on one main question: What design is best for the intersection? This question allowed for the experts to discuss problems with similar designs they have had in the past and how they can be changed. The designs were then adjusted based on these opinions.

3.4 Objective 4: Apply Evaluation Criteria to Design Recommendation(s)

The fourth objective was to develop evaluation criteria and compare each design to it. The criteria included level-of-service, public opinion, engineering opinion, and the Transportation Evaluation Criteria (TEC) results. In this criterion, level-of-service (LOS) is weighed twice more than the transportation evaluation criteria. This is because the TEC score is typically used to compare different projects across various locations instead of four within the same space. Although the TEC is not typically used to compare different designs for the same project, it still provided the team with insight into what factors are important when evaluating a project. Additionally, the engineering and public opinions are weighed three times more and twice more than the TEC, respectively. Overall, TEC is scaled times 1, expert and public opinion are scaled times 3 and 2 respectively, and level-of-service is scaled times 2. The expert opinion is weighed more heavily because these opinions were most critical in our design creation and selection.

Level-of-service was scored using a point system to indicate if the implementation of that design will improve the intersection's level-of-service.

The TEC score sheet is split into six categories: Existing Condition, Mobility, Safety, Community Effects and Support, and Land Use and Economic Development. The first category, condition, is shown below in Figure 4 while the full empty template is provided in *Appendix E*. The TEC score is determined by filling out the template and adding the points together.



Montachusett Regional Planning Commission
TRANSPORTATION EVALUATION CRITERIA (version 4.0 (2018))

Community ☐ Info as of: ☐
MassDOT Project No. ☐ Est Cost: ☐
Design Status ☐
Description ☐
Est Ad Date ☐

Category **Line Item #** **Max. Score 66**

Condition

1 What is the magnitude of impact to the pavement condition? Based on PCI (MRPC) 0
Poor to Excellent (4) ☐ (4)
Fair to Excellent (3) ☐ (3)
Good to Excellent (2) ☐ (2)
Excellent to Excellent or No Change (0) ☐ (0)

2 What are the impacts of other infrastructure elements, i.e. traffic control devices, roundabouts, other geometric design changes, sidewalks, bike lanes, drainage, utilities, etc? 0
Traffic Control Devices, Roundabout, other Geometric Changes ☐ (1)
Existing Bike/Ped/Sidewalk Upgrades ☐ (1)
Drainage (Culverts & Sewers) ☐ (1)
Utilities ☐ (1)

3 What is the Average Daily Traffic (ADT) of the Road and/or Intersection 0
Rural Less than 1,000 ADT (1) ☐ (1 to 4)
1,001 to 2,000 ADT (2)
2,001 to 5,000 ADT (3)
Greater than 5,000 ADT (4)

Urban Less than 5,000 ADT (1) ☐ (1 to 4)
5,001 to 10,000 ADT (2)
10,001 to 15,000 ADT (3)
Greater than 15,000 ADT (4)

4 Does the project incorporate Complete Street concepts? 0
Yes/NEW Shared Bike/Ped/Vehicle Elements ☐ (1)
Yes/New Separate Bike Elements ☐ (1)
Yes/New Separate Ped Elements ☐ (1)

Figure 4: TEC Sheet Category One Template

Next, the expert opinion criteria were transformed into a point scale indicating the number of experts who thought the design would benefit the intersection. For example, a +2 in this area means two experts specifically singled out that design as beneficial to the intersection while a 0 means no experts did that with that design. Lastly, community support was based on what and how well the problems of the intersection are addressed and how much disturbance is caused by implementing the design. The scale was limited to 2, with 0 having no problems addressed, 1 having one issue addressed but changes the intersection significantly, and 2 having at least one problem addressed with minimal disruption.

4 Results

The completion of the five objectives resulted in two recommendation designs. One designed as a short-term solution and another as a long-term solution. Data collected which led to these designs and others include traffic volume data, speed data, peak hour, public opinion, expert opinion, level of service, and signal warrant analysis.

4.1 Objective 1: Understand Intersection Improvement Methods Results

The first objective was to gain an understanding of intersection improvement design methods. Reviewing and discussing potential designs helped to direct data collection, making the time spent collecting data more efficient. This objective sought to answer three overarching research questions asking about potential solutions and specific intersection design regulations. Research questions also addressed the design's environmental impact and monetary costs.

1) How have these potential solutions improved other intersections?
2) How does a cost benefit analysis play a role in each preliminary design?
3) What are the geometric dimensions needed in providing a redesign of the unsignalized intersection?

From these objective questions, the team researched intersection improvement methods for the assumed main issues: speeding and lack of sight distance. A few improvements include traffic calming methods such as street parking and pedestrian features, roundabouts, and geometrically changing the intersection into a more perpendicular shape.

Next, a cost benefit analysis plays into each design differently; depending on the demolition, construction, cost of material and labor, as well as cost of permits and time for state approval of each design, the cost will vary significantly. However, as long as the design change is needed and shows true benefit based upon analysis, public and expert opinion, and other evaluation criteria, cost is a secondary concern. A design should not be ruled out due to its impending cost, but rather analyzed for its potential benefit to the area.

Lastly, the geometric dimensions needed for an unsignalized intersection are generally a perpendicular street at an angle of 90 degrees. That is the optimal geometric set up however, not all roads need to have this 90-degree angle to be a safe intersection. The optimal dimensions rely on other visual characteristics such as sight distance.

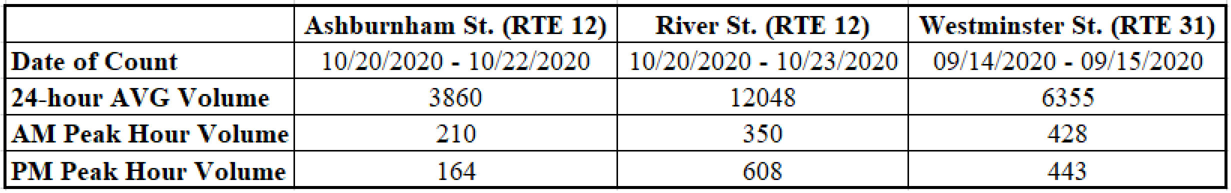
The results of roundabout and signalized intersection methods are compiled and included in the background section of this report for greater fluidity and understanding.

4.2 Objective 2: Collect & Analyze Data Results

The second objective was to collect and analyze data on the intersection. Data collected included: Automatic Traffic Counts, Manual Turning Movement Counts, intersection geometry, crash data, and local transportation routes. Data was analyzed and our results are discussed in this section.

4.2.1 Traffic Volume Data

Table 2 provides a summary report of the average 24-hour volumes, peak hour volumes, and the automatic traffic recorder volumes for Ashburnham Street, River Street and Westminster Street.



	Ashburnham St. (RTE 12)	**River St. (RTE 12)**	**Westminster St. (RTE 31)**
Date of Count	10/20/2020 - 10/22/2020	10/20/2020 - 10/23/2020	09/14/2020 - 09/15/2020
24-hour AVG Volume	3860	12048	6355
AM Peak Hour Volume	210	350	428
PM Peak Hour Volume	164	608	443

Table 2: Summary of 24-Hour and Peak Hour Volumes

Counts were taken from 10/20/20 to 10/23/20. The River Street equipment was successful for all three days, while the data was inconclusive on 10/23/20 for Ashburnham Street. Westminster Street was inconclusive for all three days because the ATR count was placed too close to the intersection. Prior data was taken for Westminster Street from 9/14/20 to 9/15/20 by the Montachusett Regional Planning Commission, which was used in the data analysis in developing peak hour data.

4.2.2 Peak Hour Turning Movement

The peak hour diagrams are represented in *Figures 5 & 6*. The results show a heavy right turning movement out of Westminster Street (Route 31) and a heavy left turning movement on River Street (Route 12). The peak hour times occurred between 7:15 AM - 8:15 AM and 3:00 PM - 4:00 PM.

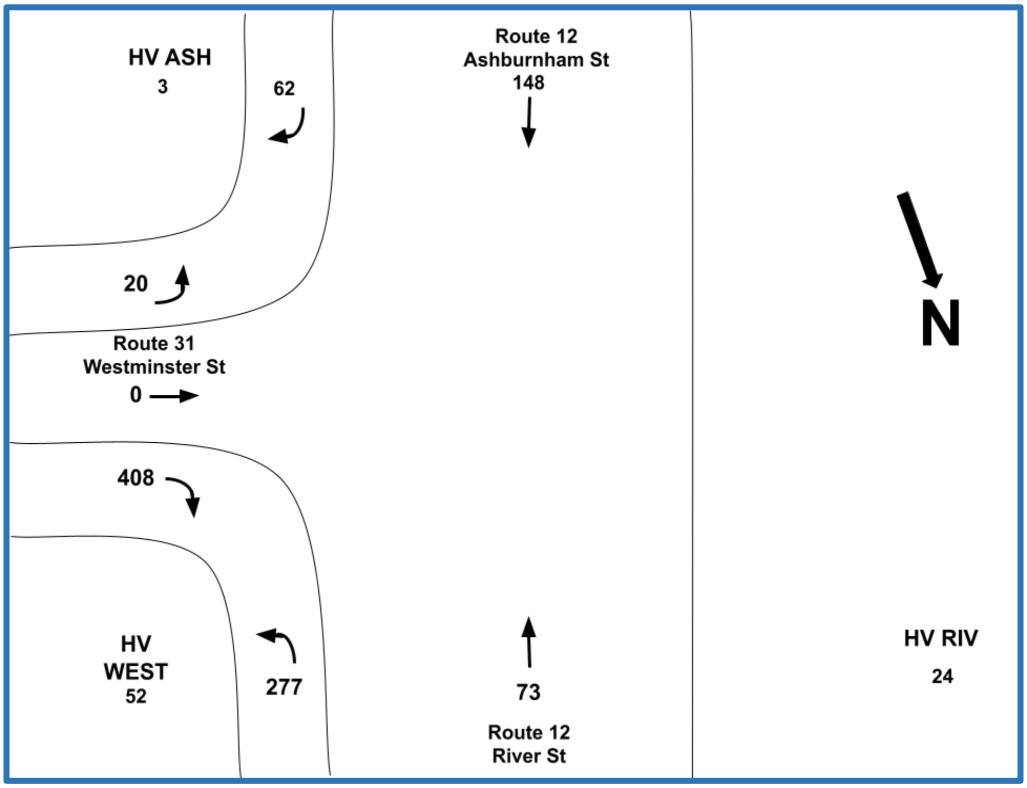


Figure 5: Morning Peak Hour Volume Diagram

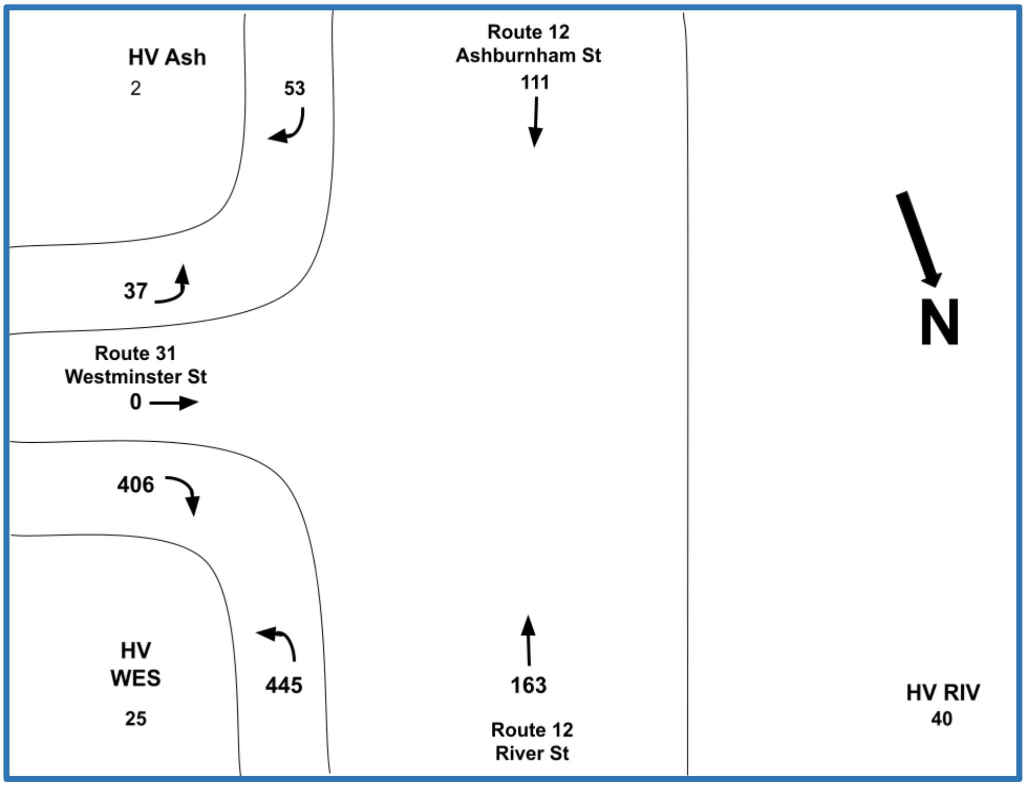
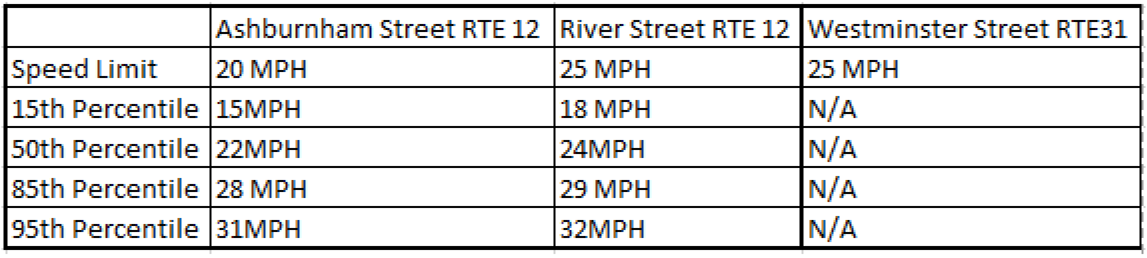


Figure 6: Afternoon Peak Hour Volume Diagram

4.2.3 Speed Data

Table 3 shows the 15th, 50th, 85th, and 95th percentile speeds from the ATR data collectors that were set up at each leg of intersection. At least half of drivers travel above the 20 MPH and 25 MPH speed limits on Ashburnham Street and River Street, respectively.

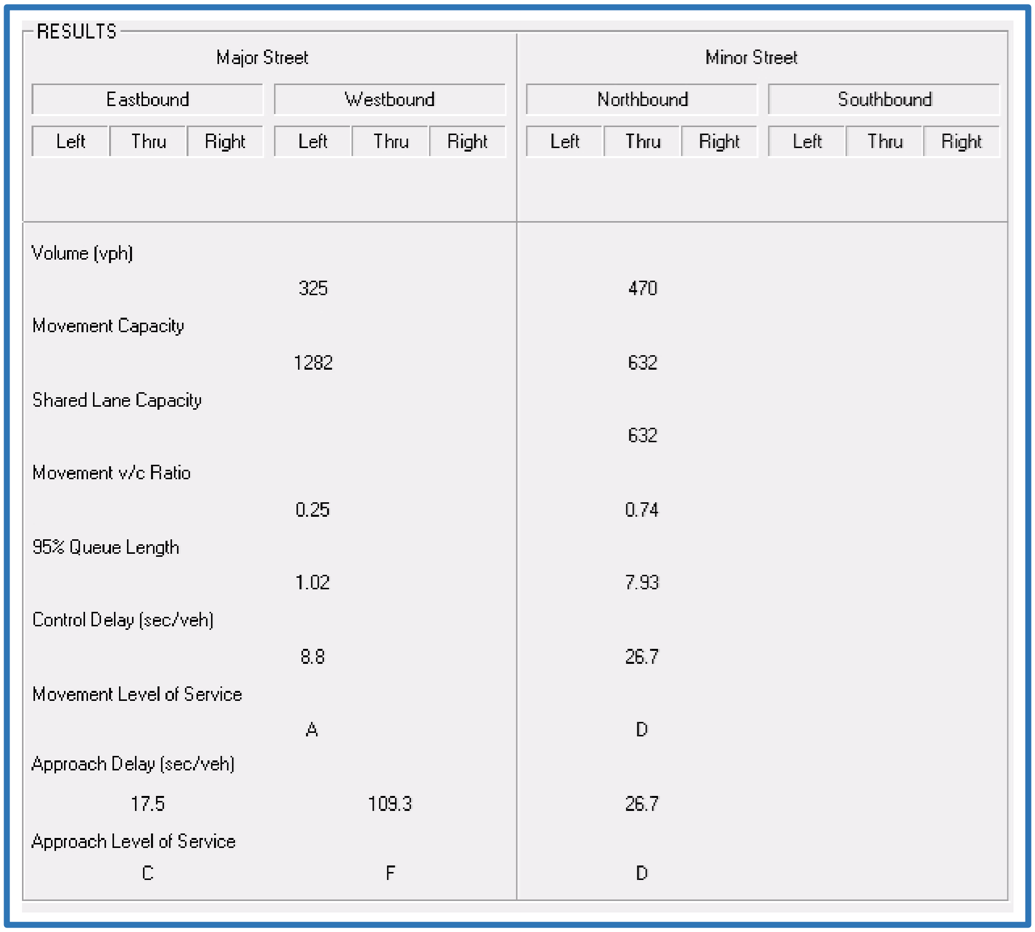


	Ashburnham Street RTE 12	River Street RTE 12	Westminster Street RTE31
Speed Limit	20 MPH	25 MPH	25 MPH
15th Percentile	15MPH	18 MPH	N/A
50th Percentile	22MPH	24MPH	N/A
85th Percentile	28 MPH	29 MPH	N/A
95th Percentile	31MPH	32MPH	N/A

Table 3: Speed data collected with Automatic Traffic Recorder

4.2.4 Intersection Level-of-Service

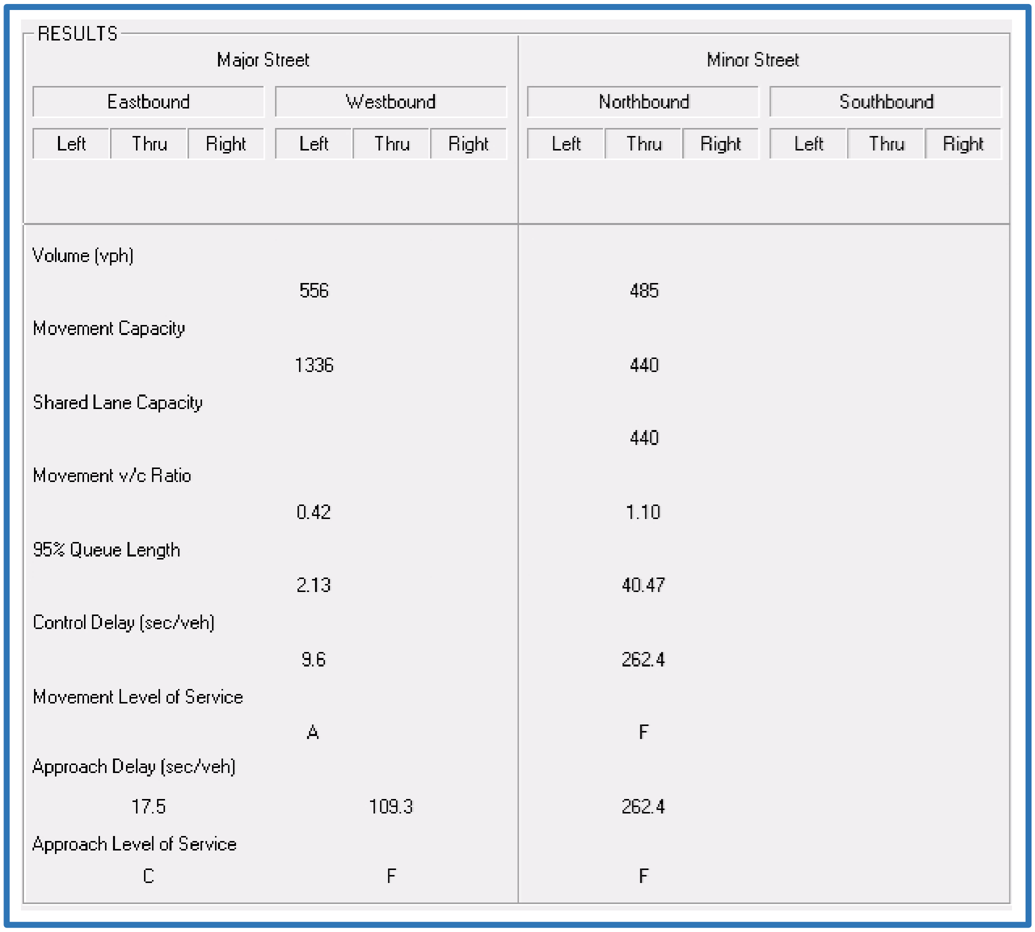
Based upon the data collected, the AM, shown in *Figure 7*, peak hour level-of-service (LOS) is level C in the eastbound direction (Route 12), level F in westbound direction (Route 12), and level D on Route 31 (Westminster Street). The PM level-of-service analysis, shown in *Figure 8*, resulted in level C in the eastbound direction (Route 12), level F in westbound direction (Route12), and level F on Route 31 (Westminster Street).



RESULTS

	Major Street						Minor Street					
	Eastbound			Westbound			Northbound			Southbound		
	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
Volume (vph)				325				470				
Movement Capacity				1282				632				
Shared Lane Capacity								632				
Movement v/c Ratio				0.25				0.74				
95% Queue Length				1.02				7.93				
Control Delay (sec/veh)				8.8				26.7				
Movement Level of Service				A				D				
Approach Delay (sec/veh)		17.5			109.3			26.7				
Approach Level of Service		C			F			D				

Figure 7: Screenshot of HCS Results for Morning Level of Service Analysis



RESULTS

	Major Street						Minor Street					
	Eastbound			Westbound			Northbound			Southbound		
	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
Volume (vph)				556				485				
Movement Capacity				1336				440				
Shared Lane Capacity								440				
Movement v/c Ratio				0.42				1.10				
95% Queue Length				2.13				40.47				
Control Delay (sec/veh)				9.6				262.4				
Movement Level of Service				A				F				
Approach Delay (sec/veh)		17.5			109.3			262.4				
Approach Level of Service		C			F			F				

Figure 8: Screenshot of HCS Results for Afternoon Level of Service Analysis

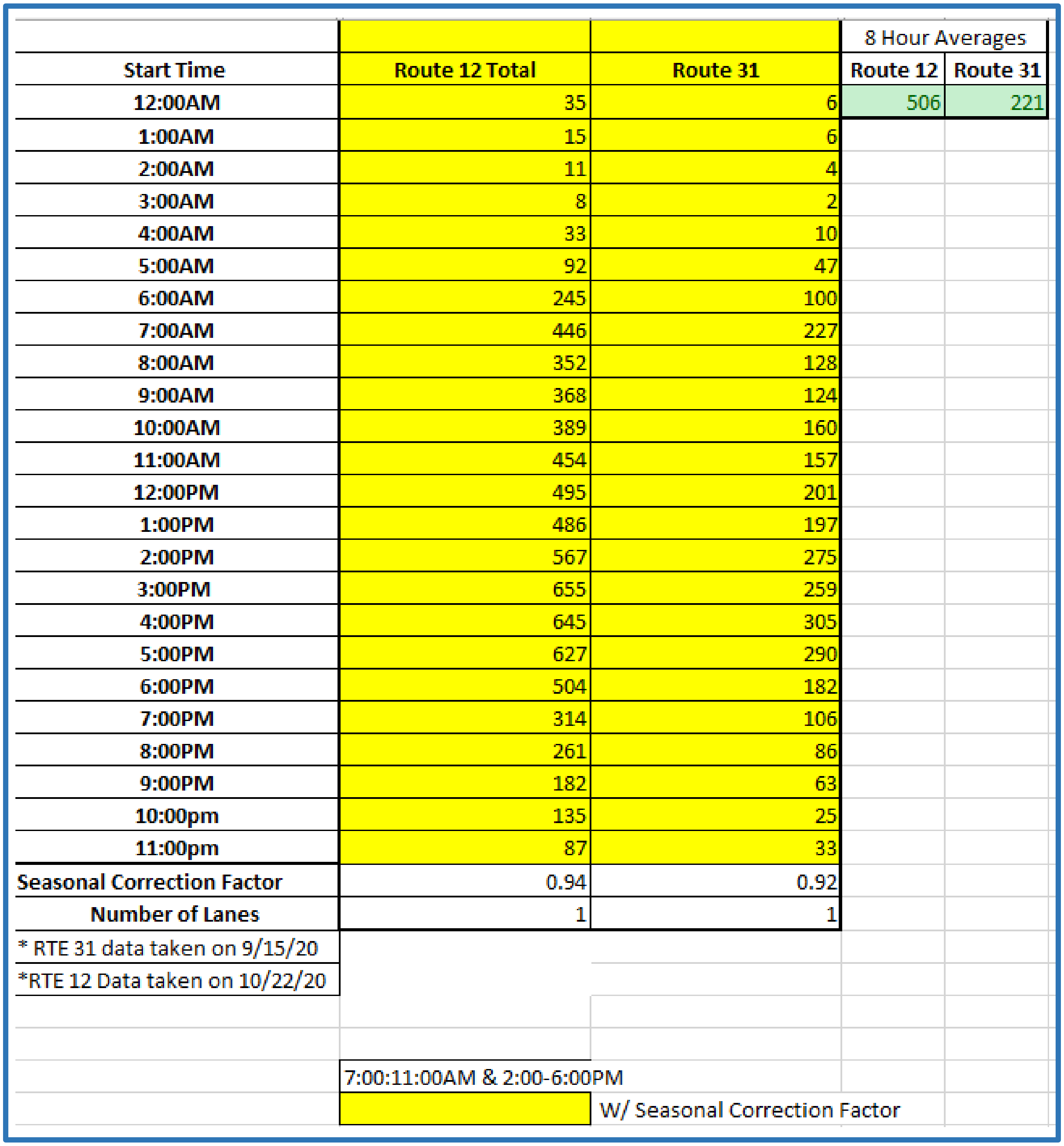
Although both state routes have similar volumes of traffic, Route 31 (Westminster Street) is under stop control. This significantly decreases the movement capacity on Route 31 (Westminster Street). A heavy number of left turns on Route 12 (Ashburnham and River Street) results in a poor level-of-service as well.

4.2.5 Signal Warrant Analysis

The team reviewed the nine warrants that would potentially indicate the need for a signal to be installed at the Route 12 (Ashburnham and River Street) & 31 intersection. The analysis detailed that only three warrants meet the minimum requirements for a signal to be installed. Those warrants are the 8- and 4-hour vehicular volumes, and the peak hour volumes.

4.2.5.1 Warrant 1: 8-Hour Vehicular Volume

Based upon the data collected, the 8-hour vehicular volume warrant meets the minimum requirements for a signal. *Figure 9* shows the results to our data per hour per route with the appropriate seasonal correction factor.



			8 Hour Averages	
Start Time	Route 12 Total	Route 31	Route 12	Route 31
12:00AM	35	6	506	221
1:00AM	15	6		
2:00AM	11	4		
3:00AM	8	2		
4:00AM	33	10		
5:00AM	92	47		
6:00AM	245	100		
7:00AM	446	227		
8:00AM	352	128		
9:00AM	368	124		
10:00AM	389	160		
11:00AM	454	157		
12:00PM	495	201		
1:00PM	486	197		
2:00PM	567	275		
3:00PM	655	259		
4:00PM	645	305		
5:00PM	627	290		
6:00PM	504	182		
7:00PM	314	106		
8:00PM	261	86		
9:00PM	182	63		
10:00pm	135	25		
11:00pm	87	33		
Seasonal Correction Factor	0.94	0.92		
Number of Lanes	1	1		

* RTE 31 data taken on 9/15/20

*RTE 12 Data taken on 10/22/20

7:00:11:00AM & 2:00-6:00PM

🟨 W/ Seasonal Correction Factor

Figure 9: Automatic Traffic Recorder Data with applied seasonal correction factor.

The data also indicates the average 8-hour volumes, 11:00 AM - 6:00PM, meet the 80% thresholds for Condition A as shown in *Figure 10*. Due to the two major approaches, River and Ashburnham Street, along with one minor street, Westminster, *Figure 10* shows the threshold numbers in which this intersection is consistently above. These numbers are 400 vehicles per hour on Route 12 (Ashburnham and River Street) and 120 vehicles per hour on Route 31 (Westminster Street).

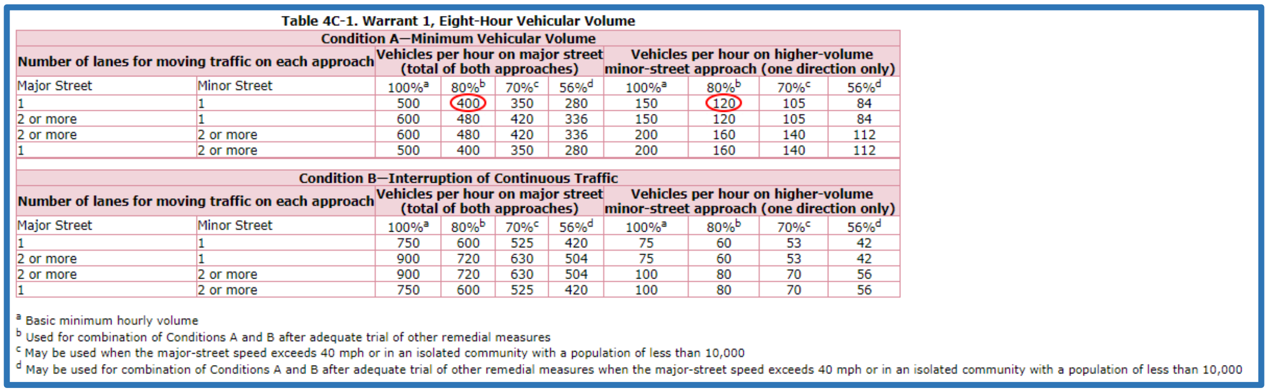


Table 4C-1. Warrant 1, Eight-Hour Vehicular Volume

Condition A—Minimum Vehicular Volume

Number of lanes for moving traffic on each approach		**Vehicles per hour on major street (total of both approaches)**				**Vehicles per hour on higher-volume minor-street approach (one direction only)**			
Major Street	Minor Street	100%[a]	80%[b]	70%[c]	56%[d]	100%[a]	80%[b]	70%[c]	56%[d]
1	1	500	400	350	280	150	120	105	84
2 or more	1	600	480	420	336	150	120	105	84
2 or more	2 or more	600	480	420	336	200	160	140	112
1	2 or more	500	400	350	280	200	160	140	112

Condition B—Interruption of Continuous Traffic

Number of lanes for moving traffic on each approach		**Vehicles per hour on major street (total of both approaches)**				**Vehicles per hour on higher-volume minor-street approach (one direction only)**			
Major Street	Minor Street	100%[a]	80%[b]	70%[c]	56%[d]	100%[a]	80%[b]	70%[c]	56%[d]
1	1	750	600	525	420	75	60	53	42
2 or more	1	900	720	630	504	75	60	53	42
2 or more	2 or more	900	720	630	504	100	80	70	56
1	2 or more	750	600	525	420	100	80	70	56

[a] Basic minimum hourly volume

[b] Used for combination of Conditions A and B after adequate trial of other remedial measures

[c] May be used when the major-street speed exceeds 40 mph or in an isolated community with a population of less than 10,000

[d] May be used for combination of Conditions A and B after adequate trial of other remedial measures when the major-street speed exceeds 40 mph or in an isolated community with a population of less than 10,000

Figure 10: Eight-Hour Warrant Vehicle Volume Conditions (FHA, 2009)

4.2.5.2 Warrant 2: 4-Hour Vehicular Volume

Based upon the volumes previously reported (*Figure 9*), the intersection meets the minimum requirements for the 4-hour vehicular volume. From the hours 2:00 PM - 6:00 PM the combined volumes on Ashburnham Street and River Street were 567, 656, 645, and 627 respectively. The volumes collected on Westminster Street from 2:00PM to 6:00PM were 276, 259, 306, and 290 respectively. When these data points were plotted on the four-hour vehicular volume graphs, all four points were above the plotted line depicted in *Figure 11*.

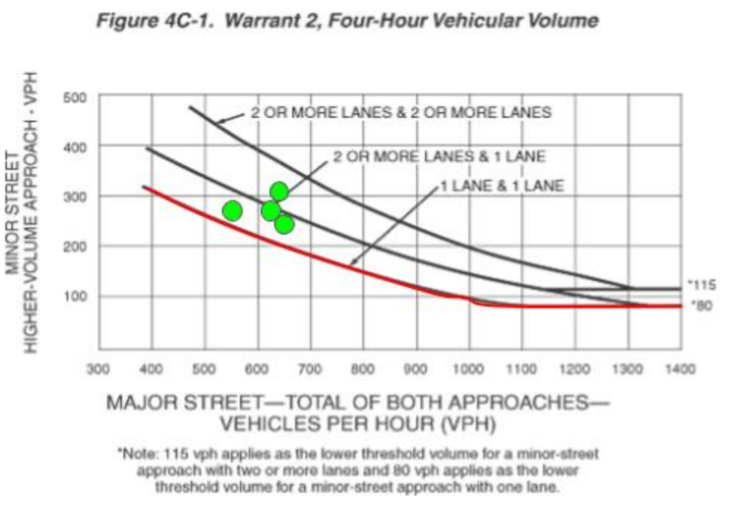


Figure 11: Four-Hour Warrant Vehicle Volume Conditions (FHA, 2009)

Therefore, the 4-hour Vehicular Volume of the intersection meets the warrant criteria. The data for Route 12 (Ashburnham and River Street) (River St.) was collected on Wednesday, 10/21/20 and Westminster data was collected on Tuesday, 9/15/20. Both sets of data accounted for their respective seasonal correction factor which was 0.92 for September and 0.94 for October.

4.2.5.3 Warrant 3: Peak Hour Volumes

Using the graphic in *Figure 12*, the intersection of Route 12 (Ashburnham and River Street) and Route 31 (Westminster Street) meets the warrant regarding peak hour volumes. The total number of vehicles from both approaches on Route 12 (Ashburnham and River Street) during the AM peak hour was 649 vehicles, while the volume on the minor approach, Route 31 (Westminster Street), totals to 339 vehicles. The PM peak hour counts on Route 12 (Major Street) and Route 31 (Minor Street) were 717 and 498 vehicles respectively. These counts are applied to the figure, detailing whether a signal should be warranted based upon the peak hour volumes.

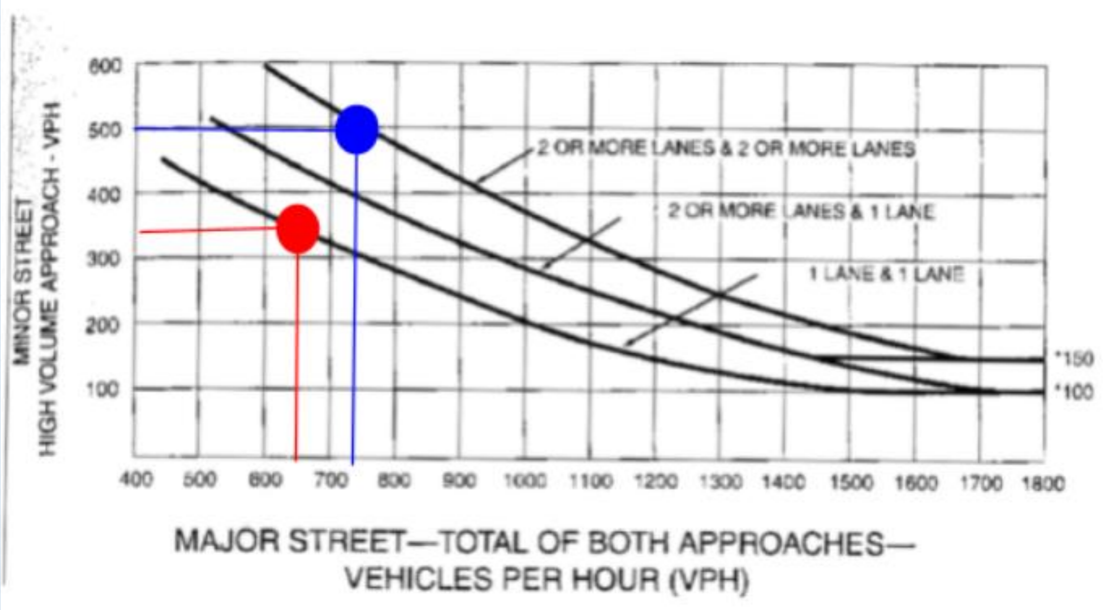


Figure 12: Morning and Afternoon Peak Turning Movement Counts

As seen in *Figure 12*, the red dot represents the AM peak hour total and the blue dot represents the PM peak hour total. The intersection falls along the curve labelled “1 lane & 1 lane”. Based upon the data collected, the AM peak hour volumes were slightly above the needed volume for a warrant, while the PM peak hour volumes easily met the Manual on Uniform Traffic Control Devices (MUTCD) peak hour signal warrant.

4.2.5.4 Warrant 4: Pedestrian Volumes

The intersection of study currently does not have any safety indicators for pedestrians such as crosswalks, sidewalks, or pedestrian crossing signs. When collecting data on the peak hour turning movement counts there were a total of 0 pedestrians. The minimum number of pedestrians required to warrant a signal is 107 pedestrians per hour based upon an average vehicle volume of 1400. *Figure 13* details the minimum number of pedestrian crossings needed to warrant a signal. Because there were no pedestrian counts during the manual counts this signal does not meet the requirements for a pedestrian volume warrant.

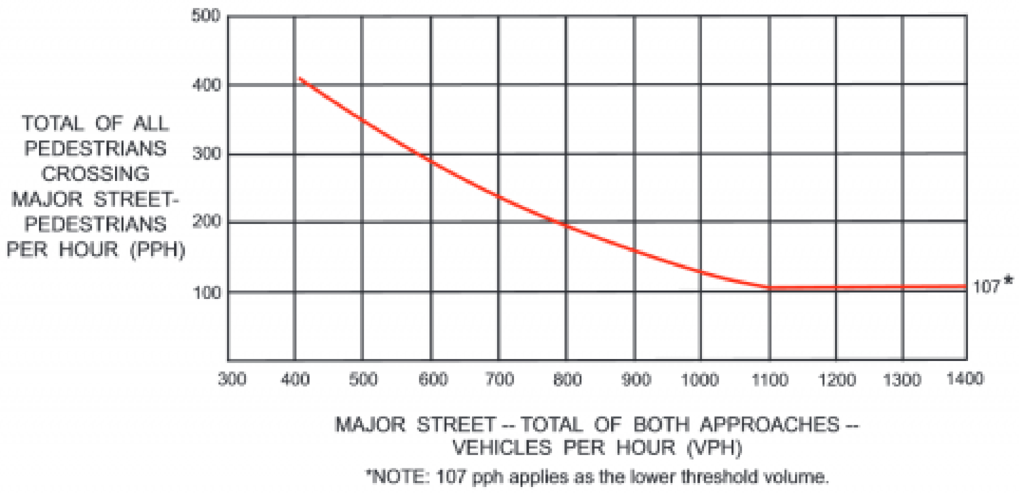


Figure 13: Major Street Total Both Approaches vs Major Street Pedestrians (FHA, 2009)

4.2.5.5 Warrant 5: School Crossing

Due to a lack of pedestrian counts, the school crossing warrant does not meet the minimum qualifications for a signal. This intersection is not used for a school crossing.

4.2.5.6 Warrant 6: Coordinated Signal System

The coordinated signal system warrant does not apply to this particular intersection. There is no other signal in coordination with the Route 12 (Ashburnham and River Street) & 31 intersection as this signal is unsignalized. Creating platoons of vehicles at this intersection is unnecessary as the traffic on this intersection is currently continuous. The coordinated signal system warrant is also justified when dissipation of traffic is needed for arterial roads, which again does not relate to the intersection under study.

4.2.5.7 Warrant 7: Crash Experience

The crash history of this intersection does not meet this warrant for signalization. Rear-end crashes were the most common crash at this intersection and adding traffic signals could potentially increase these types of crashes rather than prevent them. Angle crashes, the second most common crash, may be prevented by a traffic signal but this intersection experienced only four angle crashes over a three-year period. Therefore, the number of angle crashes do not meet warrant requirements.

4.2.5.8 Warrant 8: Roadway Network

Warrant 8 will not meet the minimum specification as there are no additional changes regarding the roadway network in the Fitchburg area.

4.2.5.9 Warrant 9: Intersection Near a Highway- Rail Crossing

This warrant does not pertain to the given intersection under study as no highway - rail crossing is located within the surrounding area of the intersection.

4.2.6 Geometrics of the Intersection

After observing and gathering data at the intersection, it became apparent to the team that vehicles approaching the stop sign on Westminster Street have difficulty seeing oncoming traffic from Ashburnham Street. To further identify the issue, the geometric shape of the intersection and the difficulties that come with it, were analyzed. First, sight distance at the stop sign on Westminster Street was calculated and compared to a minimum sight distance that is considered safe. Based upon the timing for a left turning movement, which is 7.5 seconds, and the 85th percentile speed on Ashburnham Street, 28 MPH, the calculated minimum sight distance should be 309 feet, as shown in *Figure 14* (Roess, et al, 2019). However, the calculated sight distance, line 2, is 114 feet. This is less than half much as the safe sight distance of 309 feet. This shows a key problem of the intersection geometry.

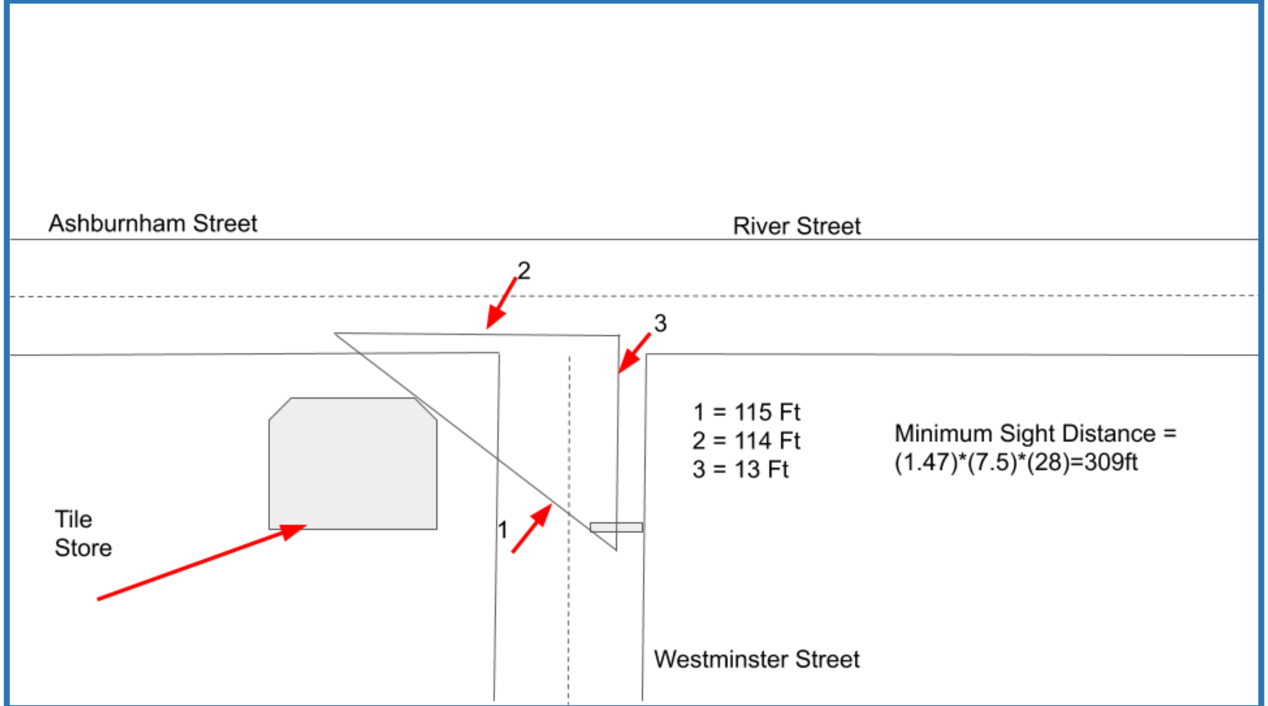
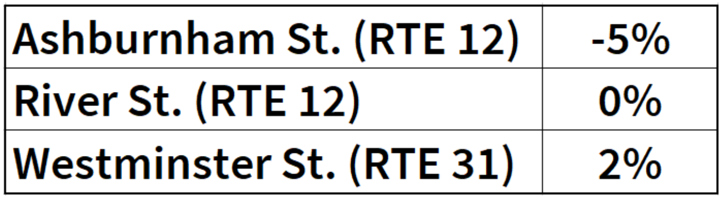


Figure 14: Sight Distance Diagram

Next, the current elevations were determined through Google Earth Pro and taking hand measurements. *Table 4* shows the calculated grade based per street leg. Ashburnham St had the steepest grade at -5%, while Westminster St and River St had grades of 2% and 0% respectively.



Ashburnham St. (RTE 12)	**-5%**
River St. (RTE 12)	**0%**
Westminster St. (RTE 31)	**2%**

Table 4: Elevation Grades per Intersection Street Leg

These elevations are crucial to understanding how difficult it can be for drivers to see other vehicles throughout the intersection. For example, a vehicle driving at a 2% incline grade on Westminster Street will have difficulty seeing a vehicle approaching the intersection at a -5% decline on Ashburnham Street due to the unsafe sight distance and presence of a hill.

4.2.7 Crash Data

Crash data was acquired through MassDOT's IMPACT Crash Query and Visualization Database, which can be accessed online through the MassDOT site. IMPACT allowed us to compile crashes within the specific area of the intersection using its Spatial Search feature. The specific area around the intersection used for identifying crashes is displayed in *Figure 15*.

Figure 15: Selected Area for Crash Data Query in IMPACT MassDOT

Data spanned three years from January 1, 2017 to January 1, 2020. A total of twenty-five crashes were found to occur at the intersection. Rear-end crashes were the most common type with fifteen rear-end crashes. Angle crashes were the second most common with four angle crashes reported. No fatal crashes were reported. Most crashes had a severity of only property damage with no injuries reported. The crash report data was exported to excel and then was compiled into a Crash Diagram, which is displayed in *Figure 16*.

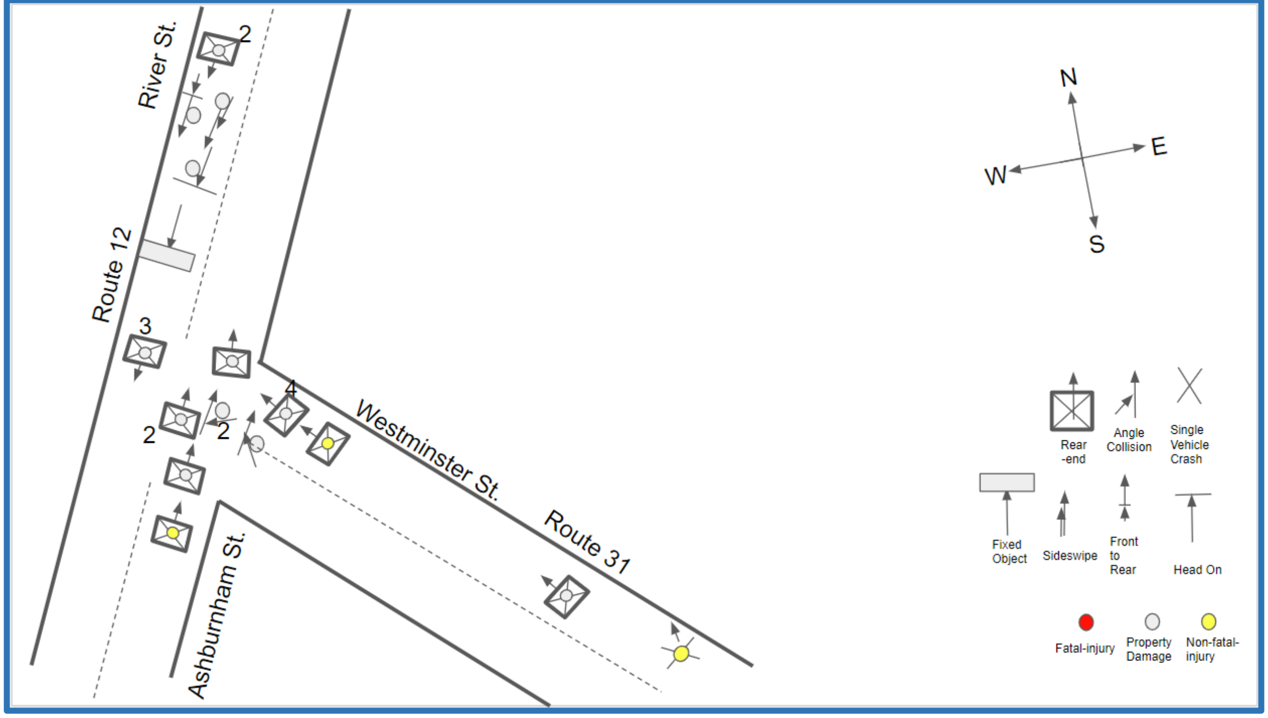


Figure 16: Crash Diagram

4.2.8 Bus Routes

Reingold Elementary School is located 0.6 miles from the intersection. Two bus paths utilize the intersection, one utilizing River St from Westminster St, and the other using Ashburnham St from Westminster St. *Figures 17* and *Figure 18* show the designated paths for each bus route.

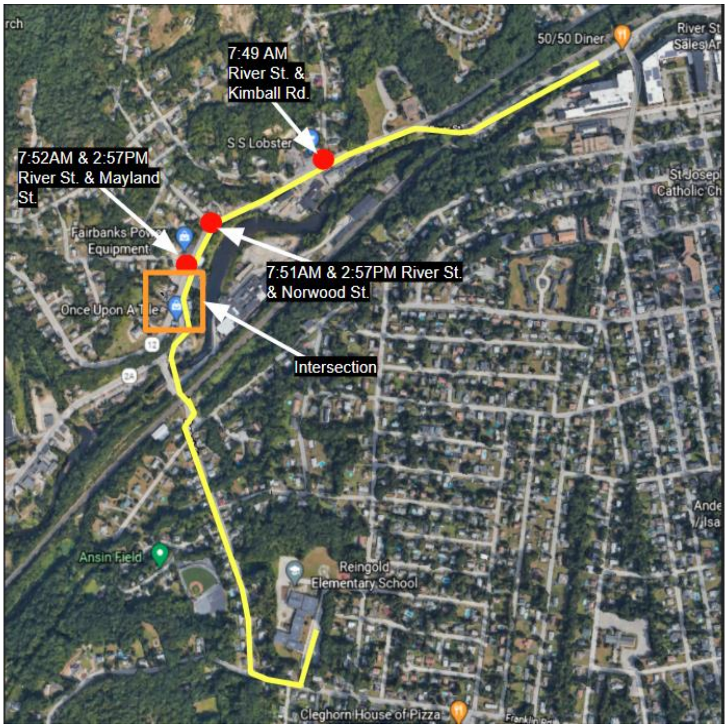


Figure 17: REINGOLD 5 AM/PM - Route 105

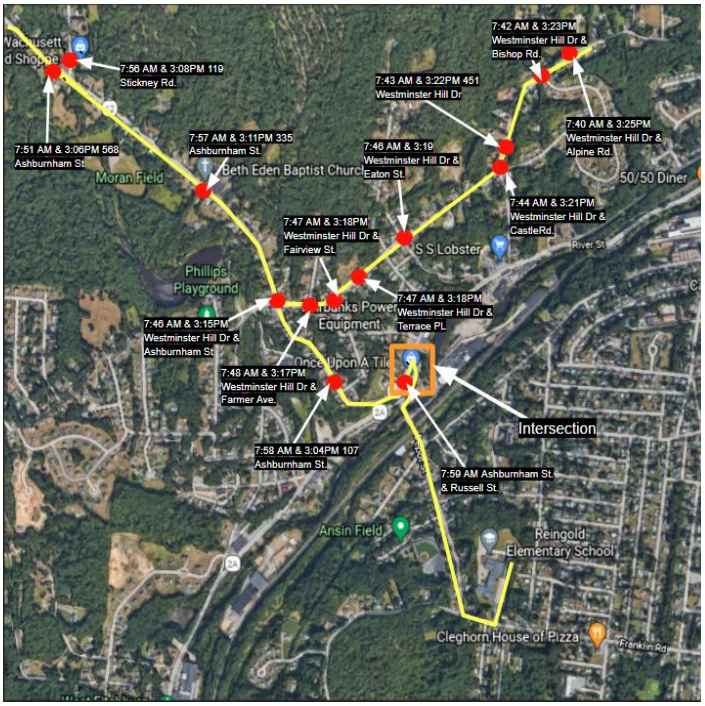


Figure 18: REINGOLD 18 AM/PM – Route 122

Figure 19 depicts the Montachusett Regional Transit Authority (MRTA) public transit route, which also travels through the intersection. The specified times are given for each individual stop on the bus route in order to give an understanding that these bus routes occur during peak hour times which are 7:00 - 9:00AM and 2:00 - 4:00 PM.

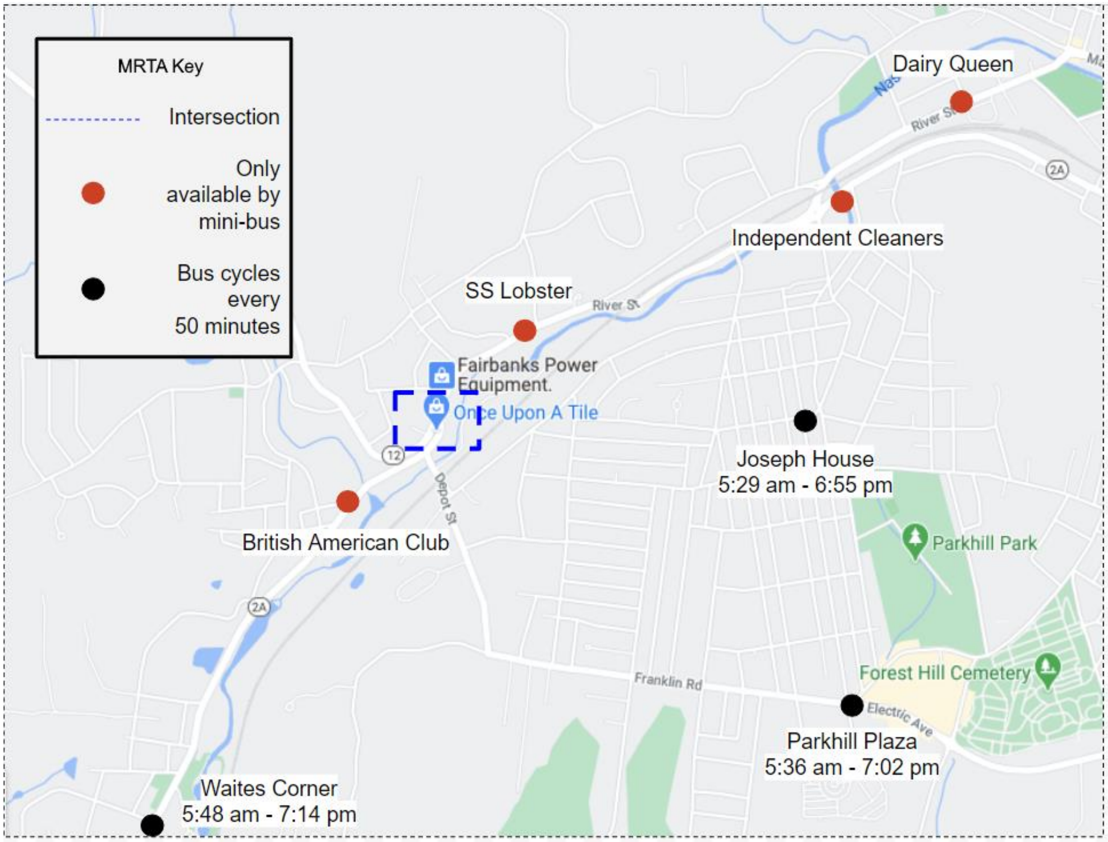


Figure 19: Montachusett Regional Transit Authority (MRTA) Bus Through Fitchburg

4.2.9 Community Opinion

Collecting opinions and information on the intersection was conducted through a community survey and short interviews.

4.2.9.1 Survey Results

The community survey received fifty-nine responses with five additional Facebook comments posted on the survey link. Results indicated community opinion predominantly was unsafe and problematic, see *Figures 20 and 21*.

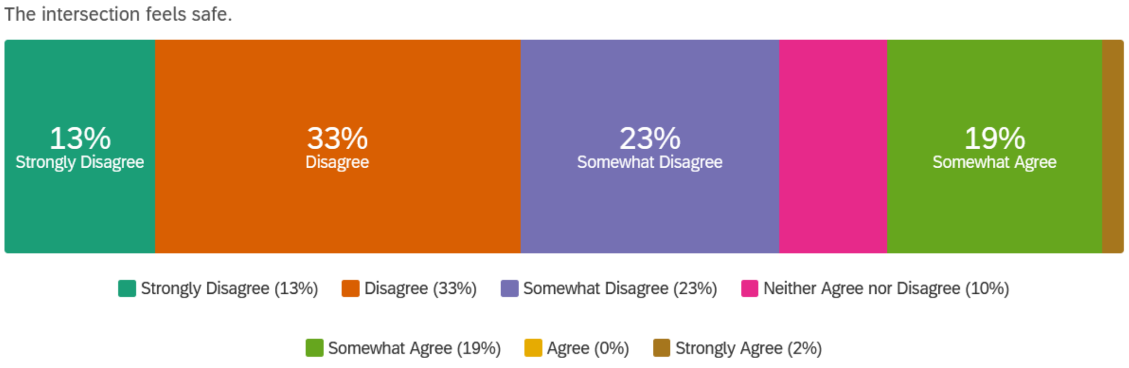


Figure 20: Breakdown Bar of Question 3 from the Community Survey

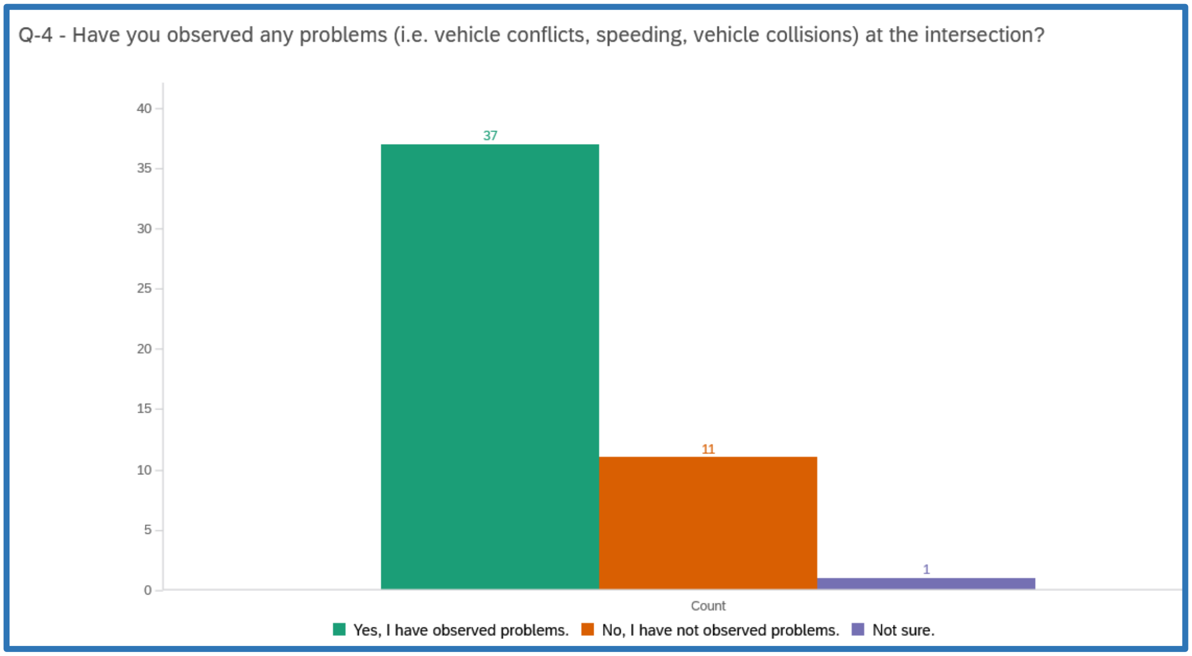


Figure 21: Bar Graph of Question 4 from the Community Survey.

Over fifty percent of responses said they were not sure of which approach had the right-of-way, the number of traffic signs was insufficient, and drivers do not have enough sight distance at the stop sign. Over seventy percent of respondents had at least witnessed conflicts or problems at the intersection. Majority of respondents, thirty-nine, have driven in Fitchburg for 20+ years, with the shortest experience being 6-8 years. Over forty respondents are current residents of Fitchburg, with thirty-four respondents having resided there for over twenty years. Extended results of the survey can be found in *Appendix D*.

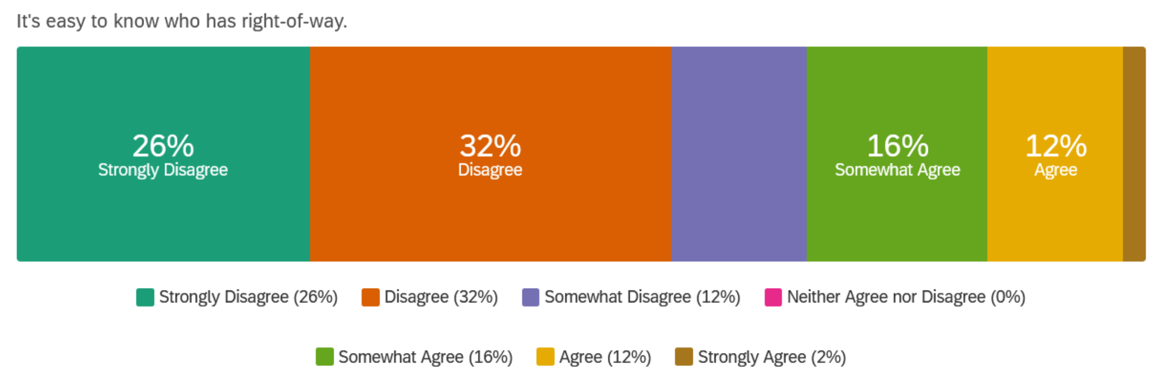


Figure 22: Breakdown Bar of part of Question 3 from the Community Survey

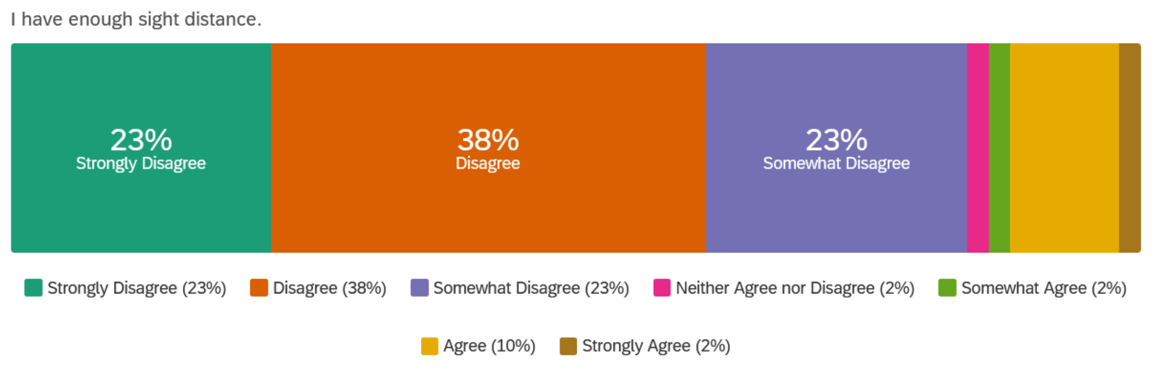


Figure 23: Breakdown Bar of another part of Question 3 from the Community Survey

4.2.9.2 Interviews

Two interviews were conducted in order to gain more valuable insight into the needs of the community. The first interview was with an engineer in wastewater for the Public Works Department of Fitchburg. They emphasized the geometry of the intersection to be the root of the issues. They offered different solutions they thought to be feasible given their experience with the city. They also gave the team contact information for the Commissioner of Public Works for Fitchburg. The second interview was with the manager of Super Mart, the small mini market located right at the curve of Westminster and River Street. The manager indicated they have wanted the intersection to be addressed for a while and would like to see a solution soon. They did not give any ideas for solutions; their focus was to emphasize the immediate need for action.

4.3 Objective 3: Develop Intersection Redesign Alternatives Results

The third objective was to develop intersection redesign alternatives. These alternatives were designed specifically to address the most prevalent issues of the intersection. These issues include unsatisfactory sight distance due to awkward geometrics and the lack of right-of-way for a high-volume street, Westminster Street.

4.3.1 Roundabout Design

Provided in F*igure 24* is a design drawing of the intersection under study. Specifically, the red circles mark the smallest and largest Inscribed Circle Diameter (ICD) acceptable by MassDOT.

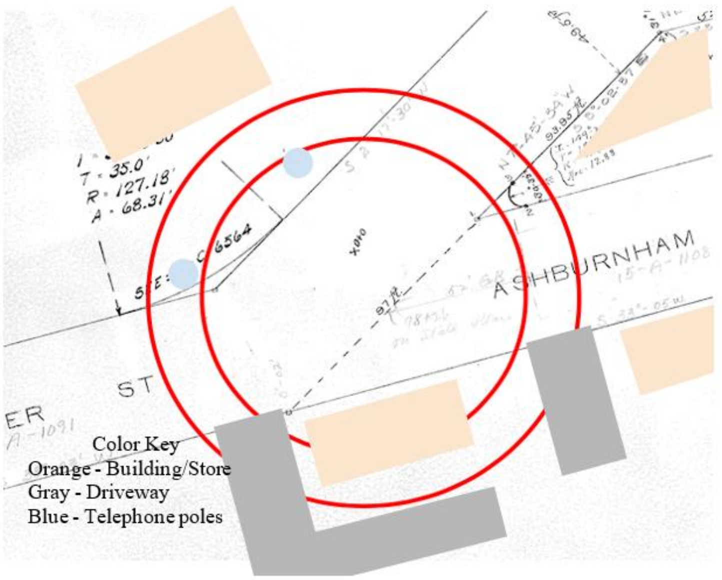


Figure 24: Roundabout Diagram

The inner circle has a diameter of 110 feet and the outer circle has a diameter of 150 feet. As shown in the figure, this range of ICD is much too large for this intersection interfering with the surrounding establishments. The surrounding establishments directly interfering with the geometry of a roundabout include two telephone poles, a driveway, and an apartment building. Additionally, there is a convenience store behind the telephone poles on the upper left-hand side of the diagram that is close in proximity to where the roundabout would be placed. Overall, the feasibility of a roundabout is low due to the extreme measures that would need to be taken in order to construct and implement it.

4.3.2 Geometric Improvements

One geometric improvement option is to widen the initial arc of the approach from Route 31 (Westminster Street) to improve sight distance. The main issue with this geometric improvement is that taking land from the mini mart may become problematic due to ethical considerations. In this case eminent domain would occur and the City of Fitchburg would have to compensate the owner of the mini mart for turning the private property into public use. This will be an additional cost of the redesign of the current intersection.

Two variations of the design are presented in *Figure 25* and *Figure 26*. The first is the Route 31 bump out that would consist of moving the utility poles approximately 20 feet away from the current location down Westminster St. The approximate cost to move the pole would be $20,000 (MassDOT, 2021). This design variation allows for a smooth transition with the bump out. The other design variation consists of fitting the bump out between the two utility poles which are spaced out by approximately 90 feet. The bump out would be more abrupt and sharp compared to a gradual bump out. The advantage to this variation is that the bump out would cause traffic headed in the northbound direction to slow down to account for the sharper turn. Also, there would not be an added cost for moving the utility pole. Both designs allow for improved safety for the intersection by increasing the sight distance for left hand turns on Route 31 (Westminster Street). This may also decrease the amount of rear end accidents on Route 31 (Westminster Street) with less stop and go movement due to limited sight distance.

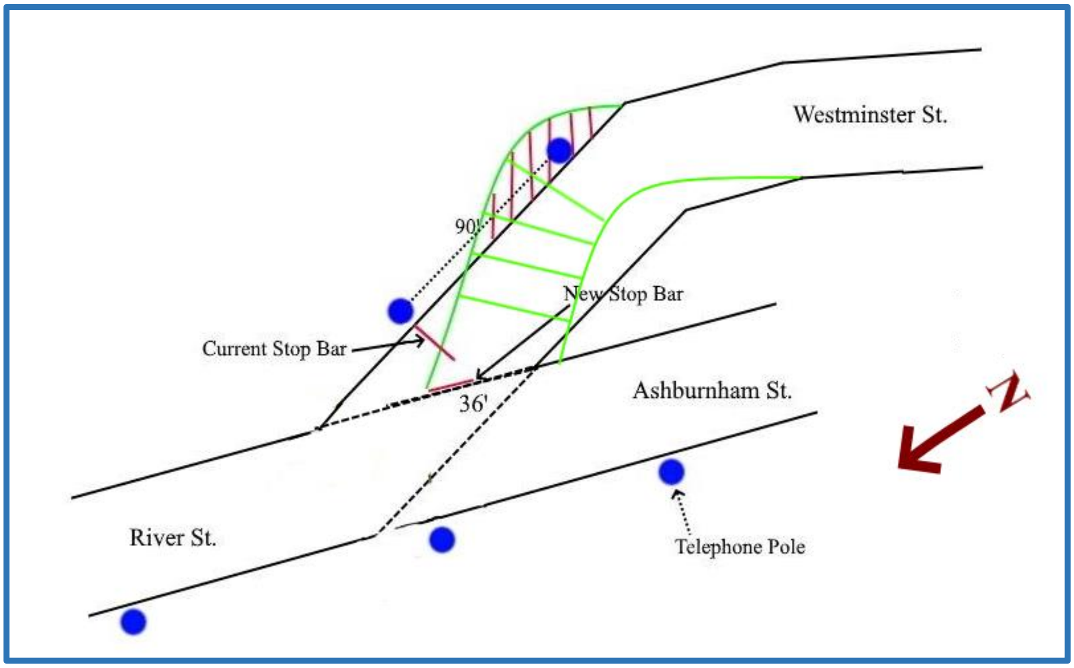


Figure 25: Route 31 Bump Out Design (Moving Utility Pole)

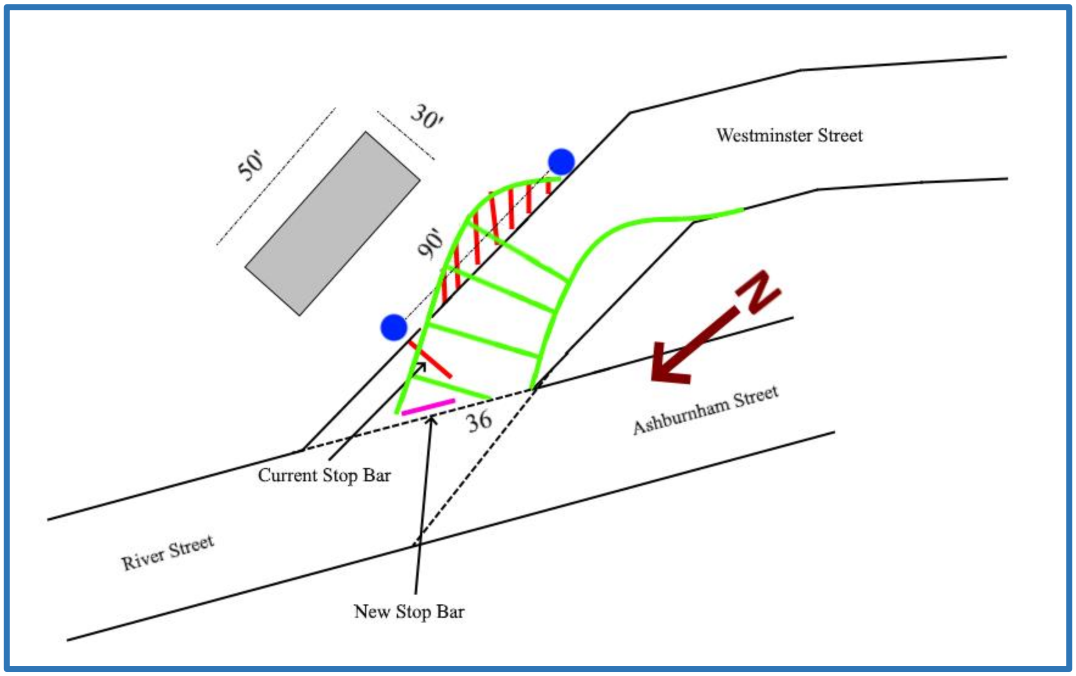


Figure 26: Route 31 Bump Out Design (Not Moving Utility Pole)

According to the MUTCD standards under section 4.0 Geometric and Safety design, the minimum lane width for roads with heavy vehicle percent less than 10% is 10 feet. The new redesign would satisfy this requirement while improving upon the left turn sight distance on Route 31 (Westminster Street). The green line marks the new boundary of the new roadway design, the blue circles indicate the current telephone poles which would not change with the new design. The area in red indicates the land that is currently owned by the mini mart. This land would be used as part of the new roadway design. The bump out design accommodates for a potential signal to be installed at a future date. Additionally, this design can be executed between the two telephone poles to cut costs, however, according to MassDOT utility engineer Ross Goodale, moving telephone poles in this area should not be a significant issue. Telephone poles are moved frequently, according to Ann Sullivan.

Another low-cost geometric improvement involves the construction of a traffic island in the center of the intersection. Shown in *Figure 27*, the island would be used to enhance sight distance for left-hand turns from Westminster Street to Ashburnham Street.

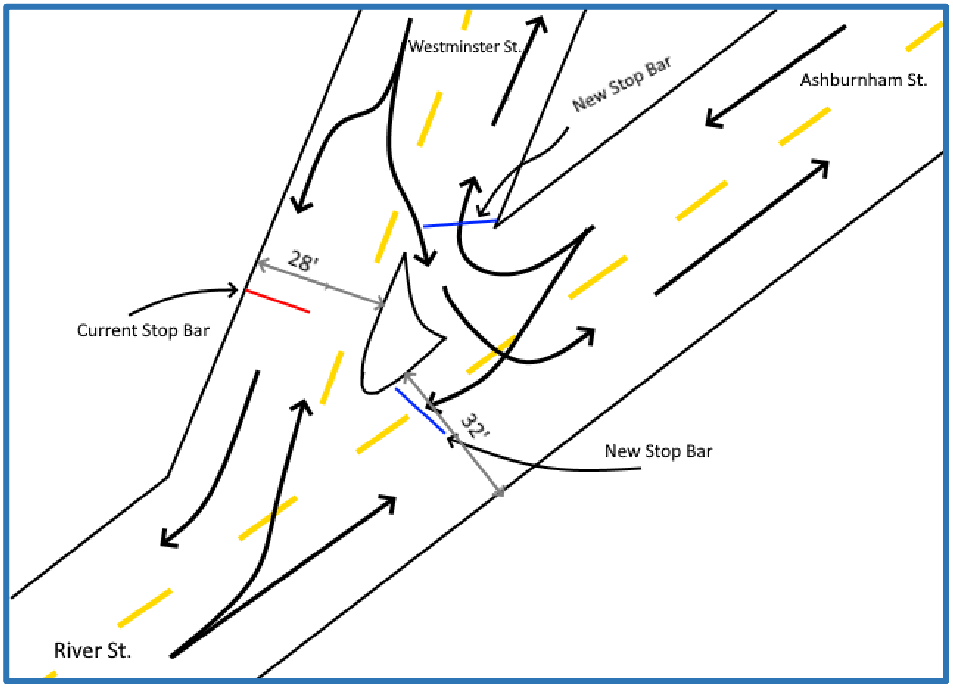


Figure 27: Island Design

Since the busiest legs of the intersection are vehicles moving to and from River/Westminster Street, this design will aid in providing these vehicles with the right-of-way. The existing stop sign on Westminster Street causes traffic buildup and allows the least travelled leg, Ashburnham Street, to have the right-of-way. Additionally, in *Figure 27*, the island would still provide 28 feet and 32 feet on Westminster Street and Ashburnham Street, respectively. This way, the vehicles taking the left onto Ashburnham Street will no longer hold up traffic, instead these vehicles are able to have their own lane to wait for an opportunity to turn.

The island is a viable option, but it would require redesign in the long term to incorporate a signal. In addition, MassDOT had concerns about the longevity of the island. Many times, cars will hit the island and unless it is anchored to the concrete, which can be costly, it will not last long.

4.3.3 Signalization

The intersection met three of the nine warrants calling for signalization. Due to the limited geometry of the intersection the team thought a mast arm style signalization would be more practical vs a span wire signal. As seen in *Figure 28*, the traffic signal would be placed on the corner of River and Westminster Street in order to be seen by each leg.

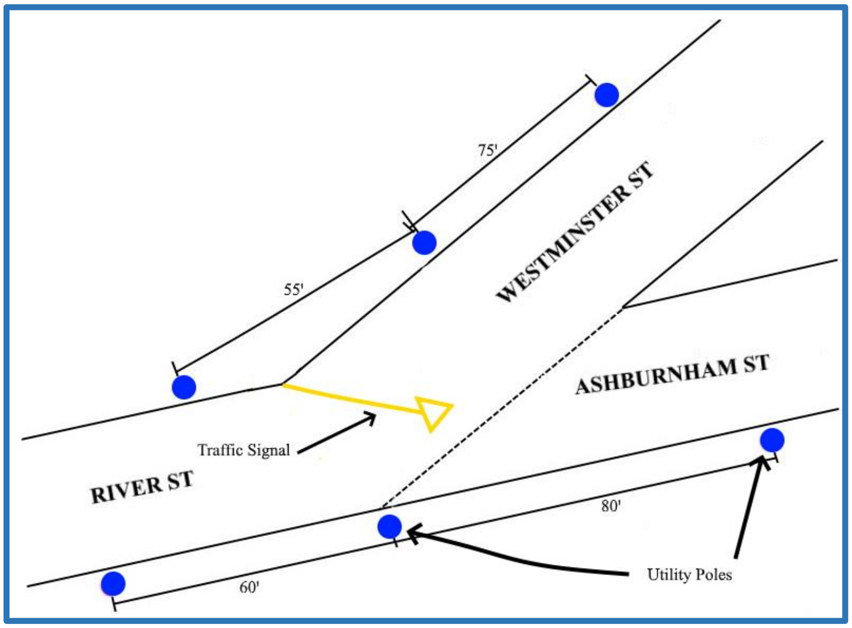


Figure 28: Signalized Intersection Design

Another option for a signal design is to supplement the bump out design with a signal. *Figure 29* below depicts this combination of the Route 31 bump out with signalization.

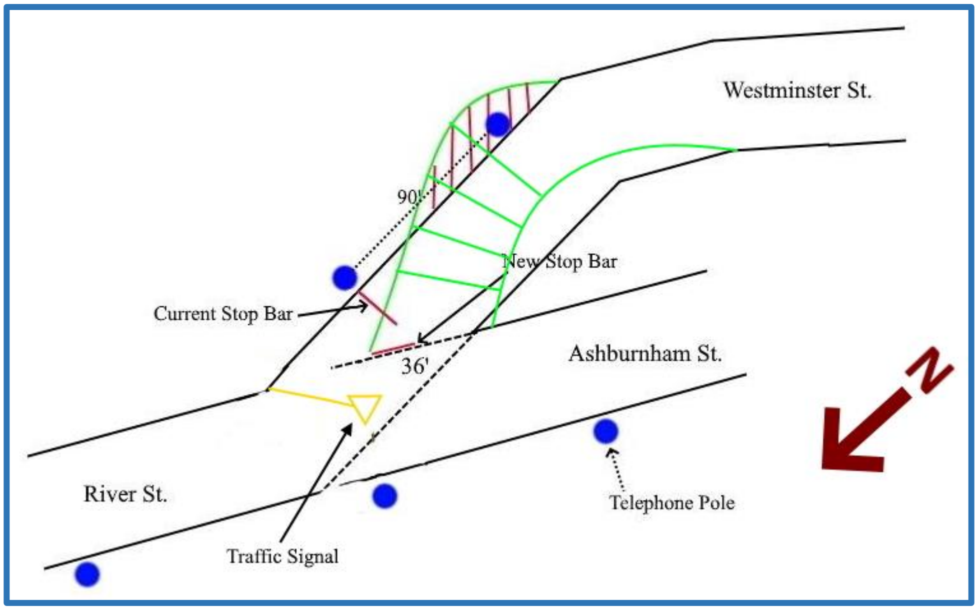


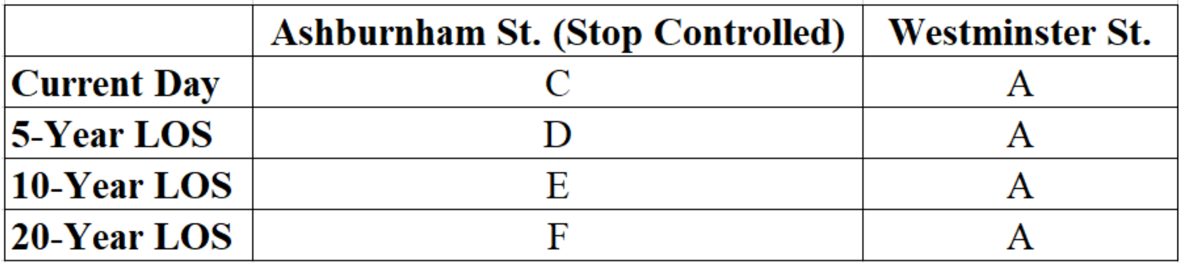
Figure 29: Signalized Intersection with Bump Out and Moving the Utility Poles

4.4 Objective 4: Apply Evaluation Criteria to Design Recommendation(s) Results

In this objective the preliminary designs were evaluated based upon several different criteria standards. The recommendation was decided through a series of evaluation criteria. The evaluation criteria included Transportation Evaluation Criteria sheet scores provided by MRPC, subject matter expert opinions, and Highway Capacity Software level-of-service analysis for the future and stop sign movement. The Transportation Evaluation Criteria (TEC) sheets provide points to proposed projects based on how the project will improve traffic, safety, and mobility of the intersection. Points are also assigned to a project if there is a positive community effect and support, land use and economic development, and environmental effects. After scoring each of the four designs with this criterion, it was determined the island received the highest score of 27 followed by the bump out at 26.5, the signal at 23, and the bump out with a signal at 21. These TEC sheets are typically used to compare proposed projects in different areas to each other instead of designs proposed for the same intersection. Therefore, the team was able to compare the advantages and disadvantages between each preliminary design, giving MassDOT and MRPC an indication of how impactful each design can be.

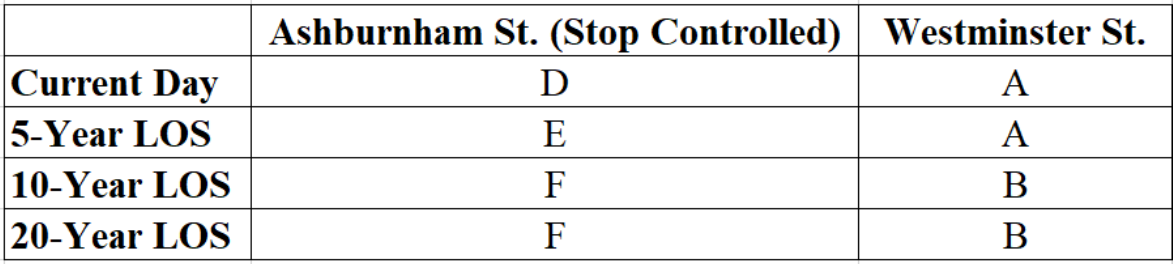
The team then met with traffic engineers, planners, and public officials to discuss the options. These experts included Ann Sullivan, a MassDOT engineer, Sara Bradbury, a MassDOT planner, Nick Bosonetto, the Commissioner of Public Works for the City of Fitchburg, Alolade Campbell, a MassDOT engineer, and Ross Goodale, a MassDOT engineer. After meeting with each expert, the bump out and island were singled out to be investigated further as short-term solutions.

The island focuses more on the geometrics of the intersection by moving the placement of the stop sign to Ashburnham Street. In order to determine how effective this change would be, an HCS level-of-service analysis was conducted. Using the data from Objective 2, a level-of-service analysis was conducted for current, 5 years and 10 years into the future with a traffic growth rate of 1.5% (MassDOT, 2018). *Table 5* and *Table 6* show the LOS of each leg for the AM and PM volumes respectively if the stop sign was moved to Ashburnham Street.



	Ashburnham St. (Stop Controlled)	Westminster St.
Current Day	C	A
5-Year LOS	D	A
10-Year LOS	E	A
20-Year LOS	F	A

Table 5: Morning Level of Service for Stop Sign Alignment

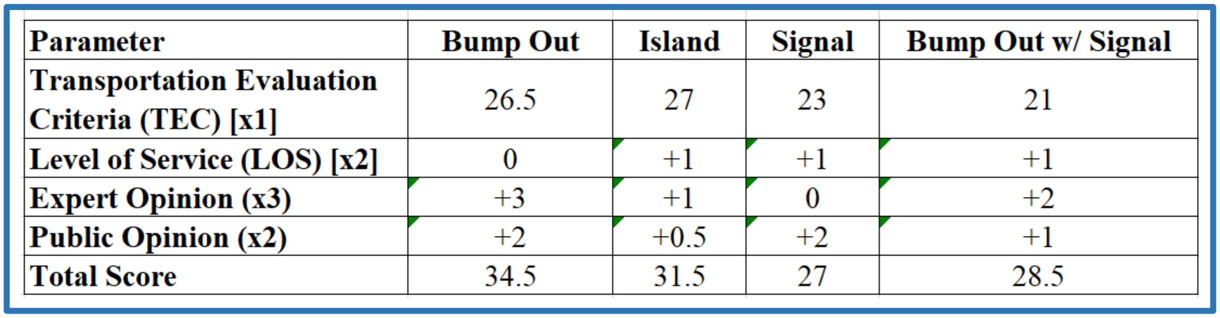


	Ashburnham St. (Stop Controlled)	Westminster St.
Current Day	D	A
5-Year LOS	E	A
10-Year LOS	F	B
20-Year LOS	F	B

Table 6: Afternoon Level of Service for Stop Sign Alignment

This stop sign adjustment provides the major street, River and Westminster Street, with an A level-of-service grade for the AM and PM volumes. This remains constant with the grade the major street received with the existing conditions. Comparing level-of-service for the 5-year future of the stop sign adjustment to the current day stop sign adjustment, the grade on the minor street decreases by one letter grade. The stop sign adjustment receives a higher 5-year grade than the level-of-service analysis grade of the existing intersection. These results, according to the analysis, mean that the stop sign adjustment will be an improvement to the intersection. However, after ten years Ashburnham Street will fail during the PM peak hour. Therefore, this improvement works until the ten-year mark when another design change is needed. Considering three signal warrants were passed in the signal warrant analysis, a signal will be needed in the future. Considering compatibility, the Route 31 bump out is more compatible with signalization based upon the geometric configuration of the design in comparison to the island design.

After compiling these criteria, *Table 7* below shows the score for each respective evaluation criteria for each preliminary design. These scores will be used to select the final recommendation.



Parameter	Bump Out	Island	Signal	Bump Out w/ Signal
Transportation Evaluation Criteria (TEC) [x1]	26.5	27	23	21
Level of Service (LOS) [x2]	0	+1	+1	+1
Expert Opinion (x3)	+3	+1	0	+2
Public Opinion (x2)	+2	+0.5	+2	+1
Total Score	34.5	31.5	27	28.5

Table 7: Evaluation Criteria and Comparative Scoring of Each Design

The TEC scores were scaled to the overall score times 1 while level-of-service and expert and public opinion scores are scaled, respectively, 2 and 5 times the overall score. This is due to the level at which each parameter contributed to the final decision as well as the level of importance in moving along a project. For example, a negative public opinion can delay or even cancel a public project due to public backlash. The TEC scores were taken from filling out the score template shown in *Appendix E* while the level-of-service score was determined by the benefit the design change provides to the LOS of the intersection. The expert opinion scores are determined by the number of experts who picked that specific design as beneficial for the intersection. Lastly the public opinion was scored based on what and how the design addressed problems and how much disturbance is caused by constructing the design. The bump out and Signal were scored with the highest of 2 because they address the problems indicated by the public. The combination scored a 1.5 because although it addresses the problems, adding both elements in would create more disturbance. The island scored lowest because this would cause great disturbance during construction and would require the behavior of the drivers to change drastically. The TEC score for each design can be found in *Appendix F* and *Appendix I*.

5 Conclusion

The final recommendation comes in the form of short term and long-term design changes. The short-term design recommendation is the bump out to correct the geometric difficulties of the intersection while the long-term recommendation includes the addition of a signal to the bump out. This way, the bump out will improve the intersection in the meantime until the signal is approved and funded, which should occur around the same time the HCS analysis shows the intersection will fail, in approximately 10+ years. The bump out design in which the utility poles are relocated was chosen to give extra room for the turn. These recommendations are shown below in *Figure 30* and *Figure 31*.

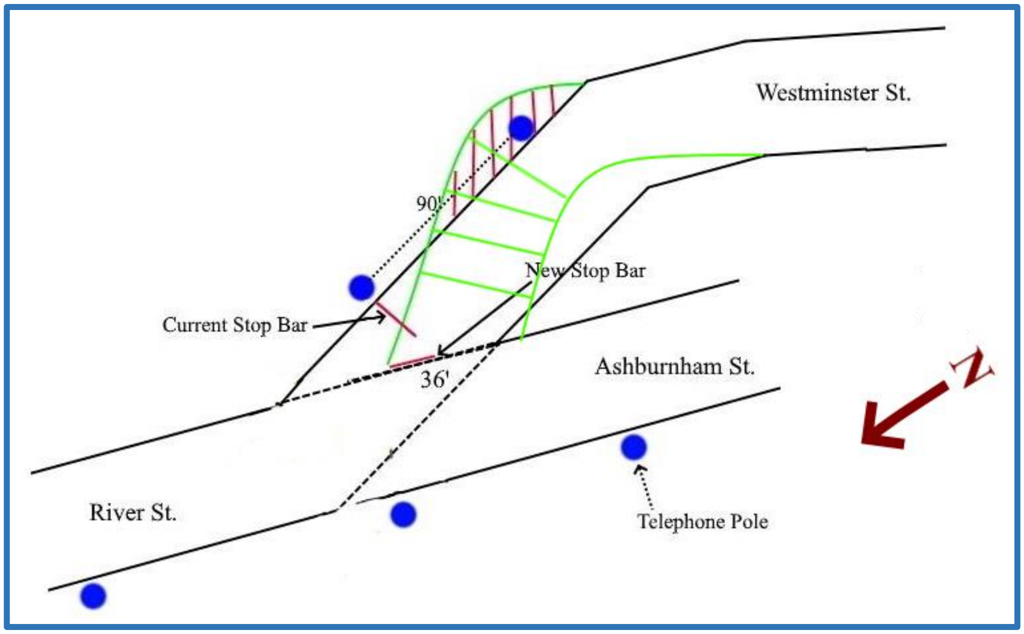


Figure 30: Short-Term Recommendation

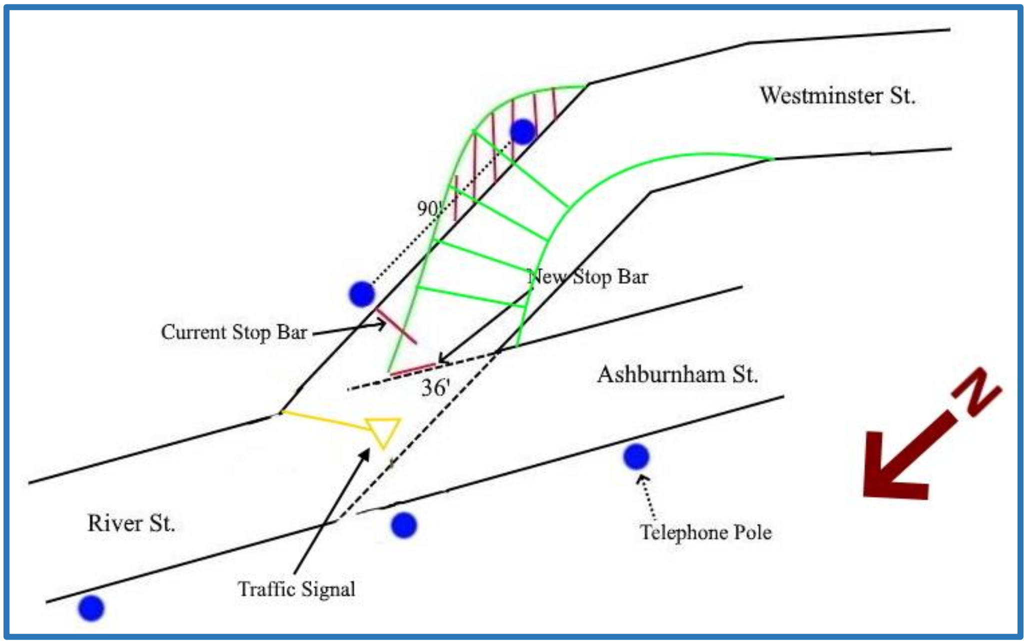
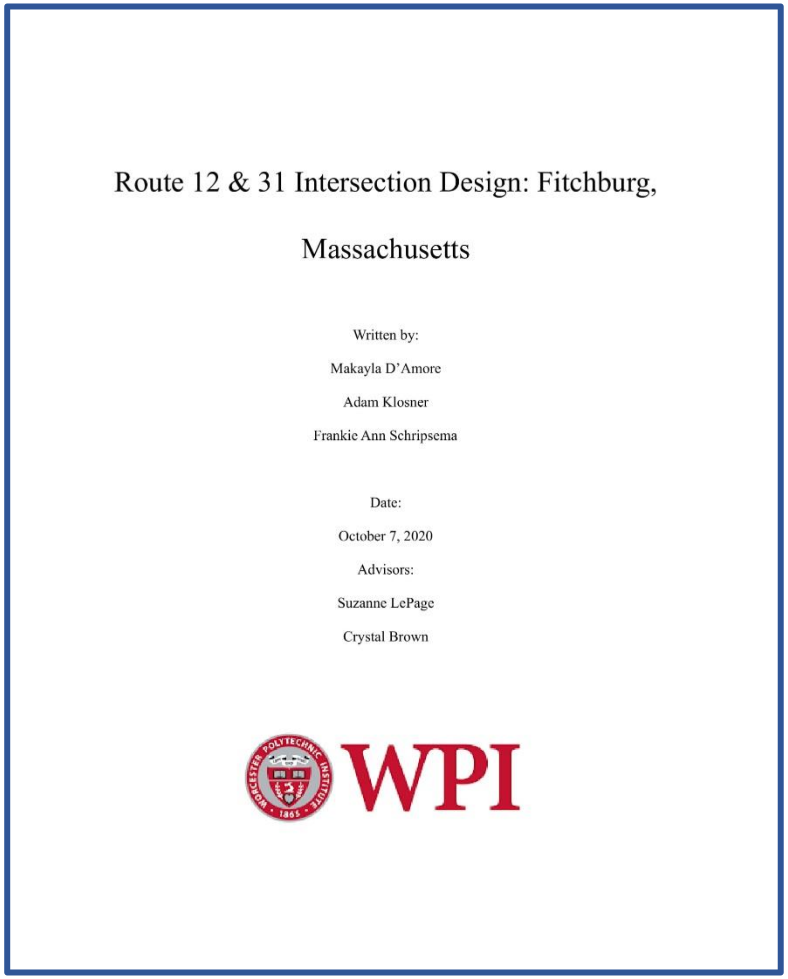


Figure 31: Long-Term Recommendation

Appendices

Appendix A: Project Proposal



Route 12 & 31 Intersection Design: Fitchburg, Massachusetts

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October 7, 2020

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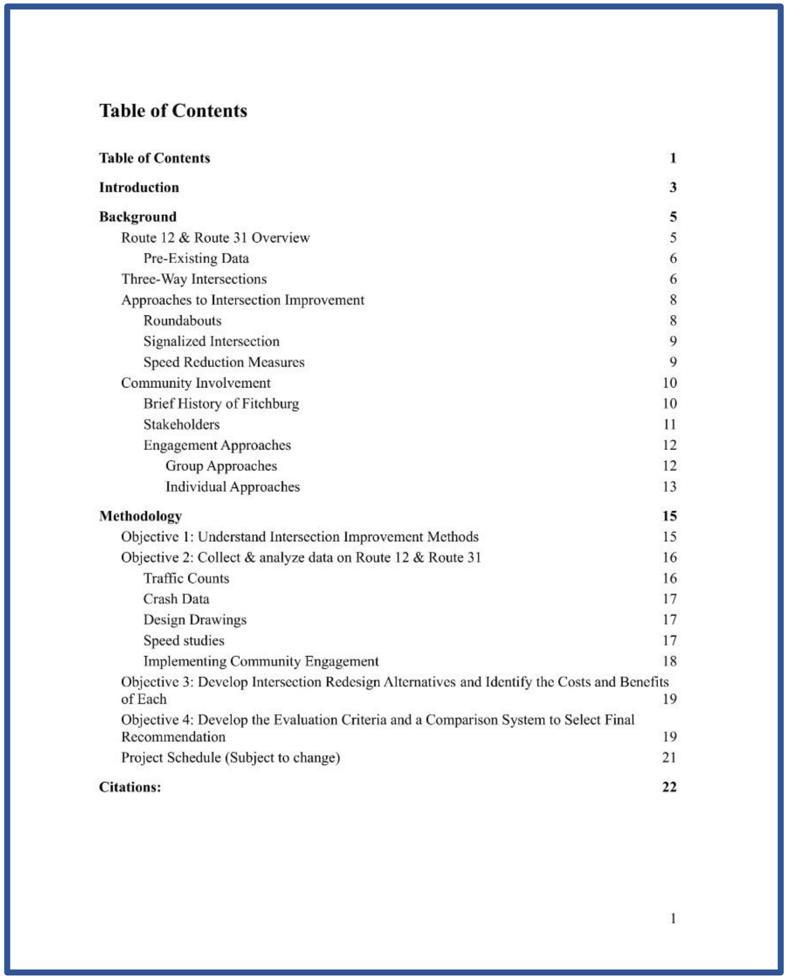

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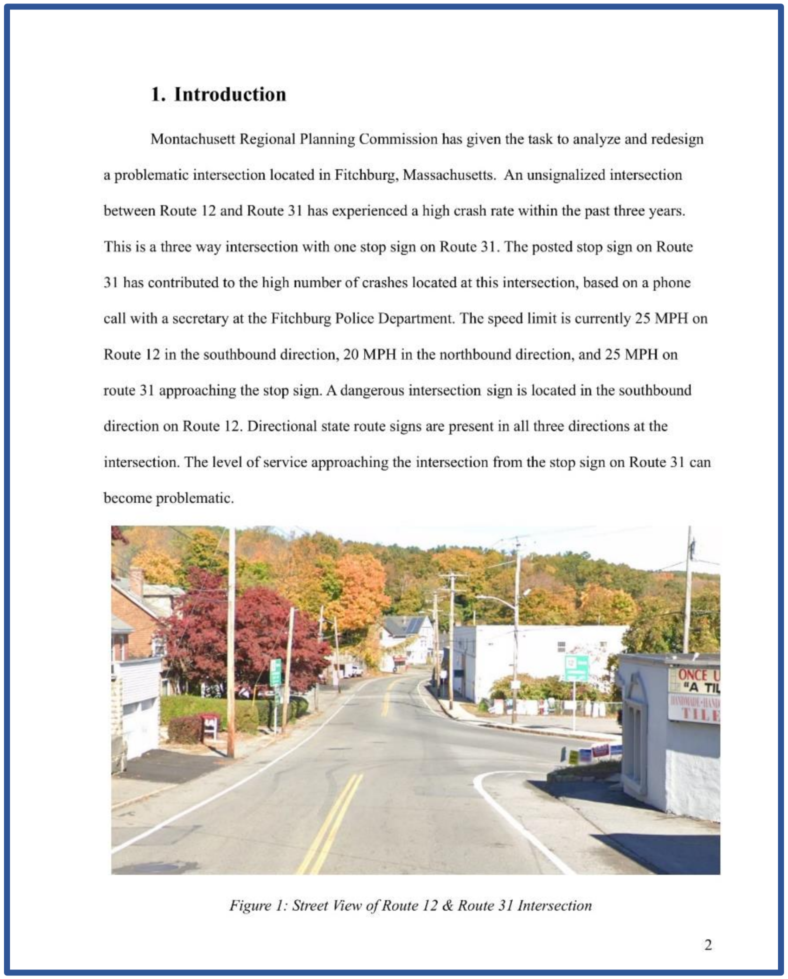
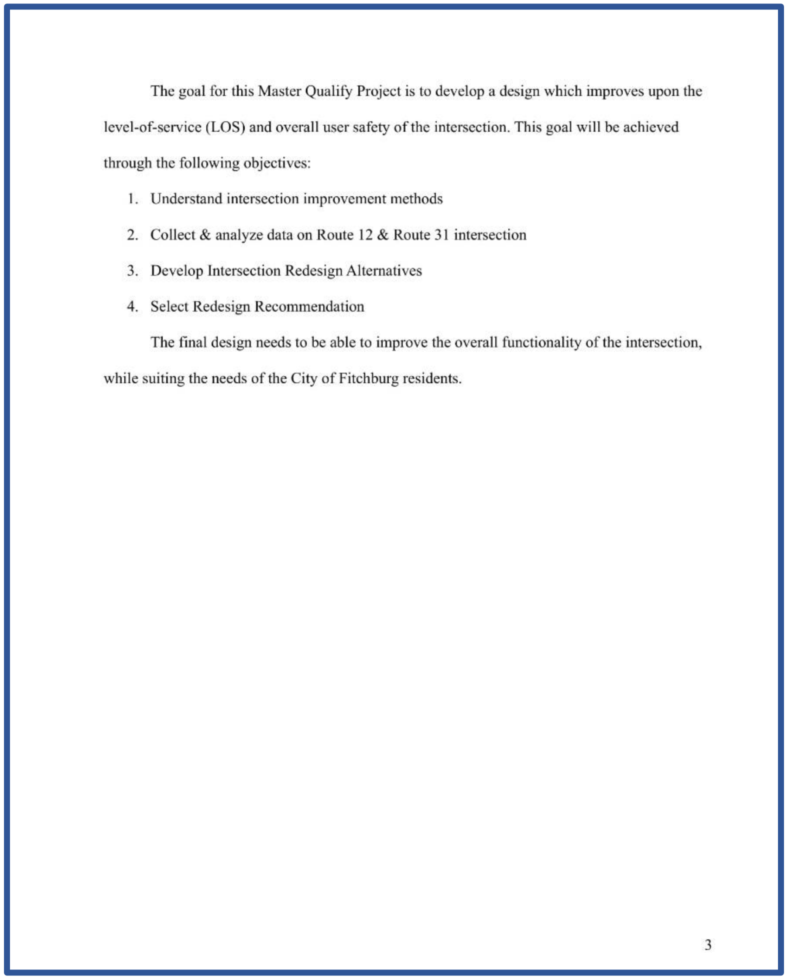


1. Introduction

Montachusett Regional Planning Commission has given the task to analyze and redesign a problematic intersection located in Fitchburg, Massachusetts. An unsignalized intersection between Route 12 and Route 31 has experienced a high crash rate within the past three years. This is a three way intersection with one stop sign on Route 31. The posted stop sign on Route 31 has contributed to the high number of crashes located at this intersection, based on a phone call with a secretary at the Fitchburg Police Department. The speed limit is currently 25 MPH on Route 12 in the southbound direction, 20 MPH in the northbound direction, and 25 MPH on route 31 approaching the stop sign. A dangerous intersection sign is located in the southbound direction on Route 12. Directional state route signs are present in all three directions at the intersection. The level of service approaching the intersection from the stop sign on Route 31 can become problematic.

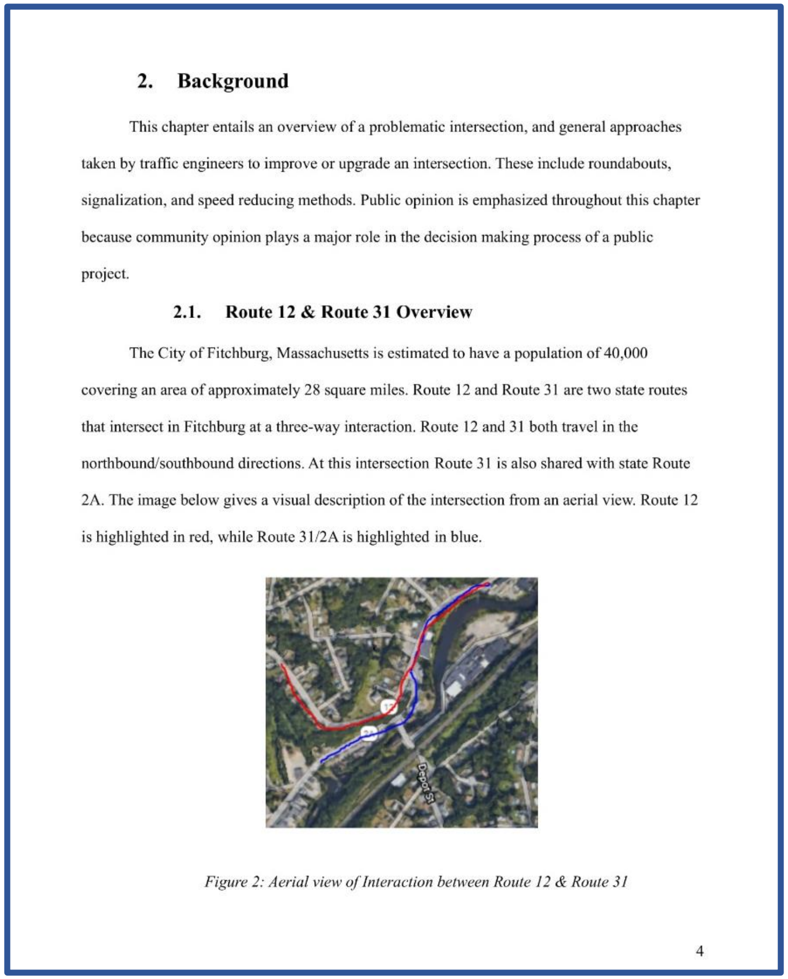
Figure 1: Street View of Route 12 & Route 31 Intersection



The goal for this Master Qualify Project is to develop a design which improves upon the level-of-service (LOS) and overall user safety of the intersection. This goal will be achieved through the following objectives:

1. Understand intersection improvement methods
2. Collect & analyze data on Route 12 & Route 31 intersection
3. Develop Intersection Redesign Alternatives
4. Select Redesign Recommendation

The final design needs to be able to improve the overall functionality of the intersection, while suiting the needs of the City of Fitchburg residents.



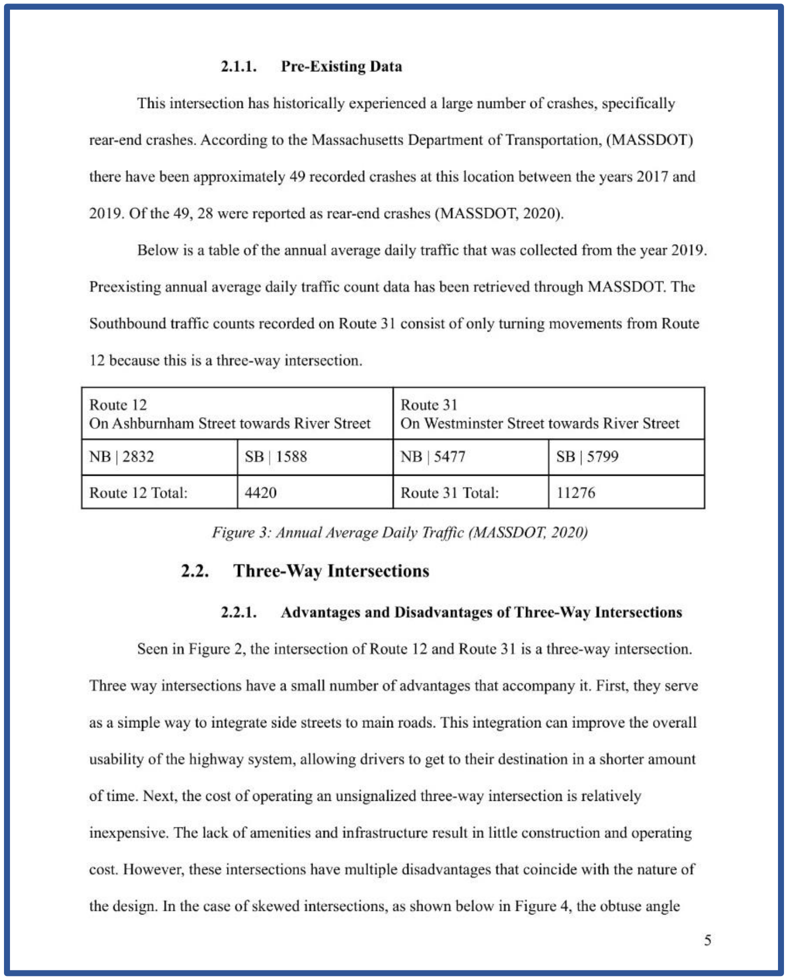
2. Background

This chapter entails an overview of a problematic intersection, and general approaches taken by traffic engineers to improve or upgrade an intersection. These include roundabouts, signalization, and speed reducing methods. Public opinion is emphasized throughout this chapter because community opinion plays a major role in the decision making process of a public project.

2.1. Route 12 & Route 31 Overview

The City of Fitchburg, Massachusetts is estimated to have a population of 40,000 covering an area of approximately 28 square miles. Route 12 and Route 31 are two state routes that intersect in Fitchburg at a three-way interaction. Route 12 and 31 both travel in the northbound/southbound directions. At this intersection Route 31 is also shared with state Route 2A. The image below gives a visual description of the intersection from an aerial view. Route 12 is highlighted in red, while Route 31/2A is highlighted in blue.

Figure 2: Aerial view of Interaction between Route 12 & Route 31



2.1.1. Pre-Existing Data

This intersection has historically experienced a large number of crashes, specifically rear-end crashes. According to the Massachusetts Department of Transportation, (MASSDOT) there have been approximately 49 recorded crashes at this location between the years 2017 and 2019. Of the 49, 28 were reported as rear-end crashes (MASSDOT, 2020).

Below is a table of the annual average daily traffic that was collected from the year 2019. Preexisting annual average daily traffic count data has been retrieved through MASSDOT. The Southbound traffic counts recorded on Route 31 consist of only turning movements from Route 12 because this is a three-way intersection.

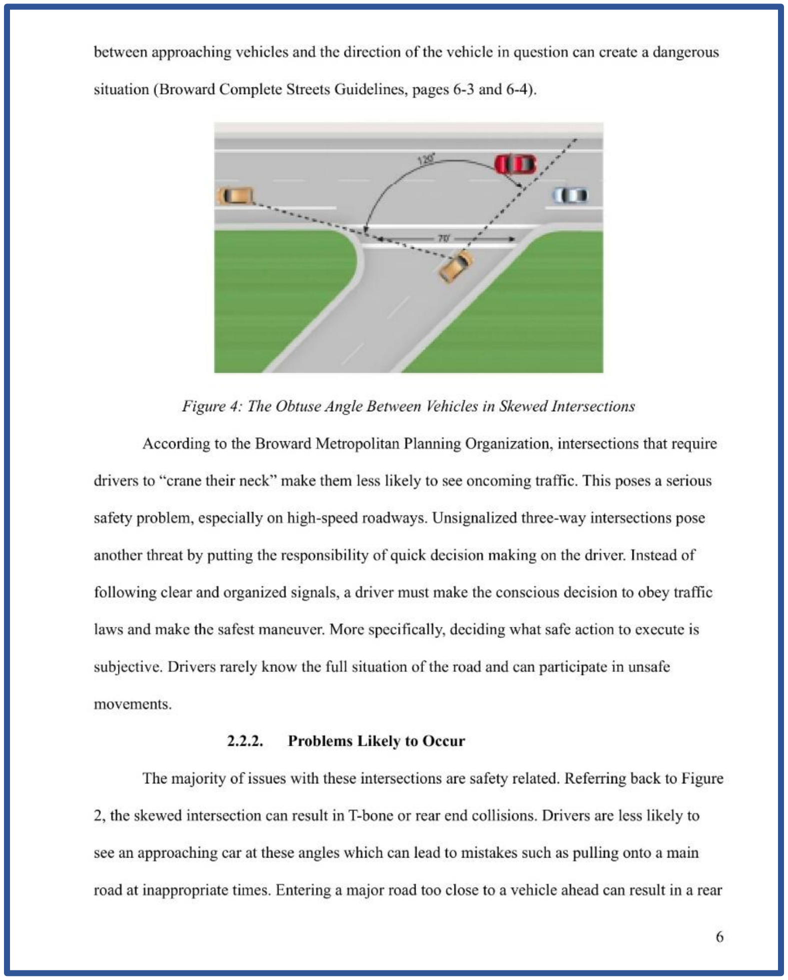
Route 12 On Ashburnham Street towards River Street		Route 31 On Westminster Street towards River Street	
NB | 2832	SB | 1588	NB | 5477	SB | 5799
Route 12 Total:	4420	Route 31 Total:	11276

Figure 3: Annual Average Daily Traffic (MASSDOT, 2020)

2.2. Three-Way Intersections

2.2.1. Advantages and Disadvantages of Three-Way Intersections

Seen in Figure 2, the intersection of Route 12 and Route 31 is a three-way intersection. Three way intersections have a small number of advantages that accompany it. First, they serve as a simple way to integrate side streets to main roads. This integration can improve the overall usability of the highway system, allowing drivers to get to their destination in a shorter amount of time. Next, the cost of operating an unsignalized three-way intersection is relatively inexpensive. The lack of amenities and infrastructure result in little construction and operating cost. However, these intersections have multiple disadvantages that coincide with the nature of the design. In the case of skewed intersections, as shown below in Figure 4, the obtuse angle



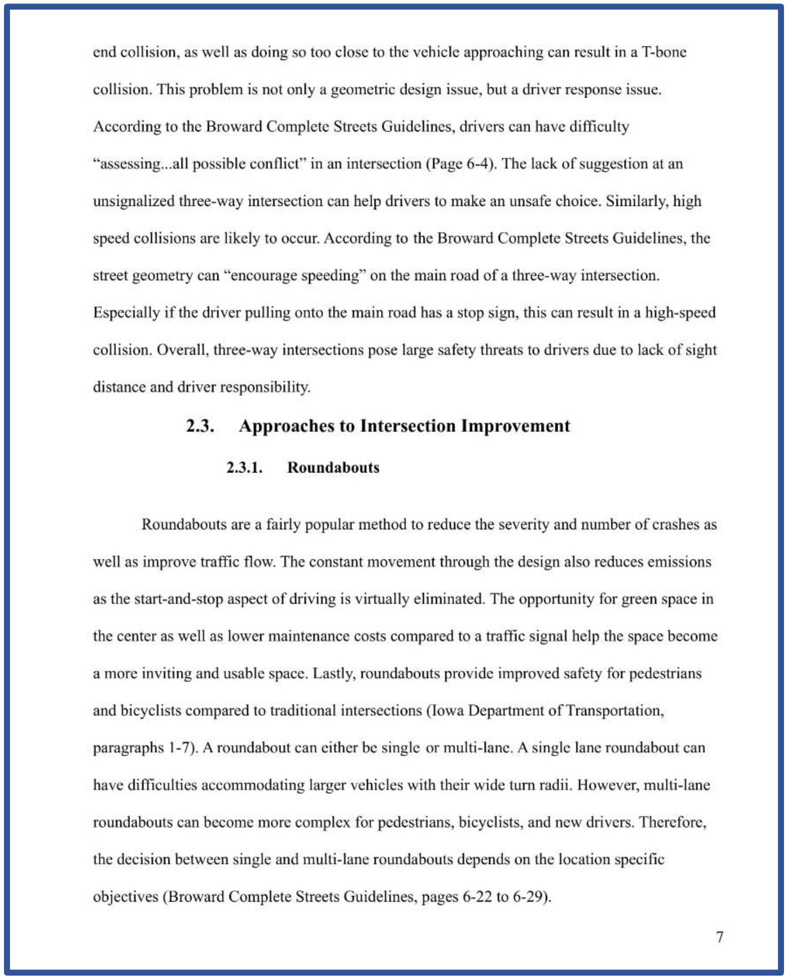
between approaching vehicles and the direction of the vehicle in question can create a dangerous situation (Broward Complete Streets Guidelines, pages 6-3 and 6-4).

Figure 4: The Obtuse Angle Between Vehicles in Skewed Intersections

According to the Broward Metropolitan Planning Organization, intersections that require drivers to "crane their neck" make them less likely to see oncoming traffic. This poses a serious safety problem, especially on high-speed roadways. Unsignalized three-way intersections pose another threat by putting the responsibility of quick decision making on the driver. Instead of following clear and organized signals, a driver must make the conscious decision to obey traffic laws and make the safest maneuver. More specifically, deciding what safe action to execute is subjective. Drivers rarely know the full situation of the road and can participate in unsafe movements.

2.2.2. Problems Likely to Occur

The majority of issues with these intersections are safety related. Referring back to Figure 2, the skewed intersection can result in T-bone or rear end collisions. Drivers are less likely to see an approaching car at these angles which can lead to mistakes such as pulling onto a main road at inappropriate times. Entering a major road too close to a vehicle ahead can result in a rear

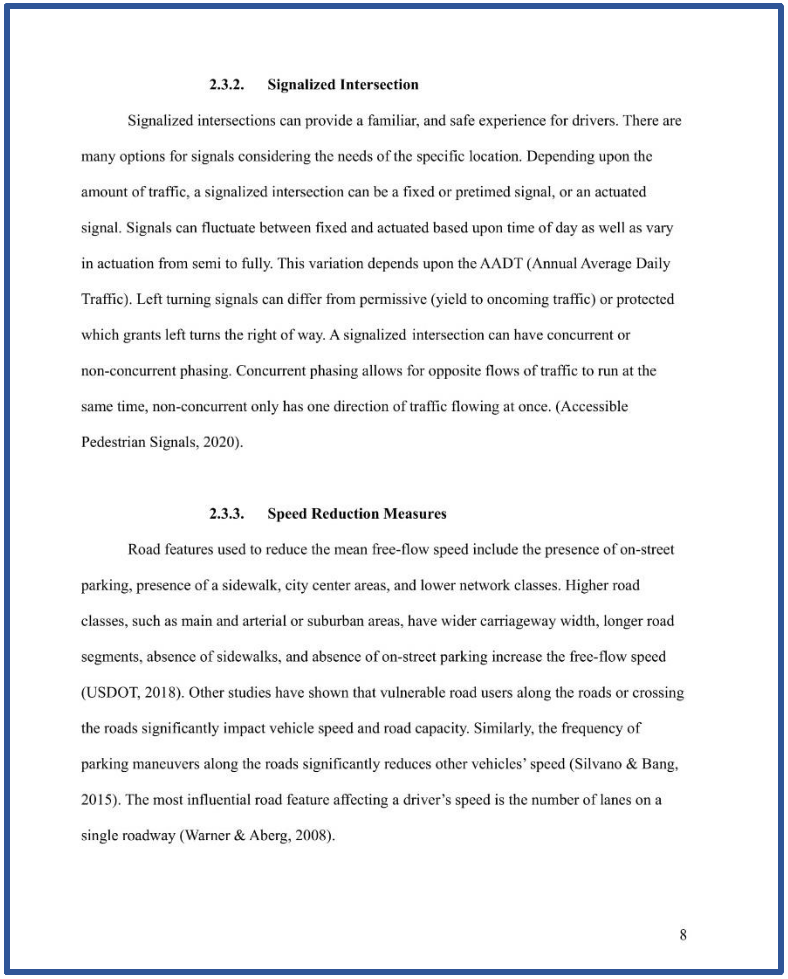


end collision, as well as doing so too close to the vehicle approaching can result in a T-bone collision. This problem is not only a geometric design issue, but a driver response issue. According to the Broward Complete Streets Guidelines, drivers can have difficulty "assessing...all possible conflict" in an intersection (Page 6-4). The lack of suggestion at an unsignalized three-way intersection can help drivers to make an unsafe choice. Similarly, high speed collisions are likely to occur. According to the Broward Complete Streets Guidelines, the street geometry can "encourage speeding" on the main road of a three-way intersection. Especially if the driver pulling onto the main road has a stop sign, this can result in a high-speed collision. Overall, three-way intersections pose large safety threats to drivers due to lack of sight distance and driver responsibility.

2.3. Approaches to Intersection Improvement

2.3.1. Roundabouts

Roundabouts are a fairly popular method to reduce the severity and number of crashes as well as improve traffic flow. The constant movement through the design also reduces emissions as the start-and-stop aspect of driving is virtually eliminated. The opportunity for green space in the center as well as lower maintenance costs compared to a traffic signal help the space become a more inviting and usable space. Lastly, roundabouts provide improved safety for pedestrians and bicyclists compared to traditional intersections (Iowa Department of Transportation, paragraphs 1-7). A roundabout can either be single or multi-lane. A single lane roundabout can have difficulties accommodating larger vehicles with their wide turn radii. However, multi-lane roundabouts can become more complex for pedestrians, bicyclists, and new drivers. Therefore, the decision between single and multi-lane roundabouts depends on the location specific objectives (Broward Complete Streets Guidelines, pages 6-22 to 6-29).

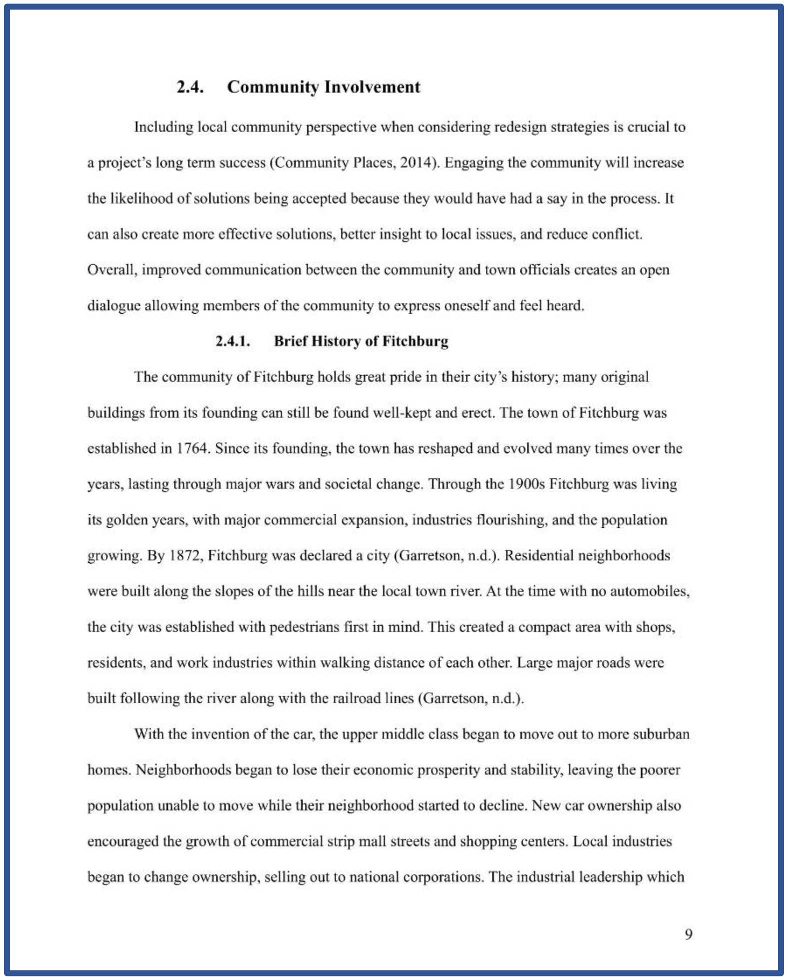


2.3.2. Signalized Intersection

Signalized intersections can provide a familiar, and safe experience for drivers. There are many options for signals considering the needs of the specific location. Depending upon the amount of traffic, a signalized intersection can be a fixed or pretimed signal, or an actuated signal. Signals can fluctuate between fixed and actuated based upon time of day as well as vary in actuation from semi to fully. This variation depends upon the AADT (Annual Average Daily Traffic). Left turning signals can differ from permissive (yield to oncoming traffic) or protected which grants left turns the right of way. A signalized intersection can have concurrent or non-concurrent phasing. Concurrent phasing allows for opposite flows of traffic to run at the same time, non-concurrent only has one direction of traffic flowing at once. (Accessible Pedestrian Signals, 2020).

2.3.3. Speed Reduction Measures

Road features used to reduce the mean free-flow speed include the presence of on-street parking, presence of a sidewalk, city center areas, and lower network classes. Higher road classes, such as main and arterial or suburban areas, have wider carriageway width, longer road segments, absence of sidewalks, and absence of on-street parking increase the free-flow speed (USDOT, 2018). Other studies have shown that vulnerable road users along the roads or crossing the roads significantly impact vehicle speed and road capacity. Similarly, the frequency of parking maneuvers along the roads significantly reduces other vehicles' speed (Silvano & Bang, 2015). The most influential road feature affecting a driver's speed is the number of lanes on a single roadway (Warner & Aberg, 2008).



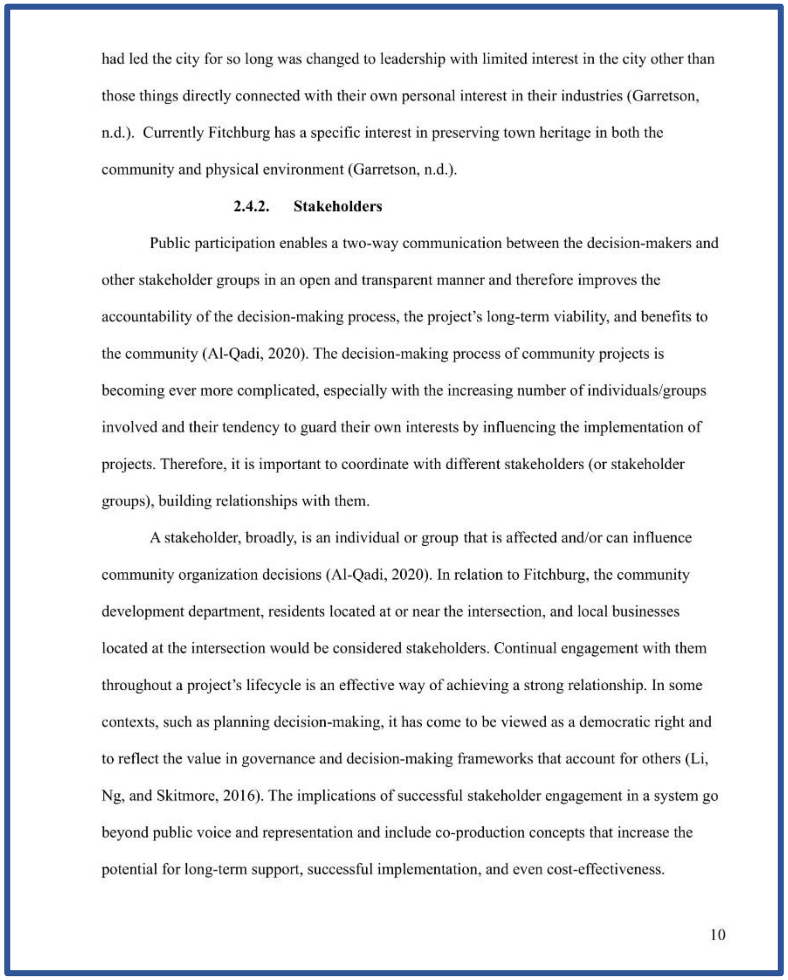
2.4. Community Involvement

Including local community perspective when considering redesign strategies is crucial to a project's long term success (Community Places, 2014). Engaging the community will increase the likelihood of solutions being accepted because they would have had a say in the process. It can also create more effective solutions, better insight to local issues, and reduce conflict. Overall, improved communication between the community and town officials creates an open dialogue allowing members of the community to express oneself and feel heard.

2.4.1. Brief History of Fitchburg

The community of Fitchburg holds great pride in their city's history; many original buildings from its founding can still be found well-kept and erect. The town of Fitchburg was established in 1764. Since its founding, the town has reshaped and evolved many times over the years, lasting through major wars and societal change. Through the 1900s Fitchburg was living its golden years, with major commercial expansion, industries flourishing, and the population growing. By 1872, Fitchburg was declared a city (Garretson, n.d.). Residential neighborhoods were built along the slopes of the hills near the local town river. At the time with no automobiles, the city was established with pedestrians first in mind. This created a compact area with shops, residents, and work industries within walking distance of each other. Large major roads were built following the river along with the railroad lines (Garretson, n.d.).

With the invention of the car, the upper middle class began to move out to more suburban homes. Neighborhoods began to lose their economic prosperity and stability, leaving the poorer population unable to move while their neighborhood started to decline. New car ownership also encouraged the growth of commercial strip mall streets and shopping centers. Local industries began to change ownership, selling out to national corporations. The industrial leadership which

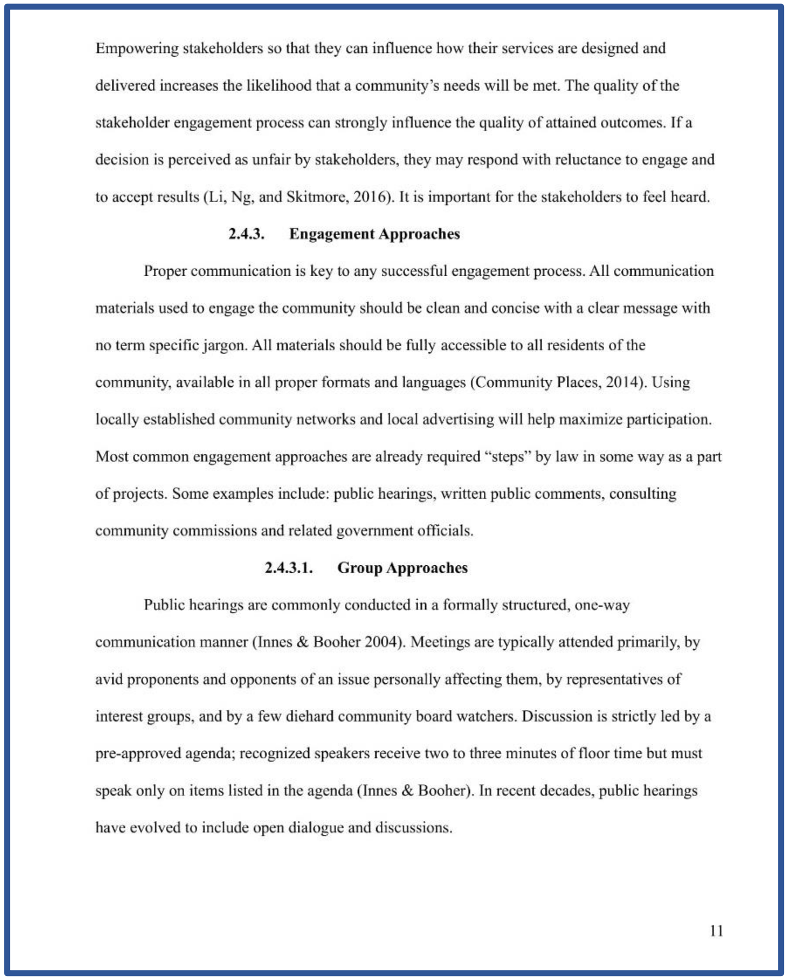


had led the city for so long was changed to leadership with limited interest in the city other than those things directly connected with their own personal interest in their industries (Garretson, n.d.). Currently Fitchburg has a specific interest in preserving town heritage in both the community and physical environment (Garretson, n.d.).

2.4.2. Stakeholders

Public participation enables a two-way communication between the decision-makers and other stakeholder groups in an open and transparent manner and therefore improves the accountability of the decision-making process, the project's long-term viability, and benefits to the community (Al-Qadi, 2020). The decision-making process of community projects is becoming ever more complicated, especially with the increasing number of individuals/groups involved and their tendency to guard their own interests by influencing the implementation of projects. Therefore, it is important to coordinate with different stakeholders (or stakeholder groups), building relationships with them.

A stakeholder, broadly, is an individual or group that is affected and/or can influence community organization decisions (Al-Qadi, 2020). In relation to Fitchburg, the community development department, residents located at or near the intersection, and local businesses located at the intersection would be considered stakeholders. Continual engagement with them throughout a project's lifecycle is an effective way of achieving a strong relationship. In some contexts, such as planning decision-making, it has come to be viewed as a democratic right and to reflect the value in governance and decision-making frameworks that account for others (Li, Ng, and Skitmore, 2016). The implications of successful stakeholder engagement in a system go beyond public voice and representation and include co-production concepts that increase the potential for long-term support, successful implementation, and even cost-effectiveness.



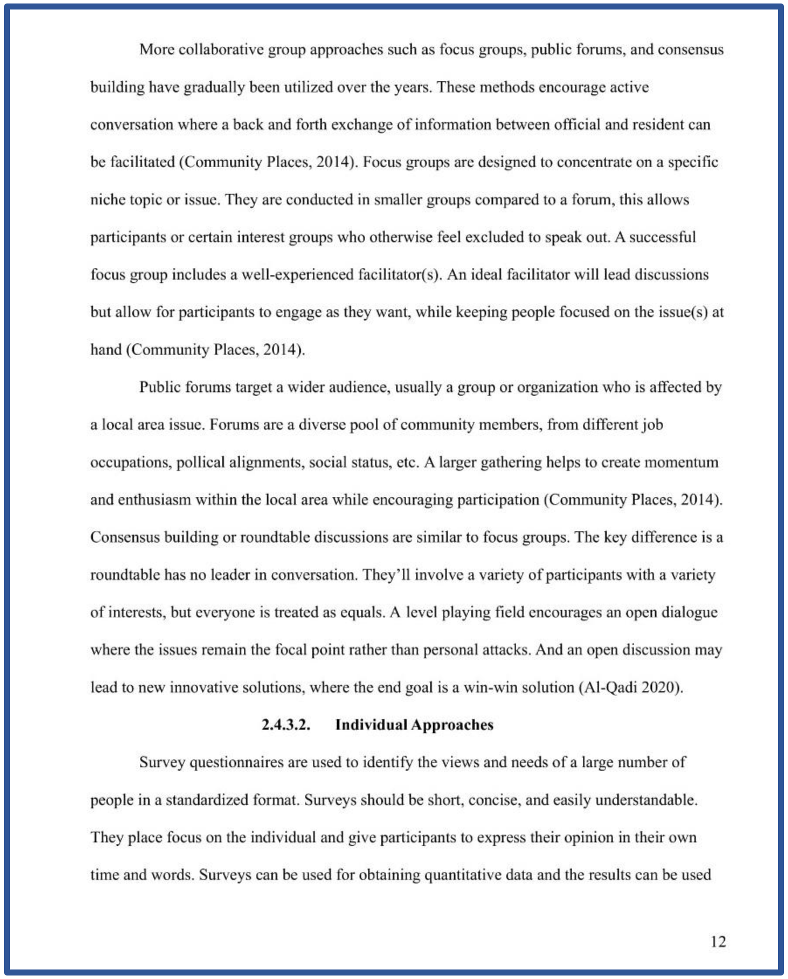
Empowering stakeholders so that they can influence how their services are designed and delivered increases the likelihood that a community's needs will be met. The quality of the stakeholder engagement process can strongly influence the quality of attained outcomes. If a decision is perceived as unfair by stakeholders, they may respond with reluctance to engage and to accept results (Li, Ng, and Skitmore, 2016). It is important for the stakeholders to feel heard.

2.4.3. Engagement Approaches

Proper communication is key to any successful engagement process. All communication materials used to engage the community should be clean and concise with a clear message with no term specific jargon. All materials should be fully accessible to all residents of the community, available in all proper formats and languages (Community Places, 2014). Using locally established community networks and local advertising will help maximize participation. Most common engagement approaches are already required "steps" by law in some way as a part of projects. Some examples include: public hearings, written public comments, consulting community commissions and related government officials.

2.4.3.1. Group Approaches

Public hearings are commonly conducted in a formally structured, one-way communication manner (Innes & Booher 2004). Meetings are typically attended primarily, by avid proponents and opponents of an issue personally affecting them, by representatives of interest groups, and by a few diehard community board watchers. Discussion is strictly led by a pre-approved agenda; recognized speakers receive two to three minutes of floor time but must speak only on items listed in the agenda (Innes & Booher). In recent decades, public hearings have evolved to include open dialogue and discussions.

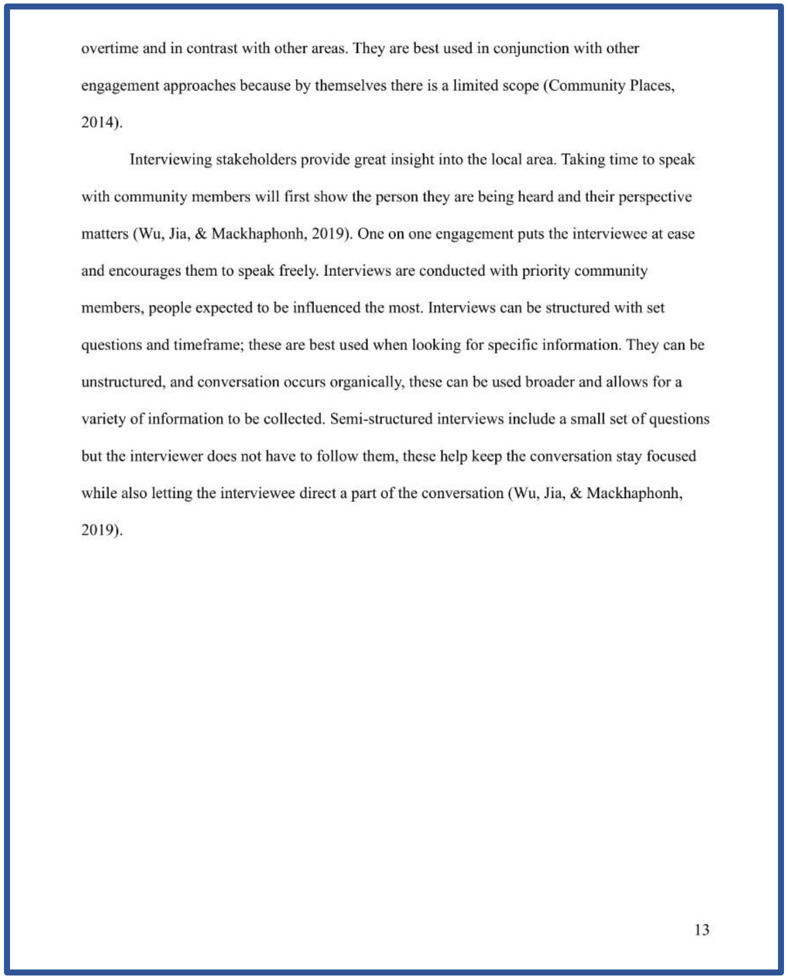


More collaborative group approaches such as focus groups, public forums, and consensus building have gradually been utilized over the years. These methods encourage active conversation where a back and forth exchange of information between official and resident can be facilitated (Community Places, 2014). Focus groups are designed to concentrate on a specific niche topic or issue. They are conducted in smaller groups compared to a forum, this allows participants or certain interest groups who otherwise feel excluded to speak out. A successful focus group includes a well-experienced facilitator(s). An ideal facilitator will lead discussions but allow for participants to engage as they want, while keeping people focused on the issue(s) at hand (Community Places, 2014).

Public forums target a wider audience, usually a group or organization who is affected by a local area issue. Forums are a diverse pool of community members, from different job occupations, pollical alignments, social status, etc. A larger gathering helps to create momentum and enthusiasm within the local area while encouraging participation (Community Places, 2014). Consensus building or roundtable discussions are similar to focus groups. The key difference is a roundtable has no leader in conversation. They'll involve a variety of participants with a variety of interests, but everyone is treated as equals. A level playing field encourages an open dialogue where the issues remain the focal point rather than personal attacks. And an open discussion may lead to new innovative solutions, where the end goal is a win-win solution (Al-Qadi 2020).

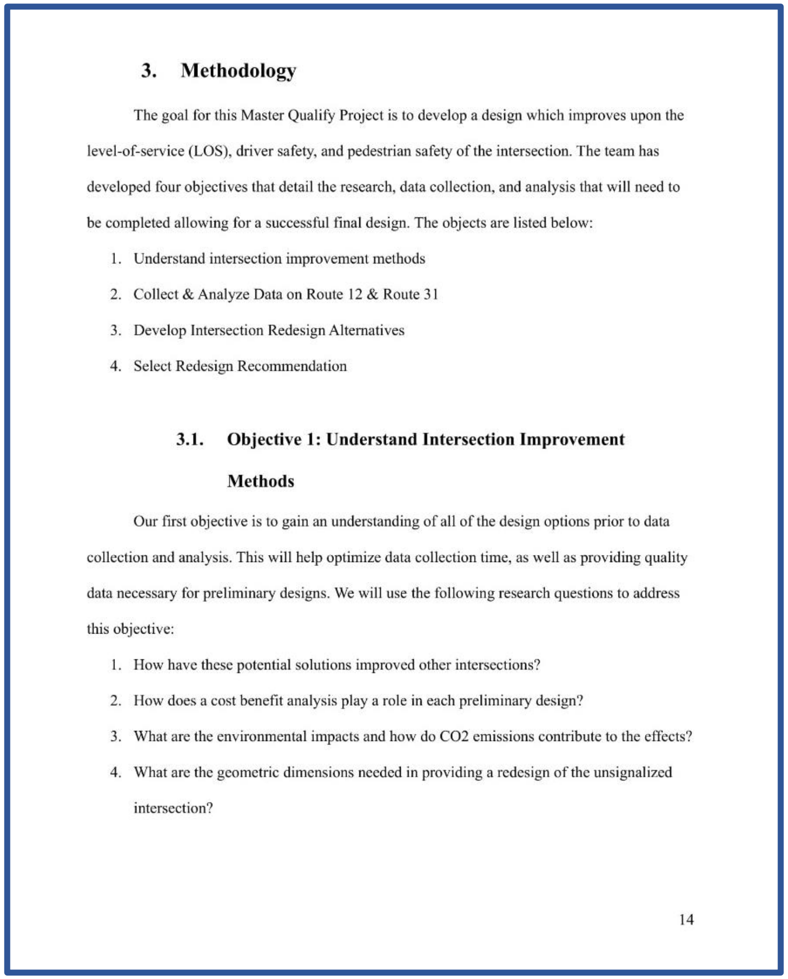
2.4.3.2. Individual Approaches

Survey questionnaires are used to identify the views and needs of a large number of people in a standardized format. Surveys should be short, concise, and easily understandable. They place focus on the individual and give participants to express their opinion in their own time and words. Surveys can be used for obtaining quantitative data and the results can be used



overtime and in contrast with other areas. They are best used in conjunction with other engagement approaches because by themselves there is a limited scope (Community Places, 2014).

Interviewing stakeholders provide great insight into the local area. Taking time to speak with community members will first show the person they are being heard and their perspective matters (Wu, Jia, & Mackhaphonh, 2019). One on one engagement puts the interviewee at ease and encourages them to speak freely. Interviews are conducted with priority community members, people expected to be influenced the most. Interviews can be structured with set questions and timeframe; these are best used when looking for specific information. They can be unstructured, and conversation occurs organically, these can be used broader and allows for a variety of information to be collected. Semi-structured interviews include a small set of questions but the interviewer does not have to follow them, these help keep the conversation stay focused while also letting the interviewee direct a part of the conversation (Wu, Jia, & Mackhaphonh, 2019).



3. Methodology

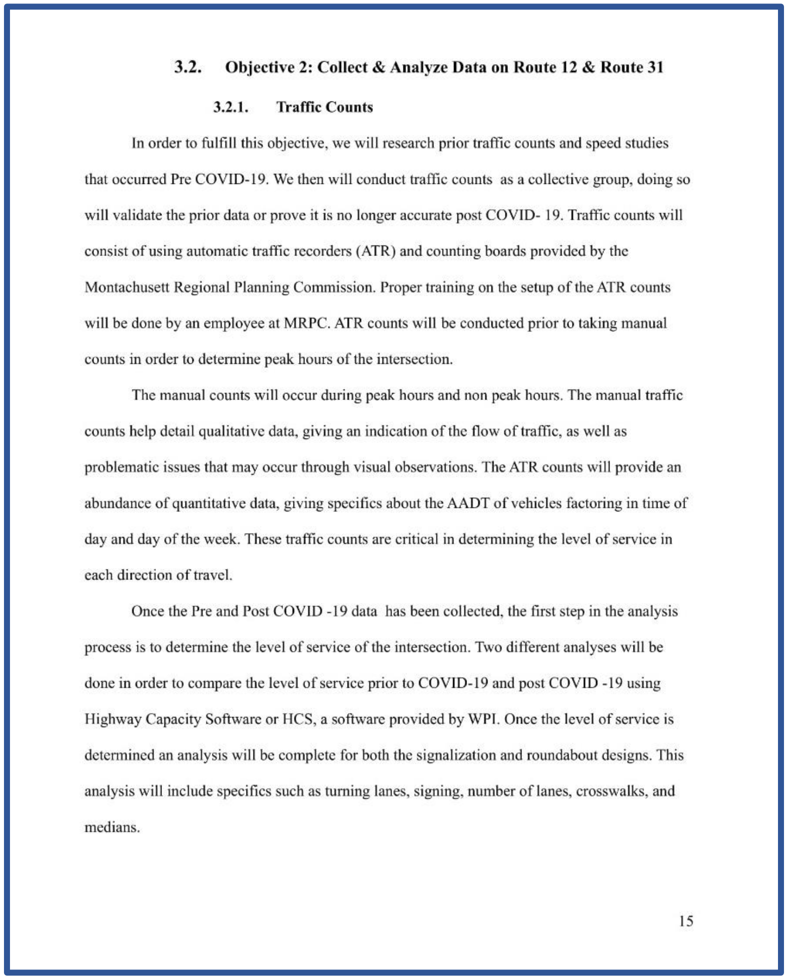
The goal for this Master Qualify Project is to develop a design which improves upon the level-of-service (LOS), driver safety, and pedestrian safety of the intersection. The team has developed four objectives that detail the research, data collection, and analysis that will need to be completed allowing for a successful final design. The objects are listed below:

1. Understand intersection improvement methods
2. Collect & Analyze Data on Route 12 & Route 31
3. Develop Intersection Redesign Alternatives
4. Select Redesign Recommendation

3.1. Objective 1: Understand Intersection Improvement Methods

Our first objective is to gain an understanding of all of the design options prior to data collection and analysis. This will help optimize data collection time, as well as providing quality data necessary for preliminary designs. We will use the following research questions to address this objective:

1. How have these potential solutions improved other intersections?
2. How does a cost benefit analysis play a role in each preliminary design?
3. What are the environmental impacts and how do CO2 emissions contribute to the effects?
4. What are the geometric dimensions needed in providing a redesign of the unsignalized intersection?



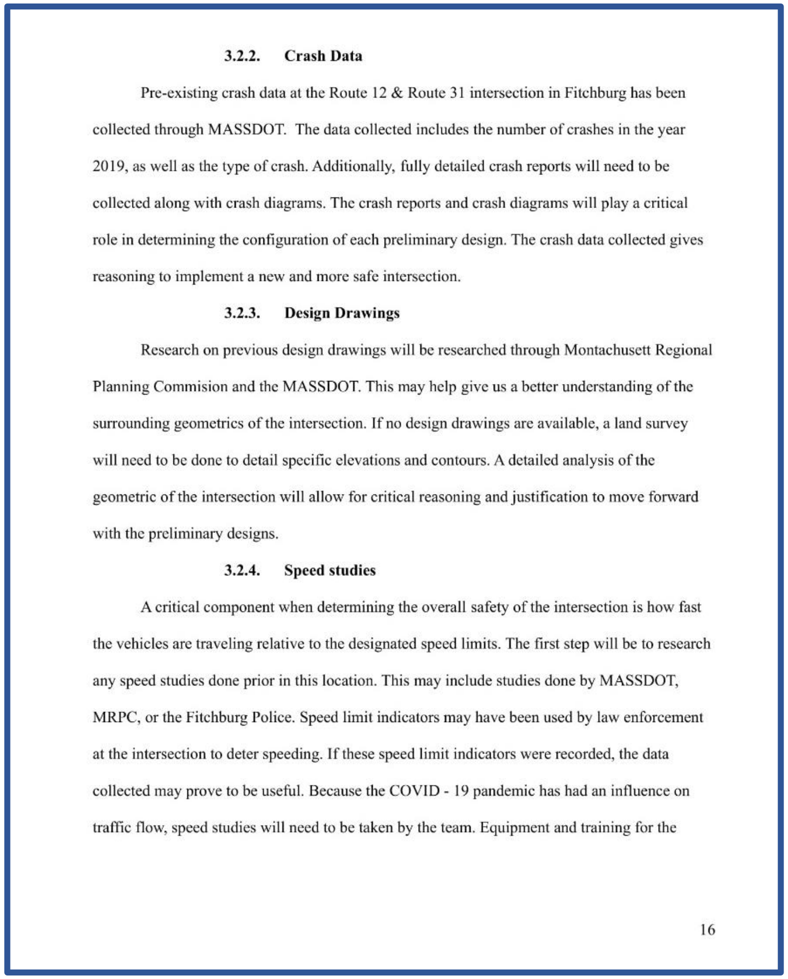
3.2. Objective 2: Collect & Analyze Data on Route 12 & Route 31

3.2.1. Traffic Counts

In order to fulfill this objective, we will research prior traffic counts and speed studies that occurred Pre COVID-19. We then will conduct traffic counts as a collective group, doing so will validate the prior data or prove it is no longer accurate post COVID- 19. Traffic counts will consist of using automatic traffic recorders (ATR) and counting boards provided by the Montachusett Regional Planning Commission. Proper training on the setup of the ATR counts will be done by an employee at MRPC. ATR counts will be conducted prior to taking manual counts in order to determine peak hours of the intersection.

The manual counts will occur during peak hours and non peak hours. The manual traffic counts help detail qualitative data, giving an indication of the flow of traffic, as well as problematic issues that may occur through visual observations. The ATR counts will provide an abundance of quantitative data, giving specifics about the AADT of vehicles factoring in time of day and day of the week. These traffic counts are critical in determining the level of service in each direction of travel.

Once the Pre and Post COVID -19 data has been collected, the first step in the analysis process is to determine the level of service of the intersection. Two different analyses will be done in order to compare the level of service prior to COVID-19 and post COVID -19 using Highway Capacity Software or HCS, a software provided by WPI. Once the level of service is determined an analysis will be complete for both the signalization and roundabout designs. This analysis will include specifics such as turning lanes, signing, number of lanes, crosswalks, and medians.



3.2.2. Crash Data

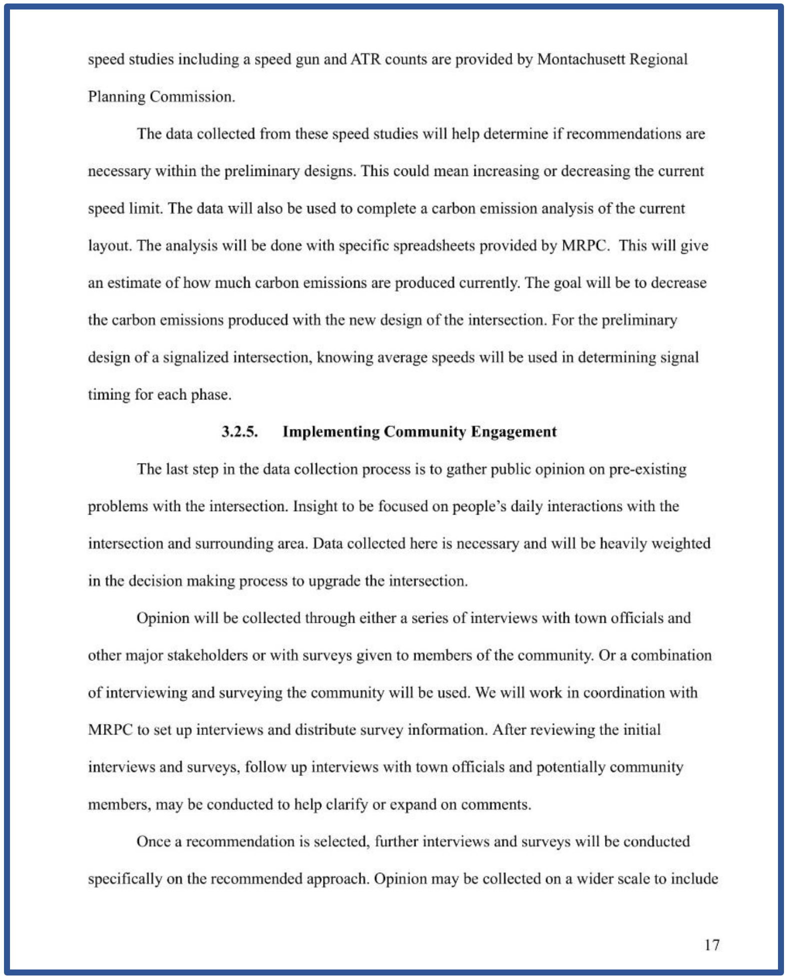
Pre-existing crash data at the Route 12 & Route 31 intersection in Fitchburg has been collected through MASSDOT. The data collected includes the number of crashes in the year 2019, as well as the type of crash. Additionally, fully detailed crash reports will need to be collected along with crash diagrams. The crash reports and crash diagrams will play a critical role in determining the configuration of each preliminary design. The crash data collected gives reasoning to implement a new and more safe intersection.

3.2.3. Design Drawings

Research on previous design drawings will be researched through Montachusett Regional Planning Commision and the MASSDOT. This may help give us a better understanding of the surrounding geometrics of the intersection. If no design drawings are available, a land survey will need to be done to detail specific elevations and contours. A detailed analysis of the geometric of the intersection will allow for critical reasoning and justification to move forward with the preliminary designs.

3.2.4. Speed studies

A critical component when determining the overall safety of the intersection is how fast the vehicles are traveling relative to the designated speed limits. The first step will be to research any speed studies done prior in this location. This may include studies done by MASSDOT, MRPC, or the Fitchburg Police. Speed limit indicators may have been used by law enforcement at the intersection to deter speeding. If these speed limit indicators were recorded, the data collected may prove to be useful. Because the COVID - 19 pandemic has had an influence on traffic flow, speed studies will need to be taken by the team. Equipment and training for the



speed studies including a speed gun and ATR counts are provided by Montachusett Regional Planning Commission.

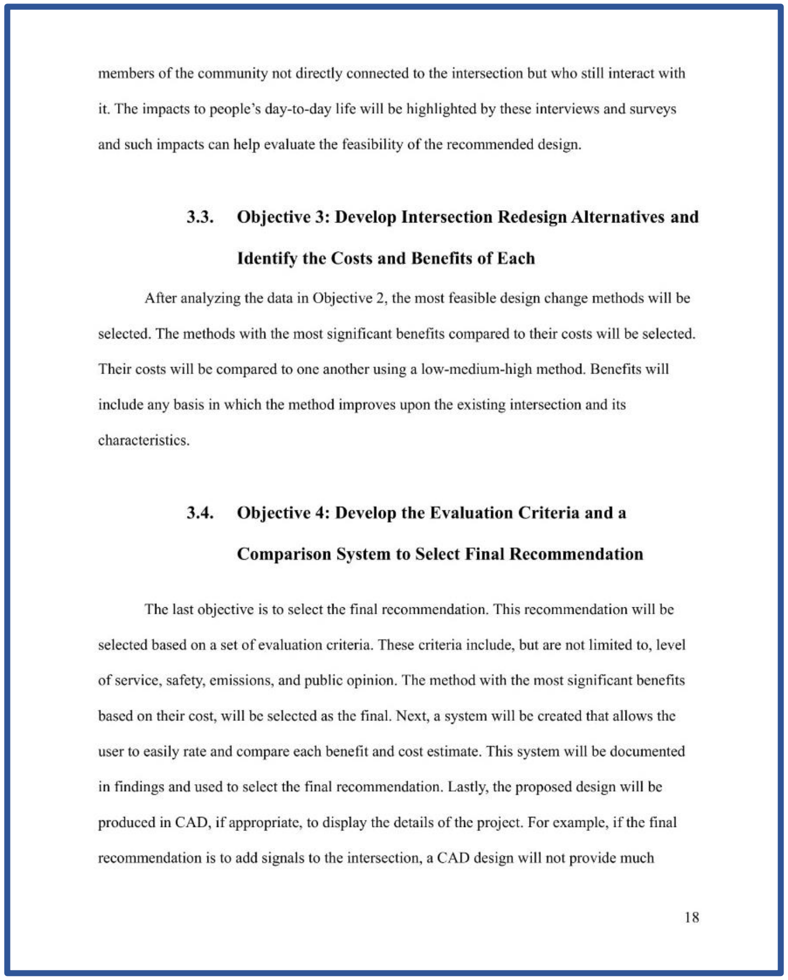
The data collected from these speed studies will help determine if recommendations are necessary within the preliminary designs. This could mean increasing or decreasing the current speed limit. The data will also be used to complete a carbon emission analysis of the current layout. The analysis will be done with specific spreadsheets provided by MRPC. This will give an estimate of how much carbon emissions are produced currently. The goal will be to decrease the carbon emissions produced with the new design of the intersection. For the preliminary design of a signalized intersection, knowing average speeds will be used in determining signal timing for each phase.

3.2.5. Implementing Community Engagement

The last step in the data collection process is to gather public opinion on pre-existing problems with the intersection. Insight to be focused on people's daily interactions with the intersection and surrounding area. Data collected here is necessary and will be heavily weighted in the decision making process to upgrade the intersection.

Opinion will be collected through either a series of interviews with town officials and other major stakeholders or with surveys given to members of the community. Or a combination of interviewing and surveying the community will be used. We will work in coordination with MRPC to set up interviews and distribute survey information. After reviewing the initial interviews and surveys, follow up interviews with town officials and potentially community members, may be conducted to help clarify or expand on comments.

Once a recommendation is selected, further interviews and surveys will be conducted specifically on the recommended approach. Opinion may be collected on a wider scale to include



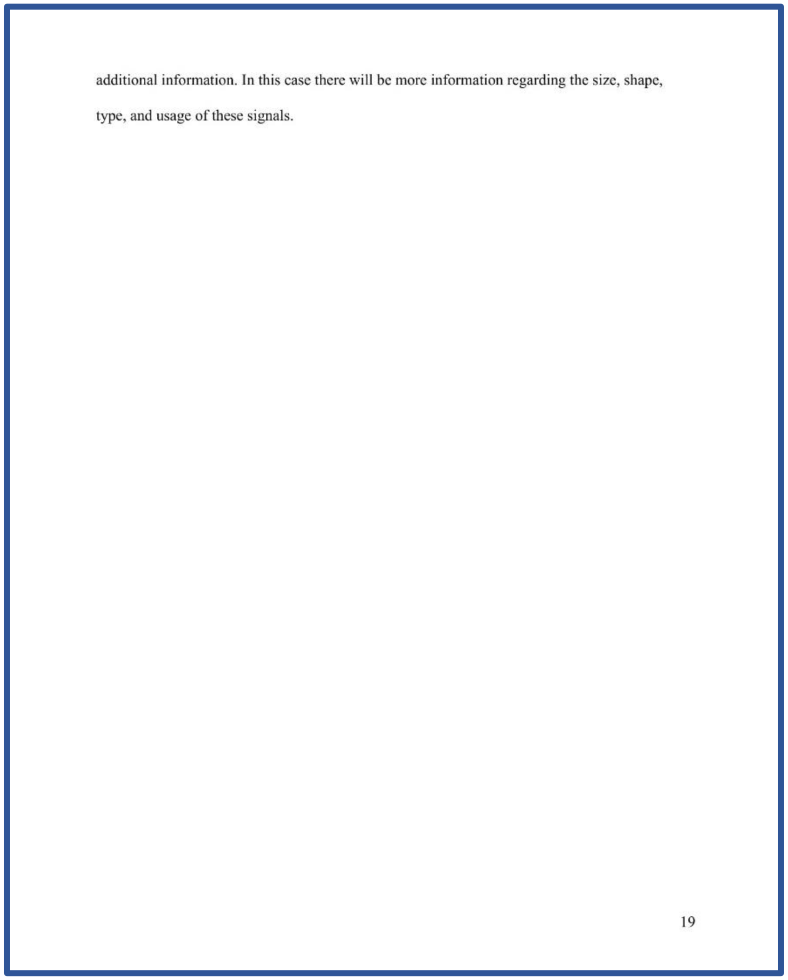
members of the community not directly connected to the intersection but who still interact with it. The impacts to people's day-to-day life will be highlighted by these interviews and surveys and such impacts can help evaluate the feasibility of the recommended design.

3.3. Objective 3: Develop Intersection Redesign Alternatives and Identify the Costs and Benefits of Each

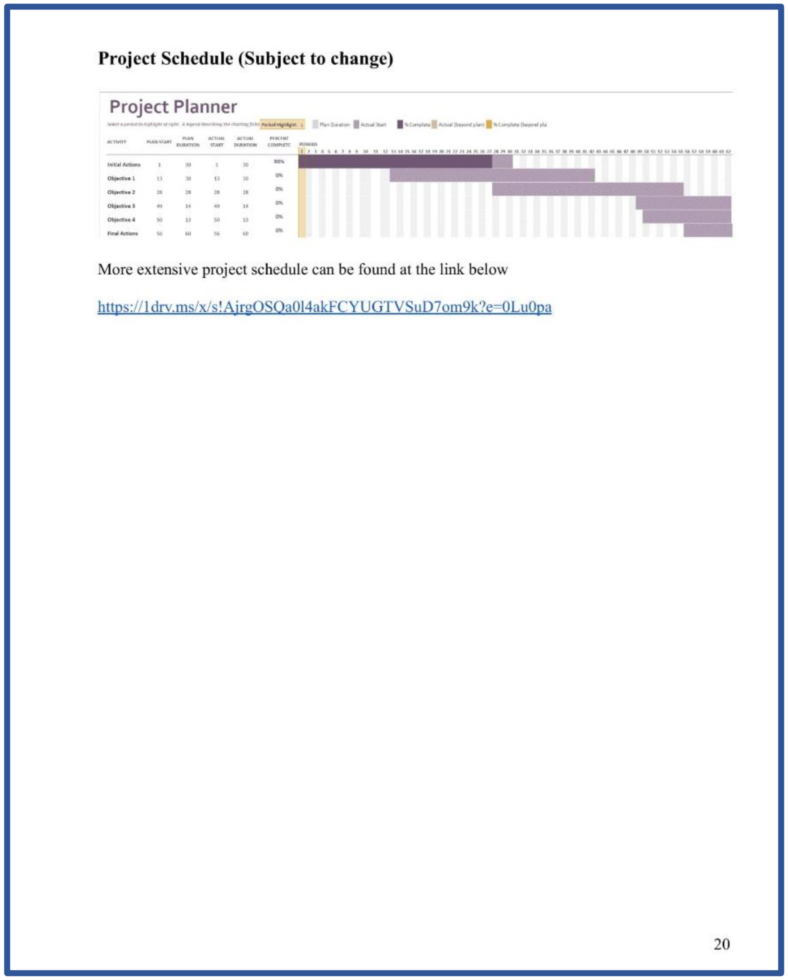
After analyzing the data in Objective 2, the most feasible design change methods will be selected. The methods with the most significant benefits compared to their costs will be selected. Their costs will be compared to one another using a low-medium-high method. Benefits will include any basis in which the method improves upon the existing intersection and its characteristics.

3.4. Objective 4: Develop the Evaluation Criteria and a Comparison System to Select Final Recommendation

The last objective is to select the final recommendation. This recommendation will be selected based on a set of evaluation criteria. These criteria include, but are not limited to, level of service, safety, emissions, and public opinion. The method with the most significant benefits based on their cost, will be selected as the final. Next, a system will be created that allows the user to easily rate and compare each benefit and cost estimate. This system will be documented in findings and used to select the final recommendation. Lastly, the proposed design will be produced in CAD, if appropriate, to display the details of the project. For example, if the final recommendation is to add signals to the intersection, a CAD design will not provide much



additional information. In this case there will be more information regarding the size, shape, type, and usage of these signals.



Project Schedule (Subject to change)

Project Planner

Select a period to highlight at right. A legend describing the charting follo Period Highlight: 1 Plan Duration Actual Start % Complete Actual (beyond plan) % Complete (beyond pla

ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Initial Actions	1	30	1	30	90%
Objective 1	13	30	13	30	0%
Objective 2	28	28	28	28	0%
Objective 3	49	14	49	14	0%
Objective 4	50	13	50	13	0%
Final Actions	56	60	56	60	0%

More extensive project schedule can be found at the link below

https://1drv.ms/x/s!AjrgOSQa0l4akFCYUGTVSuD7om9k?e=0Lu0pa

Citations:

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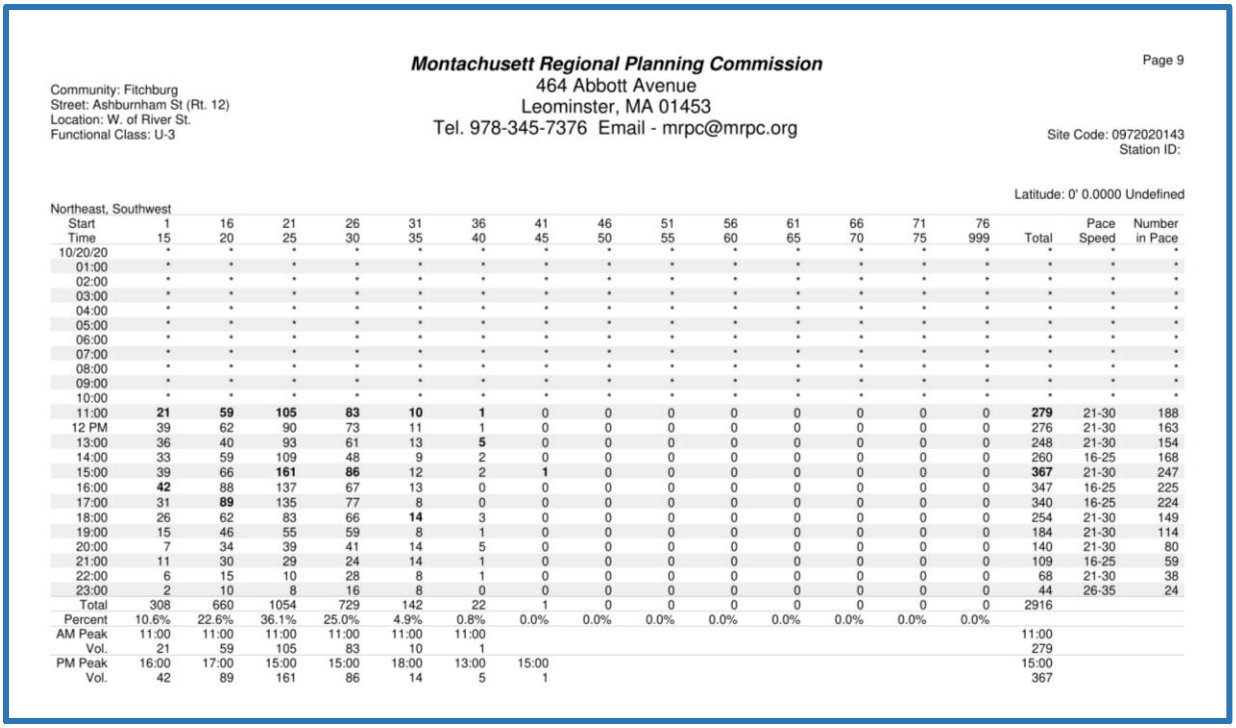
Appendix B: ATR Counts



Montachusett Regional Planning Commission
464 Abbott Avenue
Leominster, MA 01453
Tel. 978-345-7376 Email - mrpc@mrpc.org

Page 9

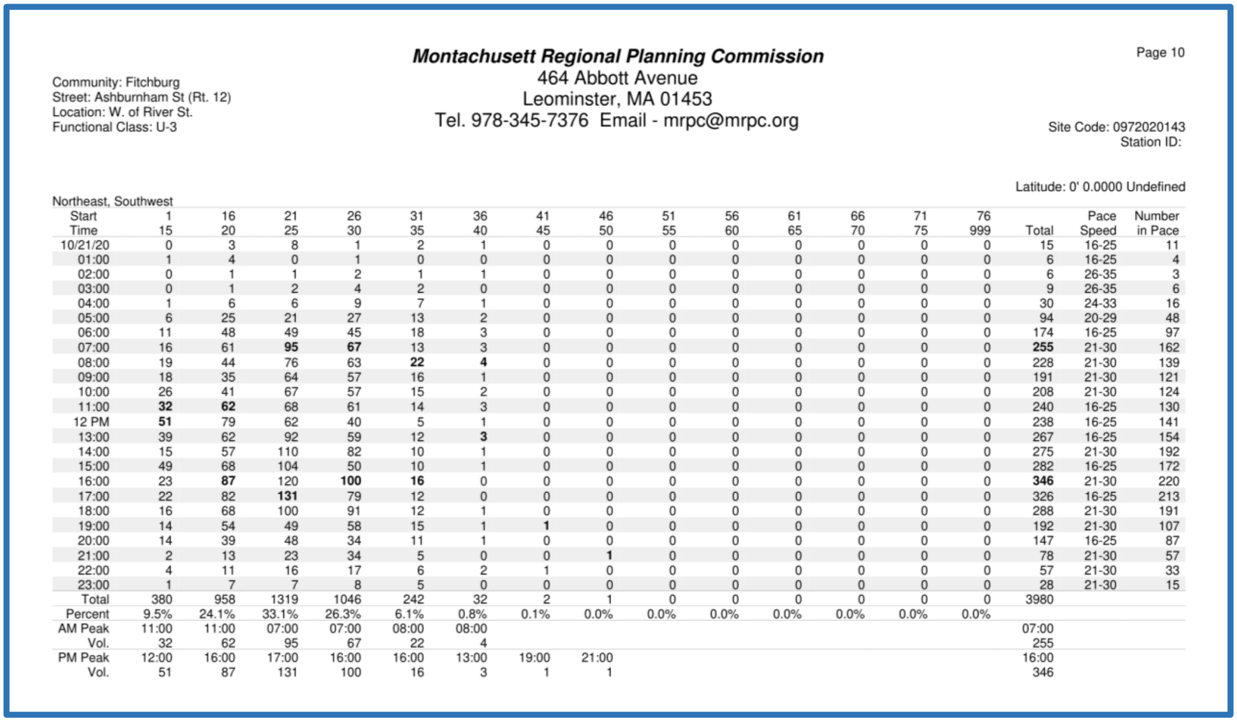
Community: Fitchburg
Street: Ashburnham St (Rt. 12)
Location: W. of River St.
Functional Class: U-3

Site Code: 0972020143
Station ID:

Latitude: 0' 0.0000 Undefined

Northeast, Southwest

Start	1	16	21	26	31	36	41	46	51	56	61	66	71	76		Pace	Number
Time	15	20	25	30	35	40	45	50	55	60	65	70	75	999	Total	Speed	in Pace
10/20/20	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
01:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
02:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
03:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
04:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
05:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
06:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
07:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
08:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
09:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
10:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
11:00	**21**	**59**	**105**	**83**	**10**	**1**	0	0	0	0	0	0	0	0	**279**	21-30	188
12 PM	39	62	90	73	11	1	0	0	0	0	0	0	0	0	276	21-30	163
13:00	36	40	93	61	13	**5**	0	0	0	0	0	0	0	0	248	21-30	154
14:00	33	59	109	48	9	2	0	0	0	0	0	0	0	0	260	16-25	168
15:00	39	66	**161**	**86**	12	2	**1**	0	0	0	0	0	0	0	**367**	21-30	247
16:00	**42**	88	137	67	13	0	0	0	0	0	0	0	0	0	347	16-25	225
17:00	31	**89**	135	77	8	0	0	0	0	0	0	0	0	0	340	16-25	224
18:00	26	62	83	66	**14**	3	0	0	0	0	0	0	0	0	254	21-30	149
19:00	15	46	55	59	8	1	0	0	0	0	0	0	0	0	184	21-30	114
20:00	7	34	39	41	14	5	0	0	0	0	0	0	0	0	140	21-30	80
21:00	11	30	29	24	14	1	0	0	0	0	0	0	0	0	109	16-25	59
22:00	6	15	10	28	8	1	0	0	0	0	0	0	0	0	68	21-30	38
23:00	2	10	8	16	8	0	0	0	0	0	0	0	0	0	44	26-35	24
Total	308	660	1054	729	142	22	1	0	0	0	0	0	0	0	2916		
Percent	10.6%	22.6%	36.1%	25.0%	4.9%	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
AM Peak	11:00	11:00	11:00	11:00	11:00	11:00									11:00		
Vol.	21	59	105	83	10	1									279		
PM Peak	16:00	17:00	15:00	15:00	18:00	13:00	15:00								15:00		
Vol.	42	89	161	86	14	5	1								367		



Montachusett Regional Planning Commission
464 Abbott Avenue
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Page 10

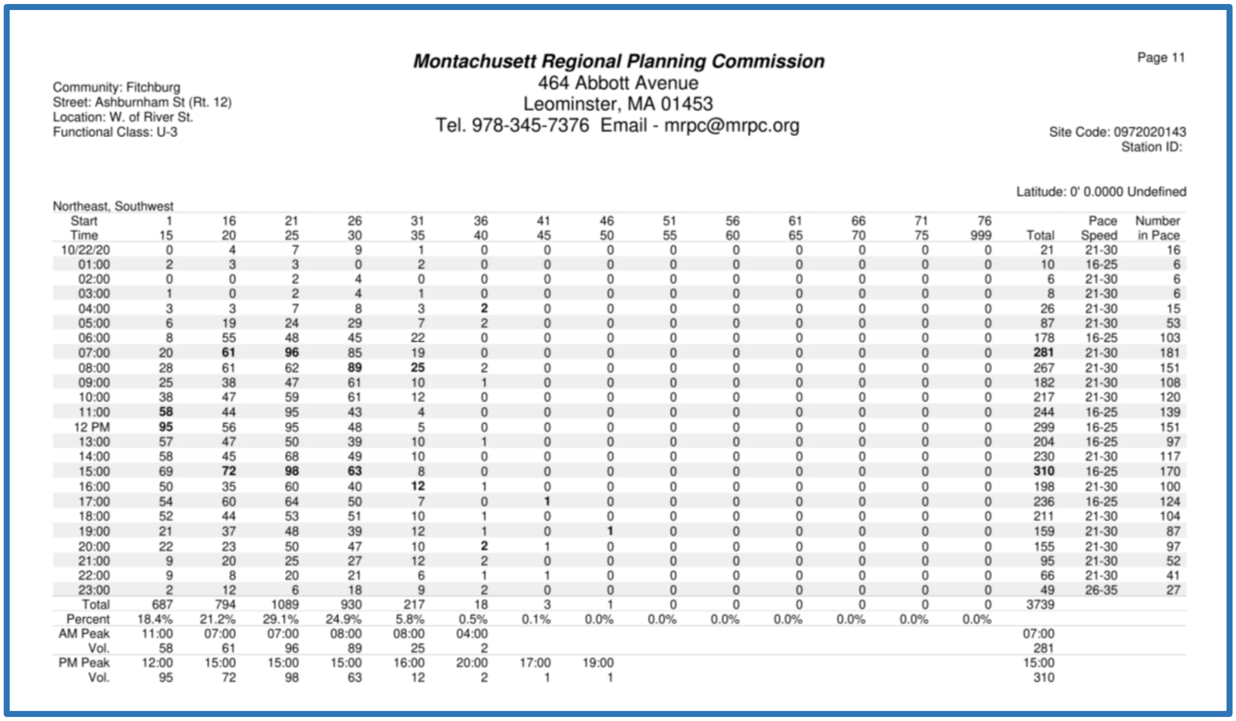
Community: Fitchburg
Street: Ashburnham St (Rt. 12)
Location: W. of River St.
Functional Class: U-3

Site Code: 0972020143
Station ID:

Latitude: 0' 0.0000 Undefined

Northeast, Southwest

Start	1	16	21	26	31	36	41	46	51	56	61	66	71	76		Pace	Number
Time	15	20	25	30	35	40	45	50	55	60	65	70	75	999	Total	Speed	in Pace
10/21/20	0	3	8	1	2	1	0	0	0	0	0	0	0	0	15	16-25	11
01:00	1	4	0	1	0	0	0	0	0	0	0	0	0	0	6	16-25	4
02:00	0	1	1	2	1	1	0	0	0	0	0	0	0	0	6	26-35	3
03:00	0	1	2	4	2	0	0	0	0	0	0	0	0	0	9	26-35	6
04:00	1	6	6	9	7	1	0	0	0	0	0	0	0	0	30	24-33	16
05:00	6	25	21	27	13	2	0	0	0	0	0	0	0	0	94	20-29	48
06:00	11	48	49	45	18	3	0	0	0	0	0	0	0	0	174	16-25	97
07:00	16	61	**95**	**67**	13	3	0	0	0	0	0	0	0	0	**255**	21-30	162
08:00	19	44	76	63	**22**	**4**	0	0	0	0	0	0	0	0	228	21-30	139
09:00	18	35	64	57	16	1	0	0	0	0	0	0	0	0	191	21-30	121
10:00	26	41	67	57	15	2	0	0	0	0	0	0	0	0	208	21-30	124
11:00	**32**	**62**	68	61	14	3	0	0	0	0	0	0	0	0	240	16-25	130
12 PM	**51**	79	62	40	5	1	0	0	0	0	0	0	0	0	238	16-25	141
13:00	39	62	92	59	12	**3**	0	0	0	0	0	0	0	0	267	16-25	154
14:00	15	57	110	82	10	1	0	0	0	0	0	0	0	0	275	21-30	192
15:00	49	68	104	50	10	1	0	0	0	0	0	0	0	0	282	16-25	172
16:00	23	**87**	120	**100**	**16**	0	0	0	0	0	0	0	0	0	**346**	21-30	220
17:00	22	82	**131**	79	12	0	0	0	0	0	0	0	0	0	326	16-25	213
18:00	16	68	100	91	12	1	0	0	0	0	0	0	0	0	288	21-30	191
19:00	14	54	49	58	15	1	**1**	0	0	0	0	0	0	0	192	21-30	107
20:00	14	39	48	34	11	1	0	0	0	0	0	0	0	0	147	16-25	87
21:00	2	13	23	34	5	0	0	**1**	0	0	0	0	0	0	78	21-30	57
22:00	4	11	16	17	6	2	1	0	0	0	0	0	0	0	57	21-30	33
23:00	1	7	7	8	5	0	0	0	0	0	0	0	0	0	28	21-30	15
Total	380	958	1319	1046	242	32	2	1	0	0	0	0	0	0	3980		
Percent	9.5%	24.1%	33.1%	26.3%	6.1%	0.8%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
AM Peak	11:00	11:00	07:00	07:00	08:00	08:00									07:00		
Vol.	32	62	95	67	22	4									255		
PM Peak	12:00	16:00	17:00	16:00	16:00	13:00	19:00	21:00							16:00		
Vol.	51	87	131	100	16	3	1	1							346		



Page 11

Community: Fitchburg
Street: Ashburnham St (Rt. 12)
Location: W. of River St.
Functional Class: U-3

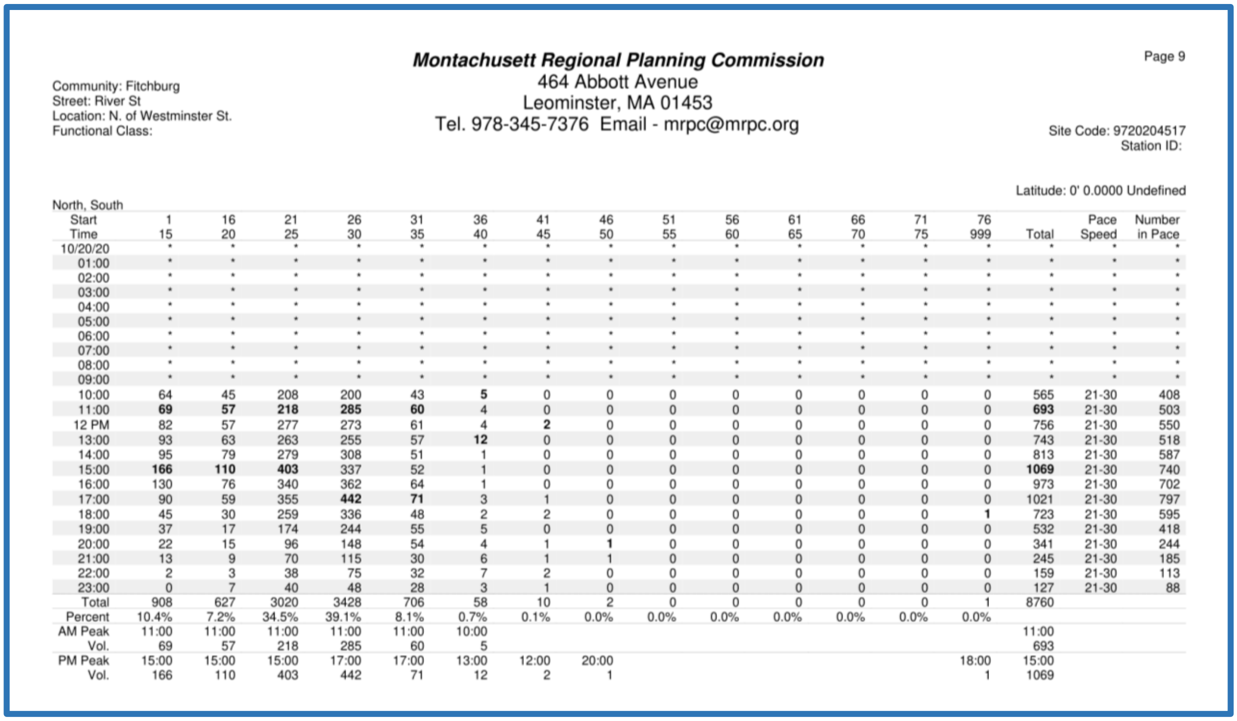
Montachusett Regional Planning Commission
464 Abbott Avenue
Leominster, MA 01453
Tel. 978-345-7376 Email - mrpc@mrpc.org

Site Code: 0972020143
Station ID:

Latitude: 0' 0.0000 Undefined

Northeast, Southwest

Start	1	16	21	26	31	36	41	46	51	56	61	66	71	76		Pace	Number
Time	15	20	25	30	35	40	45	50	55	60	65	70	75	999	Total	Speed	in Pace
10/22/20	0	4	7	9	1	0	0	0	0	0	0	0	0	0	21	21-30	16
01:00	2	3	3	0	2	0	0	0	0	0	0	0	0	0	10	16-25	6
02:00	0	0	2	4	0	0	0	0	0	0	0	0	0	0	6	21-30	6
03:00	1	0	2	4	1	0	0	0	0	0	0	0	0	0	8	21-30	6
04:00	3	3	7	8	3	**2**	0	0	0	0	0	0	0	0	26	21-30	15
05:00	6	19	24	29	7	2	0	0	0	0	0	0	0	0	87	21-30	53
06:00	8	55	48	45	22	0	0	0	0	0	0	0	0	0	178	16-25	103
07:00	20	**61**	**96**	85	19	0	0	0	0	0	0	0	0	0	**281**	21-30	181
08:00	28	61	62	**89**	**25**	2	0	0	0	0	0	0	0	0	267	21-30	151
09:00	25	38	47	61	10	1	0	0	0	0	0	0	0	0	182	21-30	108
10:00	38	47	59	61	12	0	0	0	0	0	0	0	0	0	217	21-30	120
11:00	**58**	44	95	43	4	0	0	0	0	0	0	0	0	0	244	16-25	139
12 PM	**95**	56	95	48	5	0	0	0	0	0	0	0	0	0	299	16-25	151
13:00	57	47	50	39	10	1	0	0	0	0	0	0	0	0	204	16-25	97
14:00	58	45	68	49	10	0	0	0	0	0	0	0	0	0	230	21-30	117
15:00	69	**72**	**98**	**63**	8	0	0	0	0	0	0	0	0	0	**310**	16-25	170
16:00	50	35	60	40	**12**	1	0	0	0	0	0	0	0	0	198	21-30	100
17:00	54	60	64	50	7	0	**1**	0	0	0	0	0	0	0	236	16-25	124
18:00	52	44	53	51	10	1	0	0	0	0	0	0	0	0	211	21-30	104
19:00	21	37	48	39	12	1	0	**1**	0	0	0	0	0	0	159	21-30	87
20:00	22	23	50	47	10	**2**	1	0	0	0	0	0	0	0	155	21-30	97
21:00	9	20	25	27	12	2	0	0	0	0	0	0	0	0	95	21-30	52
22:00	9	8	20	21	6	1	1	0	0	0	0	0	0	0	66	21-30	41
23:00	2	12	6	18	9	2	0	0	0	0	0	0	0	0	49	26-35	27
Total	687	794	1089	930	217	18	3	1	0	0	0	0	0	0	3739		
Percent	18.4%	21.2%	29.1%	24.9%	5.8%	0.5%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
AM Peak	11:00	07:00	07:00	08:00	08:00	04:00									07:00		
Vol.	58	61	96	89	25	2									281		
PM Peak	12:00	15:00	15:00	15:00	16:00	20:00	17:00	19:00							15:00		
Vol.	95	72	98	63	12	2	1	1							310		



Page 9

Community: Fitchburg
Street: River St
Location: N. of Westminster St.
Functional Class:

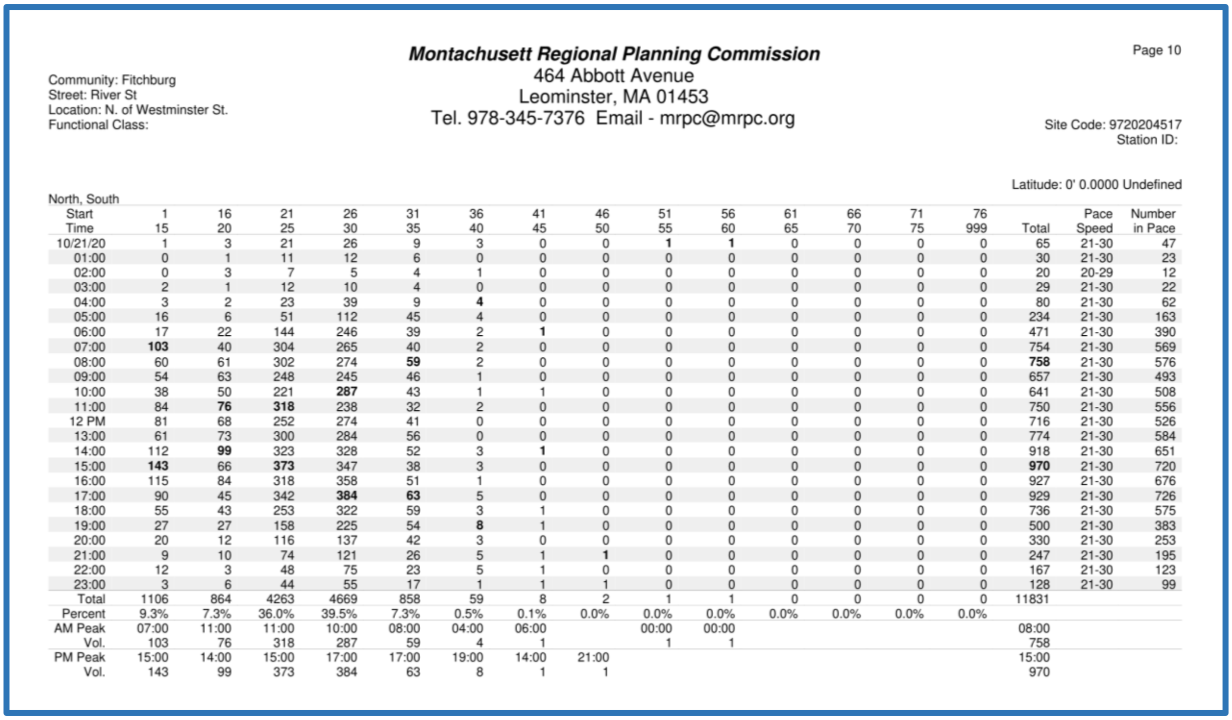
Montachusett Regional Planning Commission
464 Abbott Avenue
Leominster, MA 01453
Tel. 978-345-7376 Email - mrpc@mrpc.org

Site Code: 9720204517
Station ID:

Latitude: 0' 0.0000 Undefined

North, South

Start	1	16	21	26	31	36	41	46	51	56	61	66	71	76		Pace	Number
Time	15	20	25	30	35	40	45	50	55	60	65	70	75	999	Total	Speed	in Pace
10/20/20	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
01:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
02:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
03:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
04:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
05:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
06:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
07:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
08:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
09:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
10:00	64	45	208	200	43	**5**	0	0	0	0	0	0	0	0	565	21-30	408
11:00	**69**	**57**	**218**	**285**	**60**	4	0	0	0	0	0	0	0	0	**693**	21-30	503
12 PM	82	57	277	273	61	4	**2**	0	0	0	0	0	0	0	756	21-30	550
13:00	93	63	263	255	57	**12**	0	0	0	0	0	0	0	0	743	21-30	518
14:00	95	79	279	308	51	1	0	0	0	0	0	0	0	0	813	21-30	587
15:00	**166**	**110**	**403**	337	52	1	0	0	0	0	0	0	0	0	**1069**	21-30	740
16:00	130	76	340	362	64	1	0	0	0	0	0	0	0	0	973	21-30	702
17:00	90	59	355	**442**	**71**	3	1	0	0	0	0	0	0	0	1021	21-30	797
18:00	45	30	259	336	48	2	2	0	0	0	0	0	0	**1**	723	21-30	595
19:00	37	17	174	244	55	5	0	0	0	0	0	0	0	0	532	21-30	418
20:00	22	15	96	148	54	4	1	**1**	0	0	0	0	0	0	341	21-30	244
21:00	13	9	70	115	30	6	1	1	0	0	0	0	0	0	245	21-30	185
22:00	2	3	38	75	32	7	2	0	0	0	0	0	0	0	159	21-30	113
23:00	0	7	40	48	28	3	1	0	0	0	0	0	0	0	127	21-30	88
Total	908	627	3020	3428	706	58	10	2	0	0	0	0	0	1	8760		
Percent	10.4%	7.2%	34.5%	39.1%	8.1%	0.7%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
AM Peak	11:00	11:00	11:00	11:00	11:00	10:00									11:00		
Vol.	69	57	218	285	60	5									693		
PM Peak	15:00	15:00	15:00	17:00	17:00	13:00	12:00	20:00						18:00	15:00		
Vol.	166	110	403	442	71	12	2	1						1	1069		



Page 10

Montachusett Regional Planning Commission
464 Abbott Avenue
Leominster, MA 01453
Tel. 978-345-7376 Email - mrpc@mrpc.org

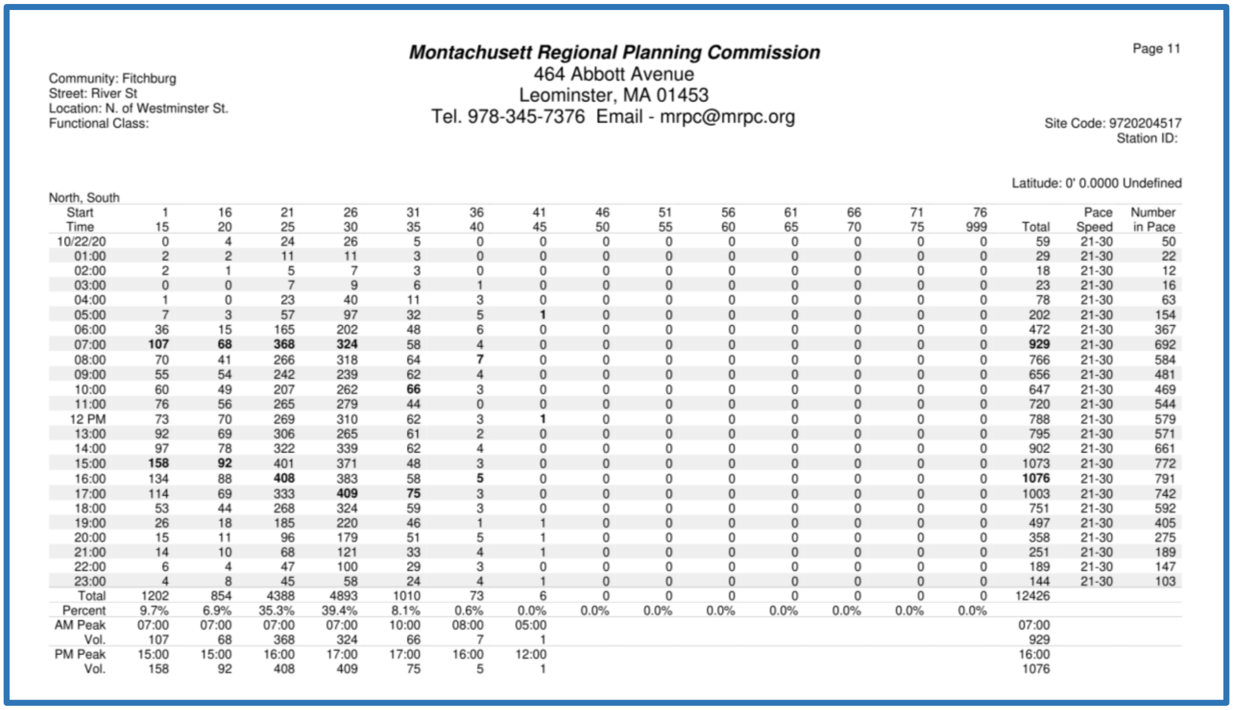
Community: Fitchburg
Street: River St
Location: N. of Westminster St.
Functional Class:

Site Code: 9720204517
Station ID:

Latitude: 0' 0.0000 Undefined

North, South

Start	1	16	21	26	31	36	41	46	51	56	61	66	71	76		Pace	Number
Time	15	20	25	30	35	40	45	50	55	60	65	70	75	999	Total	Speed	in Pace
10/21/20	1	3	21	26	9	3	0	0	**1**	**1**	0	0	0	0	65	21-30	47
01:00	0	1	11	12	6	0	0	0	0	0	0	0	0	0	30	21-30	23
02:00	0	3	7	5	4	1	0	0	0	0	0	0	0	0	20	20-29	12
03:00	2	1	12	10	4	0	0	0	0	0	0	0	0	0	29	21-30	22
04:00	3	2	23	39	9	**4**	0	0	0	0	0	0	0	0	80	21-30	62
05:00	16	6	51	112	45	4	0	0	0	0	0	0	0	0	234	21-30	163
06:00	17	22	144	246	39	2	**1**	0	0	0	0	0	0	0	471	21-30	390
07:00	**103**	40	304	265	40	2	0	0	0	0	0	0	0	0	754	21-30	569
08:00	60	61	302	274	**59**	2	0	0	0	0	0	0	0	0	**758**	21-30	576
09:00	54	63	248	245	46	1	0	0	0	0	0	0	0	0	657	21-30	493
10:00	38	50	221	**287**	43	1	1	0	0	0	0	0	0	0	641	21-30	508
11:00	84	**76**	**318**	238	32	2	0	0	0	0	0	0	0	0	750	21-30	556
12 PM	81	68	252	274	41	0	0	0	0	0	0	0	0	0	716	21-30	526
13:00	61	73	300	284	56	0	0	0	0	0	0	0	0	0	774	21-30	584
14:00	112	**99**	323	328	52	3	**1**	0	0	0	0	0	0	0	918	21-30	651
15:00	**143**	66	**373**	347	38	3	0	0	0	0	0	0	0	0	**970**	21-30	720
16:00	115	84	318	358	51	1	0	0	0	0	0	0	0	0	927	21-30	676
17:00	90	45	342	**384**	**63**	5	0	0	0	0	0	0	0	0	929	21-30	726
18:00	55	43	253	322	59	3	1	0	0	0	0	0	0	0	736	21-30	575
19:00	27	27	158	225	54	**8**	1	0	0	0	0	0	0	0	500	21-30	383
20:00	20	12	116	137	42	3	0	0	0	0	0	0	0	0	330	21-30	253
21:00	9	10	74	121	26	5	1	**1**	0	0	0	0	0	0	247	21-30	195
22:00	12	3	48	75	23	5	1	0	0	0	0	0	0	0	167	21-30	123
23:00	3	6	44	55	17	1	1	1	0	0	0	0	0	0	128	21-30	99
Total	1106	864	4263	4669	858	59	8	2	1	1	0	0	0	0	11831		
Percent	9.3%	7.3%	36.0%	39.5%	7.3%	0.5%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
AM Peak	07:00	11:00	11:00	10:00	08:00	04:00	06:00		00:00	00:00					08:00		
Vol.	103	76	318	287	59	4	1		1	1					758		
PM Peak	15:00	14:00	15:00	17:00	17:00	19:00	14:00	21:00							15:00		
Vol.	143	99	373	384	63	8	1	1							970		



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Montachusett Regional Planning Commission
464 Abbott Avenue
Leominster, MA 01453
Tel. 978-345-7376 Email - mrpc@mrpc.org

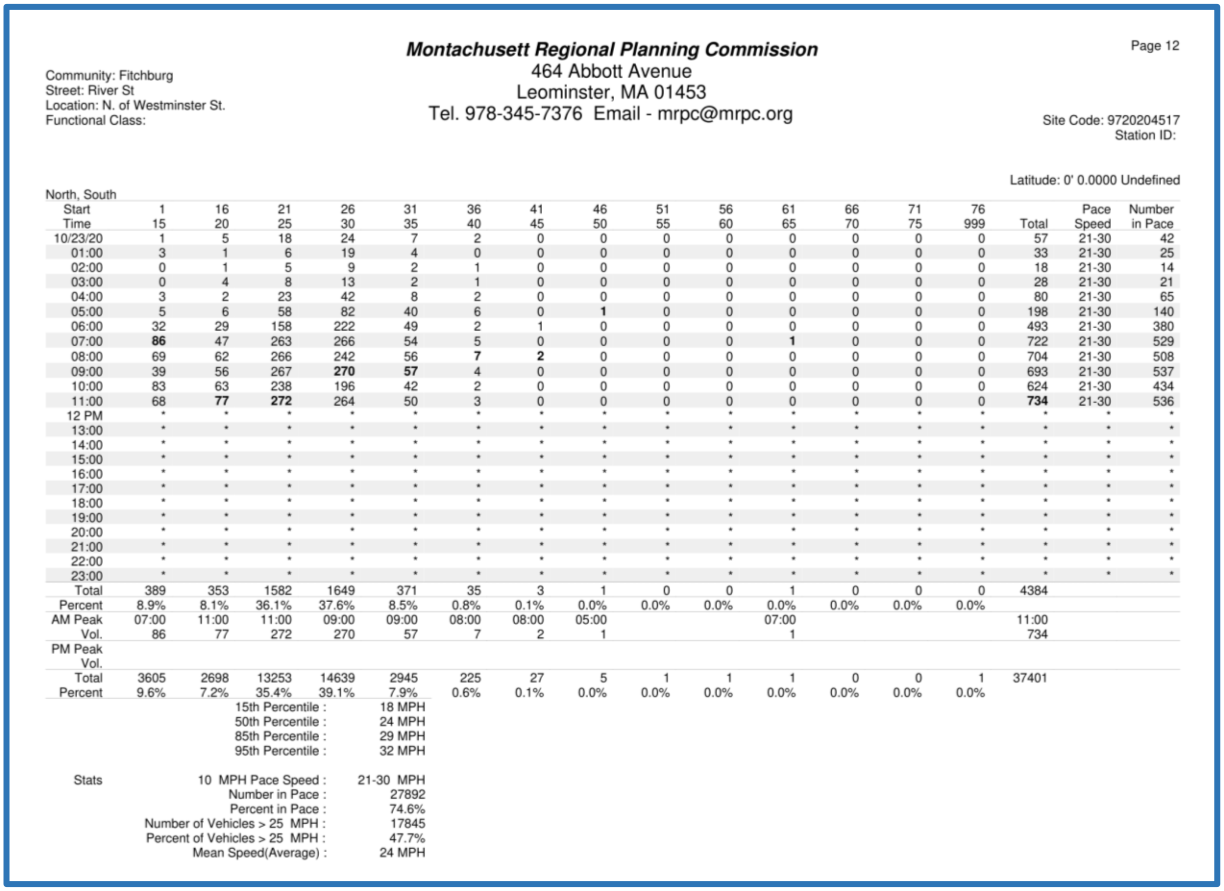
Community: Fitchburg
Street: River St
Location: N. of Westminster St.
Functional Class:

Site Code: 9720204517
Station ID:

Latitude: 0' 0.0000 Undefined

North, South

Start	1	16	21	26	31	36	41	46	51	56	61	66	71	76		Pace	Number
Time	15	20	25	30	35	40	45	50	55	60	65	70	75	999	Total	Speed	in Pace
10/22/20	0	4	24	26	5	0	0	0	0	0	0	0	0	0	59	21-30	50
01:00	2	2	11	11	3	0	0	0	0	0	0	0	0	0	29	21-30	22
02:00	2	1	5	7	3	0	0	0	0	0	0	0	0	0	18	21-30	12
03:00	0	0	7	9	6	1	0	0	0	0	0	0	0	0	23	21-30	16
04:00	1	0	23	40	11	3	0	0	0	0	0	0	0	0	78	21-30	63
05:00	7	3	57	97	32	5	**1**	0	0	0	0	0	0	0	202	21-30	154
06:00	36	15	165	202	48	6	0	0	0	0	0	0	0	0	472	21-30	367
07:00	**107**	**68**	**368**	**324**	58	4	0	0	0	0	0	0	0	0	**929**	21-30	692
08:00	70	41	266	318	64	**7**	0	0	0	0	0	0	0	0	766	21-30	584
09:00	55	54	242	239	62	4	0	0	0	0	0	0	0	0	656	21-30	481
10:00	60	49	207	262	**66**	3	0	0	0	0	0	0	0	0	647	21-30	469
11:00	76	56	265	279	44	0	0	0	0	0	0	0	0	0	720	21-30	544
12 PM	73	70	269	310	62	3	**1**	0	0	0	0	0	0	0	788	21-30	579
13:00	92	69	306	265	61	2	0	0	0	0	0	0	0	0	795	21-30	571
14:00	97	78	322	339	62	4	0	0	0	0	0	0	0	0	902	21-30	661
15:00	**158**	**92**	401	371	48	3	0	0	0	0	0	0	0	0	1073	21-30	772
16:00	134	88	**408**	383	58	**5**	0	0	0	0	0	0	0	0	**1076**	21-30	791
17:00	114	69	333	**409**	**75**	3	0	0	0	0	0	0	0	0	1003	21-30	742
18:00	53	44	268	324	59	3	0	0	0	0	0	0	0	0	751	21-30	592
19:00	26	18	185	220	46	1	1	0	0	0	0	0	0	0	497	21-30	405
20:00	15	11	96	179	51	5	1	0	0	0	0	0	0	0	358	21-30	275
21:00	14	10	68	121	33	4	1	0	0	0	0	0	0	0	251	21-30	189
22:00	6	4	47	100	29	3	0	0	0	0	0	0	0	0	189	21-30	147
23:00	4	8	45	58	24	4	1	0	0	0	0	0	0	0	144	21-30	103
Total	1202	854	4388	4893	1010	73	6	0	0	0	0	0	0	0	12426		
Percent	9.7%	6.9%	35.3%	39.4%	8.1%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
AM Peak	07:00	07:00	07:00	07:00	10:00	08:00	05:00								07:00		
Vol.	107	68	368	324	66	7	1								929		
PM Peak	15:00	15:00	16:00	17:00	17:00	16:00	12:00								16:00		
Vol.	158	92	408	409	75	5	1								1076		



Montachusett Regional Planning Commission
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Leominster, MA 01453
Tel. 978-345-7376 Email - mrpc@mrpc.org

Page 12

Community: Fitchburg
Street: River St
Location: N. of Westminster St.
Functional Class:

Site Code: 9720204517
Station ID:

Latitude: 0' 0.0000 Undefined

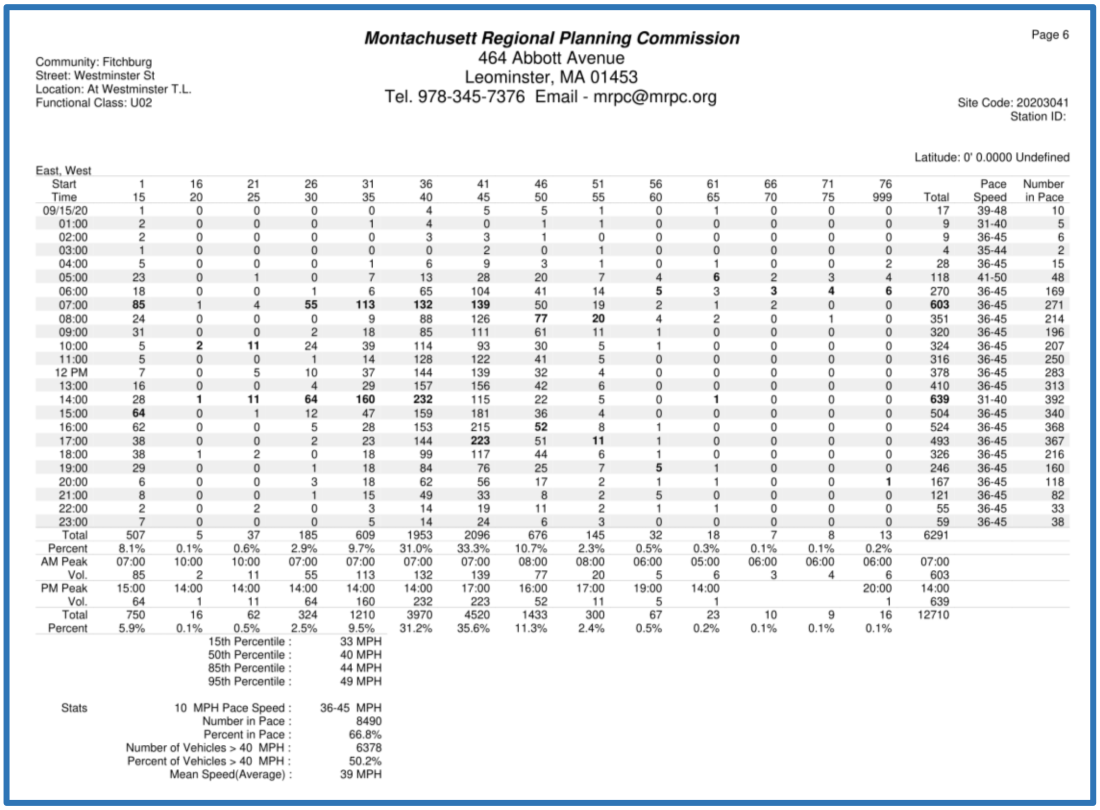
North, South

Start Time	1 15	16 20	21 25	26 30	31 35	36 40	41 45	46 50	51 55	56 60	61 65	66 70	71 75	76 999	Total	Pace Speed	Number in Pace
10/23/20	1	5	18	24	7	2	0	0	0	0	0	0	0	0	57	21-30	42
01:00	3	1	6	19	4	0	0	0	0	0	0	0	0	0	33	21-30	25
02:00	0	1	5	9	2	1	0	0	0	0	0	0	0	0	18	21-30	14
03:00	0	4	8	13	2	1	0	0	0	0	0	0	0	0	28	21-30	21
04:00	3	2	23	42	8	2	0	0	0	0	0	0	0	0	80	21-30	65
05:00	5	6	58	82	40	6	0	**1**	0	0	0	0	0	0	198	21-30	140
06:00	32	29	158	222	49	2	1	0	0	0	0	0	0	0	493	21-30	380
07:00	**86**	47	263	266	54	5	0	0	0	0	**1**	0	0	0	722	21-30	529
08:00	69	62	266	242	56	**7**	**2**	0	0	0	0	0	0	0	704	21-30	508
09:00	39	56	267	**270**	**57**	4	0	0	0	0	0	0	0	0	693	21-30	537
10:00	83	63	238	196	42	2	0	0	0	0	0	0	0	0	624	21-30	434
11:00	68	**77**	**272**	264	50	3	0	0	0	0	0	0	0	0	**734**	21-30	536
12 PM	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
13:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
14:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
15:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
16:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
17:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
18:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
19:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
20:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
21:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
22:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
23:00	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Total	389	353	1582	1649	371	35	3	1	0	0	1	0	0	0	4384		
Percent	8.9%	8.1%	36.1%	37.6%	8.5%	0.8%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
AM Peak	07:00	11:00	11:00	09:00	09:00	08:00	08:00	05:00			07:00				11:00		
Vol.	86	77	272	270	57	7	2	1			1				734		
PM Peak																	
Vol.																	
Total	3605	2698	13253	14639	2945	225	27	5	1	1	1	0	0	1	37401		
Percent	9.6%	7.2%	35.4%	39.1%	7.9%	0.6%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			

15th Percentile : 18 MPH
50th Percentile : 24 MPH
85th Percentile : 29 MPH
95th Percentile : 32 MPH

Stats

10 MPH Pace Speed : 21-30 MPH
Number in Pace : 27892
Percent in Pace : 74.6%
Number of Vehicles > 25 MPH : 17845
Percent of Vehicles > 25 MPH : 47.7%
Mean Speed(Average) : 24 MPH



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Page 6

Community: Fitchburg
Street: Westminster St
Location: At Westminster T.L.
Functional Class: U02

Site Code: 20203041
Station ID:

Latitude: 0' 0.0000 Undefined

East, West

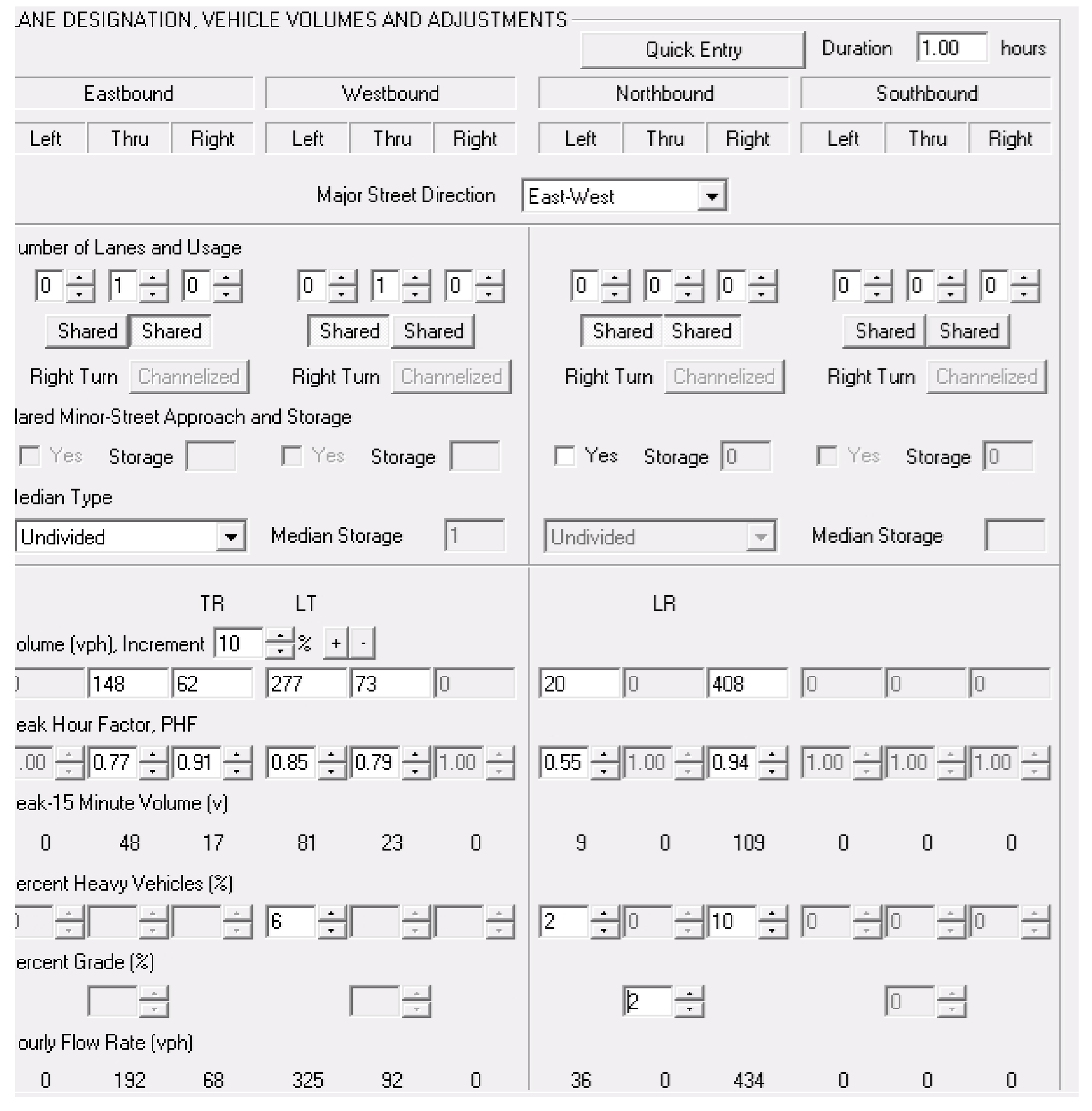
Start Time	1 15	16 20	21 25	26 30	31 35	36 40	41 45	46 50	51 55	56 60	61 65	66 70	71 75	76 999	Total	Pace Speed	Number in Pace
09/15/20	1	0	0	0	0	4	5	5	1	0	1	0	0	0	17	39-48	10
01:00	2	0	0	0	1	4	0	1	1	0	0	0	0	0	9	31-40	5
02:00	2	0	0	0	0	3	3	1	0	0	0	0	0	0	9	36-45	6
03:00	1	0	0	0	0	0	2	0	1	0	0	0	0	0	4	35-44	2
04:00	5	0	0	0	1	6	9	3	1	0	1	0	0	2	28	36-45	15
05:00	23	0	1	0	7	13	28	20	7	4	**6**	2	3	4	118	41-50	48
06:00	18	0	0	1	6	65	104	41	14	**5**	3	**3**	**4**	**6**	270	36-45	169
07:00	**85**	1	4	**55**	**113**	**132**	**139**	50	19	2	1	2	0	0	**603**	36-45	271
08:00	24	0	0	0	9	88	126	**77**	**20**	4	2	0	1	0	351	36-45	214
09:00	31	0	0	2	18	85	111	61	11	1	0	0	0	0	320	36-45	196
10:00	5	**2**	**11**	24	39	114	93	30	5	1	0	0	0	0	324	36-45	207
11:00	5	0	0	1	14	128	122	41	5	0	0	0	0	0	316	36-45	250
12 PM	7	0	5	10	37	144	139	32	4	0	0	0	0	0	378	36-45	283
13:00	16	0	0	4	29	157	156	42	6	0	0	0	0	0	410	36-45	313
14:00	28	**1**	**11**	**64**	**160**	**232**	115	22	5	0	**1**	0	0	0	**639**	31-40	392
15:00	**64**	0	1	12	47	159	181	36	4	0	0	0	0	0	504	36-45	340
16:00	62	0	0	5	28	153	215	**52**	8	1	0	0	0	0	524	36-45	368
17:00	38	0	0	2	23	144	**223**	51	**11**	1	0	0	0	0	493	36-45	367
18:00	38	1	2	0	18	99	117	44	6	1	0	0	0	0	326	36-45	216
19:00	29	0	0	1	18	84	76	25	7	**5**	1	0	0	0	246	36-45	160
20:00	6	0	0	3	18	62	56	17	2	1	1	0	0	**1**	167	36-45	118
21:00	8	0	0	1	15	49	33	8	2	5	0	0	0	0	121	36-45	82
22:00	2	0	2	0	3	14	19	11	2	1	1	0	0	0	55	36-45	33
23:00	7	0	0	0	5	14	24	6	3	0	0	0	0	0	59	36-45	38
Total	507	5	37	185	609	1953	2096	676	145	32	18	7	8	13	6291		
Percent	8.1%	0.1%	0.6%	2.9%	9.7%	31.0%	33.3%	10.7%	2.3%	0.5%	0.3%	0.1%	0.1%	0.2%			
AM Peak	07:00	10:00	10:00	07:00	07:00	07:00	07:00	08:00	08:00	06:00	05:00	06:00	06:00	06:00	07:00		
Vol.	85	2	11	55	113	132	139	77	20	5	6	3	4	6	603		
PM Peak	15:00	14:00	14:00	14:00	14:00	14:00	17:00	16:00	17:00	19:00	14:00			20:00	14:00		
Vol.	64	1	11	64	160	232	223	52	11	5	1			1	639		
Total	750	16	62	324	1210	3970	4520	1433	300	67	23	10	9	16	12710		
Percent	5.9%	0.1%	0.5%	2.5%	9.5%	31.2%	35.6%	11.3%	2.4%	0.5%	0.2%	0.1%	0.1%	0.1%			

15th Percentile : 33 MPH
50th Percentile : 40 MPH
85th Percentile : 44 MPH
95th Percentile : 49 MPH

Stats

10 MPH Pace Speed : 36-45 MPH
Number in Pace : 8490
Percent in Pace : 66.8%
Number of Vehicles > 40 MPH : 6378
Percent of Vehicles > 40 MPH : 50.2%
Mean Speed(Average) : 39 MPH

Appendix C: Level-of-service HCS Screenshots Input Data



ANE DESIGNATION, VEHICLE VOLUMES AND ADJUSTMENTS

Duration 1.00 hours

Major Street Direction East-West

umber of Lanes and Usage

Shared Shared (each approach)

Right Turn Channelized (each approach)

lared Minor-Street Approach and Storage

☐ Yes Storage (Eastbound, Westbound)

☐ Yes Storage 0 (Northbound, Southbound)

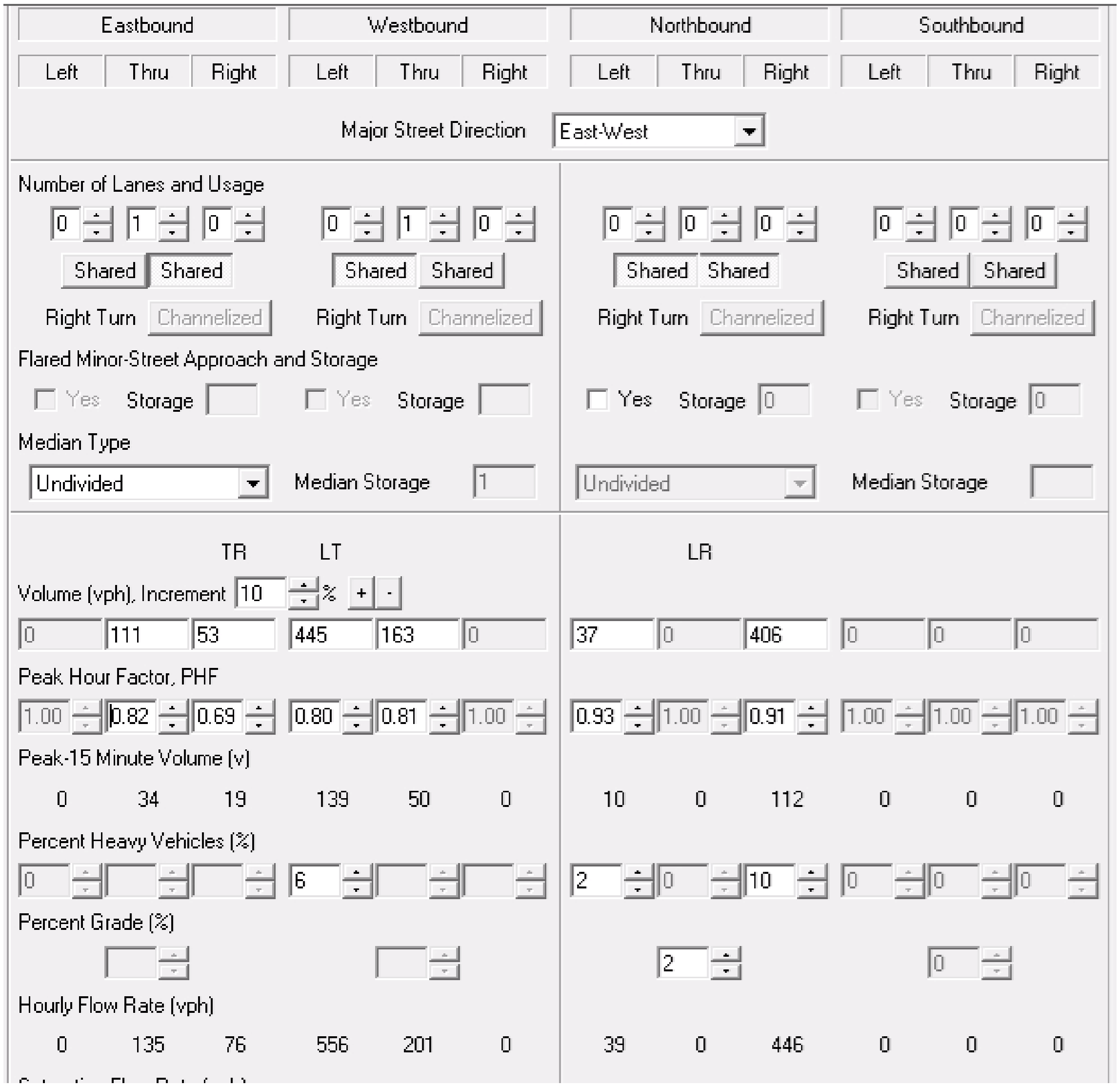
ledian Type

Undivided Median Storage 1

Undivided Median Storage

	Eastbound			Westbound			Northbound			Southbound		
	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
umber of Lanes and Usage	0	1	0	0	1	0	0	0	0	0	0	0
		TR		LT			LR					
olume (vph), Increment 10 %		148	62	277	73	0	20	0	408	0	0	0
eak Hour Factor, PHF	.00	0.77	0.91	0.85	0.79	1.00	0.55	1.00	0.94	1.00	1.00	1.00
eak-15 Minute Volume (v)	0	48	17	81	23	0	9	0	109	0	0	0
ercent Heavy Vehicles (%)				6			2	0	10	0	0	0
ercent Grade (%)								2			0	
ourly Flow Rate (vph)	0	192	68	325	92	0	36	0	434	0	0	0

Screenshot of Morning Input Data for HCS Analysis

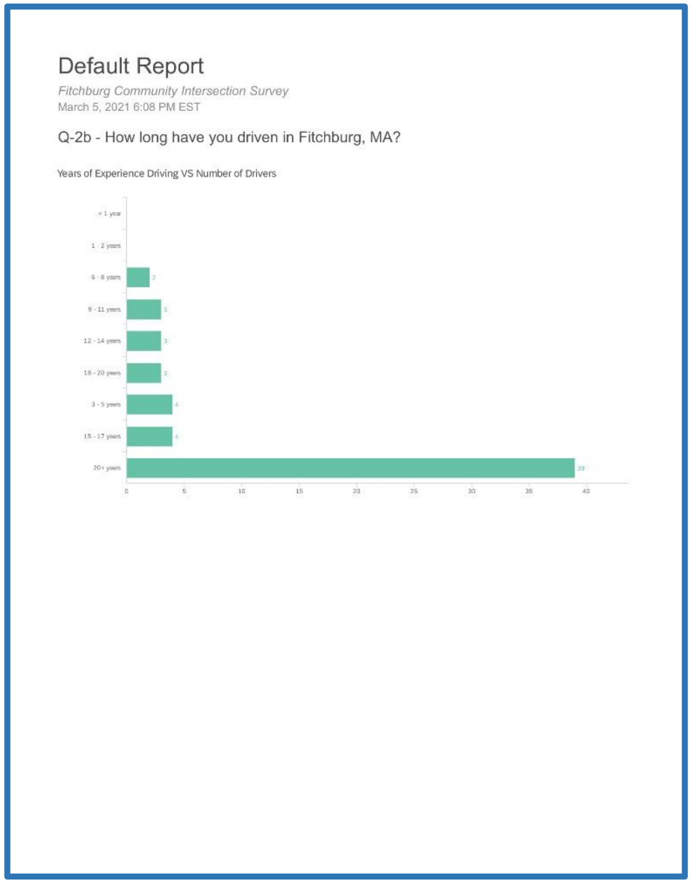


Major Street Direction: East-West

	Eastbound			Westbound			Northbound			Southbound		
	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
Number of Lanes and Usage	0	1	0	0	1	0	0	0	0	0	0	0
	Shared	Shared		Shared	Shared		Shared	Shared		Shared	Shared	
	Right Turn	Channelized		Right Turn	Channelized		Right Turn	Channelized		Right Turn	Channelized	
Flared Minor-Street Approach and Storage	☐ Yes	Storage		☐ Yes	Storage		☐ Yes	Storage	0	☐ Yes	Storage	0
Median Type	Undivided	Median Storage	1				Undivided	Median Storage				
		TR	LT					LR				
Volume (vph), Increment 10 %	0	111	53	445	163	0	37	0	406	0	0	0
Peak Hour Factor, PHF	1.00	0.82	0.69	0.80	0.81	1.00	0.93	1.00	0.91	1.00	1.00	1.00
Peak-15 Minute Volume (v)	0	34	19	139	50	0	10	0	112	0	0	0
Percent Heavy Vehicles (%)	0			6			2	0	10	0	0	0
Percent Grade (%)								2			0	
Hourly Flow Rate (vph)	0	135	76	556	201	0	39	0	446	0	0	0

Screenshot of Afternoon Input Data for HCS Analysis

Appendix D: Community Survey Results Report

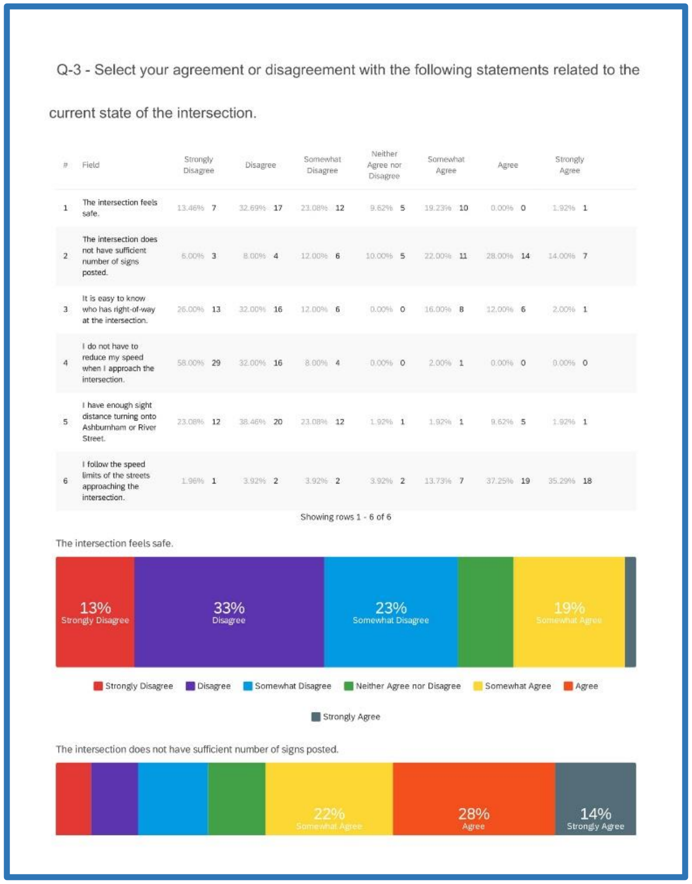


Default Report

Fitchburg Community Intersection Survey
March 5, 2021 6:08 PM EST

Q-2b - How long have you driven in Fitchburg, MA?

Years of Experience Driving VS Number of Drivers



Q-3 - Select your agreement or disagreement with the following statements related to the current state of the intersection.

#	Field	Strongly Disagree		Disagree		Somewhat Disagree		Neither Agree nor Disagree		Somewhat Agree		Agree		Strongly Agree	
1	The intersection feels safe.	13.46%	7	32.69%	17	23.08%	12	9.62%	5	19.23%	10	0.00%	0	1.92%	1
2	The intersection does not have sufficient number of signs posted.	6.00%	3	8.00%	4	12.00%	6	10.00%	5	22.00%	11	28.00%	14	14.00%	7
3	It is easy to know who has right-of-way at the intersection.	26.00%	13	32.00%	16	12.00%	6	0.00%	0	16.00%	8	12.00%	6	2.00%	1
4	I do not have to reduce my speed when I approach the intersection.	58.00%	29	32.00%	16	8.00%	4	0.00%	0	2.00%	1	0.00%	0	0.00%	0
5	I have enough sight distance turning onto Ashburnham or River Street.	23.08%	12	38.46%	20	23.08%	12	1.92%	1	1.92%	1	9.62%	5	1.92%	1
6	I follow the speed limits of the streets approaching the intersection.	1.96%	1	3.92%	2	3.92%	2	3.92%	2	13.73%	7	37.25%	19	35.29%	18

Showing rows 1 - 6 of 6

The intersection feels safe.

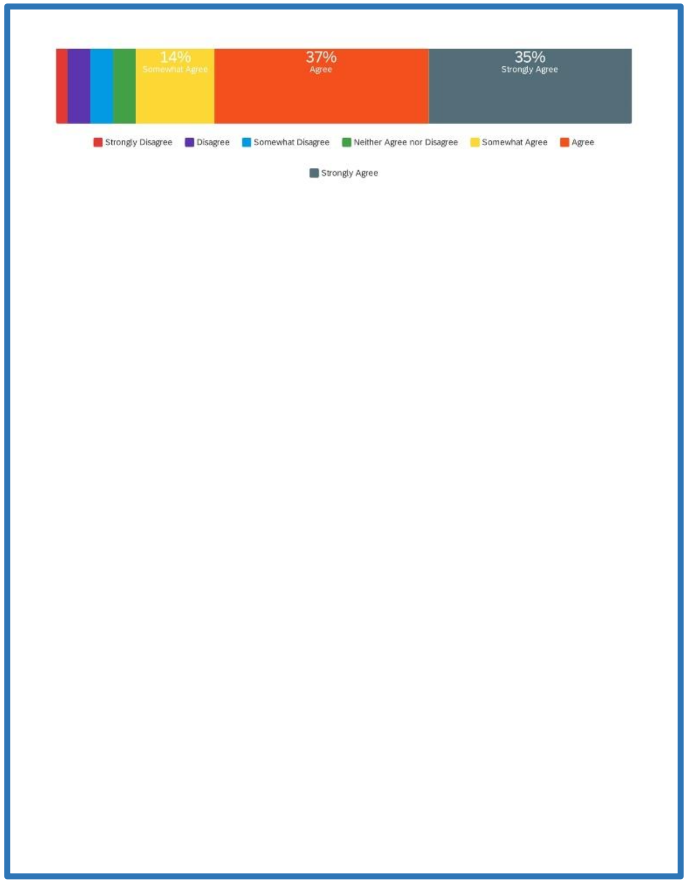
The intersection does not have sufficient number of signs posted.

It's easy to know who has right-of-way.

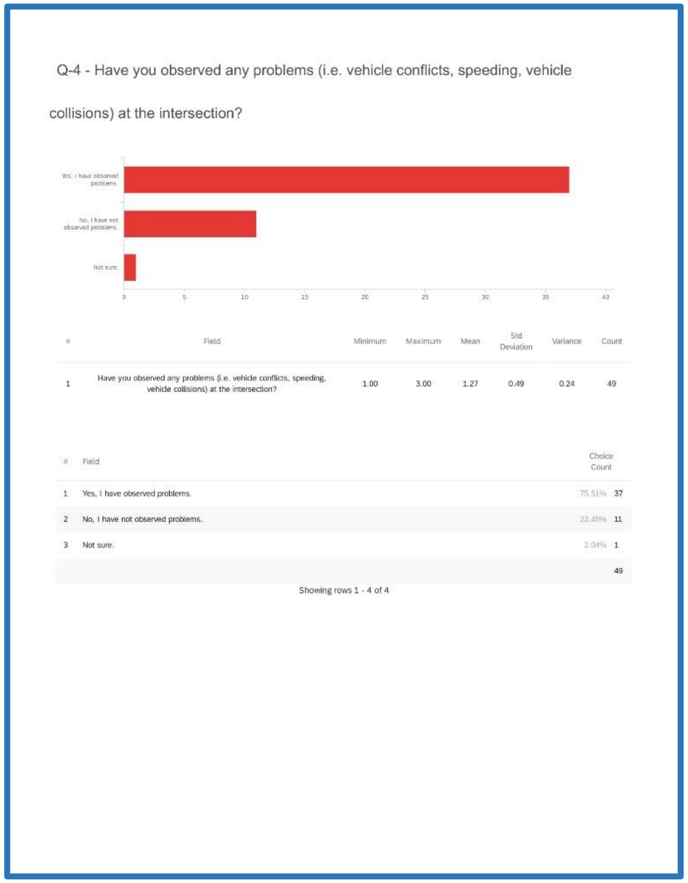
I don't reduce my speed when I approach the intersection

I have enough sight distance.

I follow speed limits.



v

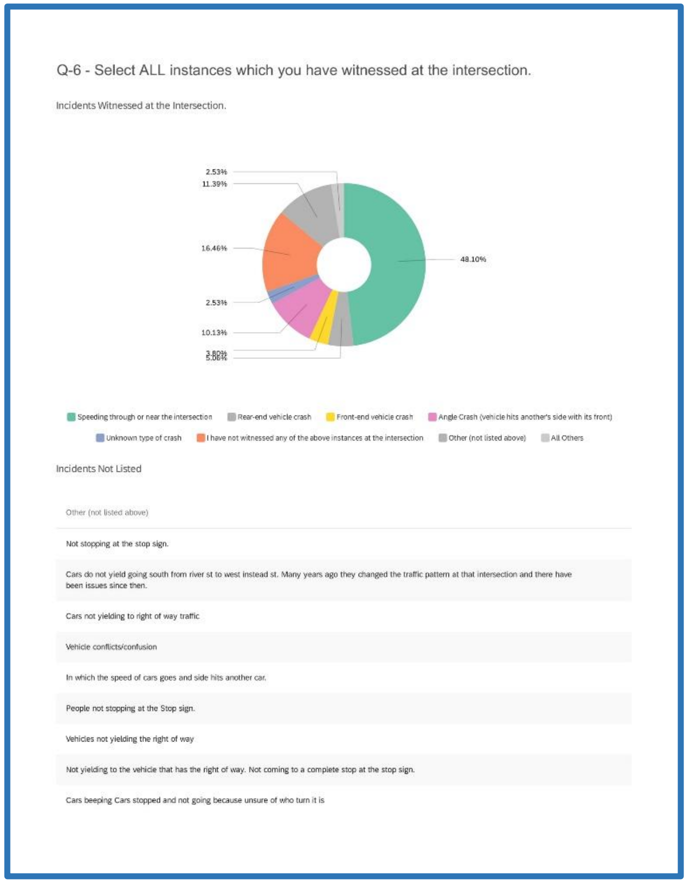


Q-4 - Have you observed any problems (i.e. vehicle conflicts, speeding, vehicle collisions) at the intersection?

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Have you observed any problems (i.e. vehicle conflicts, speeding, vehicle collisions) at the intersection?	1.00	3.00	1.27	0.49	0.24	49

#	Field	Choice Count	
1	Yes, I have observed problems.	75.51%	37
2	No, I have not observed problems.	22.45%	11
3	Not sure.	2.04%	1
			49

Showing rows 1 - 4 of 4

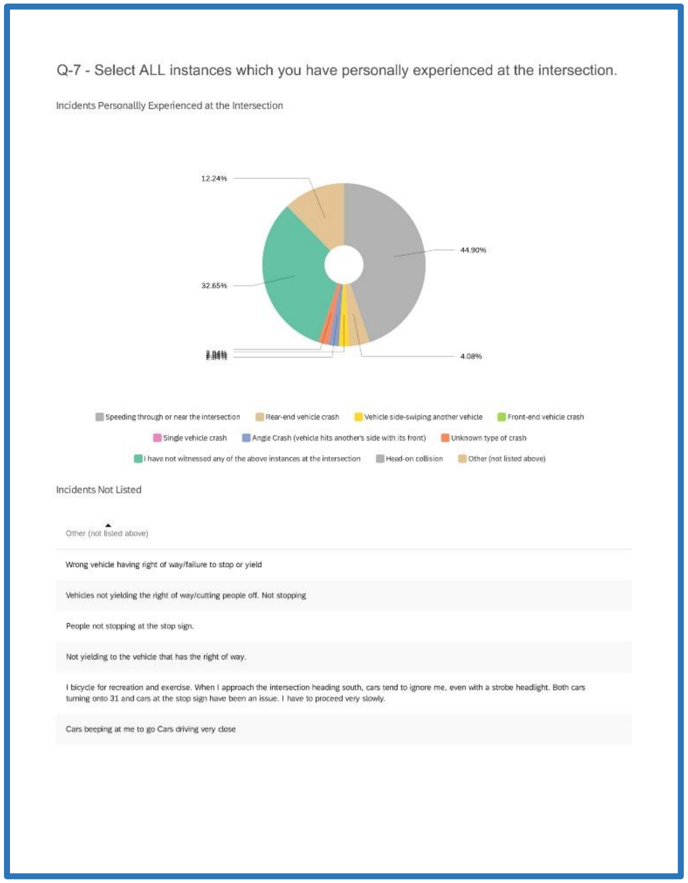


Q-6 - Select ALL instances which you have witnessed at the intersection.

Incidents Witnessed at the Intersection.

Incidents Not Listed

Other (not listed above)
Not stopping at the stop sign.
Cars do not yield going south from river st to west instead st. Many years ago they changed the traffic pattern at that intersection and there have been issues since then.
Cars not yielding to right of way traffic
Vehicle conflicts/confusion
In which the speed of cars goes and side hits another car.
People not stopping at the Stop sign.
Vehicles not yielding the right of way
Not yielding to the vehicle that has the right of way. Not coming to a complete stop at the stop sign.
Cars beeping Cars stopped and not going because unsure of who turn it is

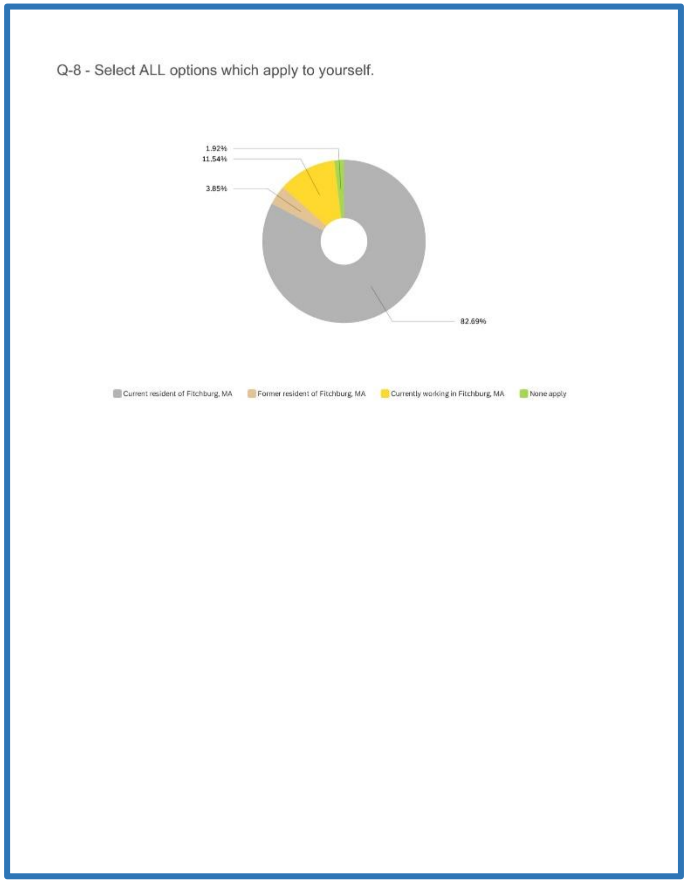


Q-7 - Select ALL instances which you have personally experienced at the intersection.

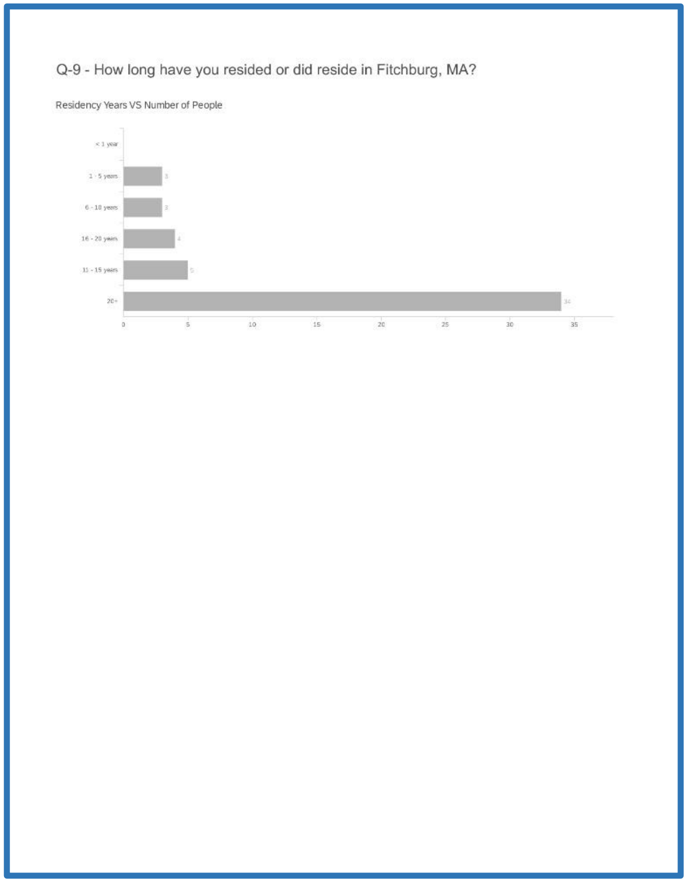
Incidents Personallly Experienced at the Intersection

Incidents Not Listed

Other (not listed above)
Wrong vehicle having right of way/failure to stop or yield
Vehicles not yielding the right of way/cutting people off. Not stopping
People not stopping at the stop sign.
Not yielding to the vehicle that has the right of way.
I bicycle for recreation and exercise. When I approach the intersection heading south, cars tend to ignore me, even with a strobe headlight. Both cars turning onto 31 and cars at the stop sign have been an issue. I have to proceed very slowly.
Cars beeping at me to go Cars driving very close

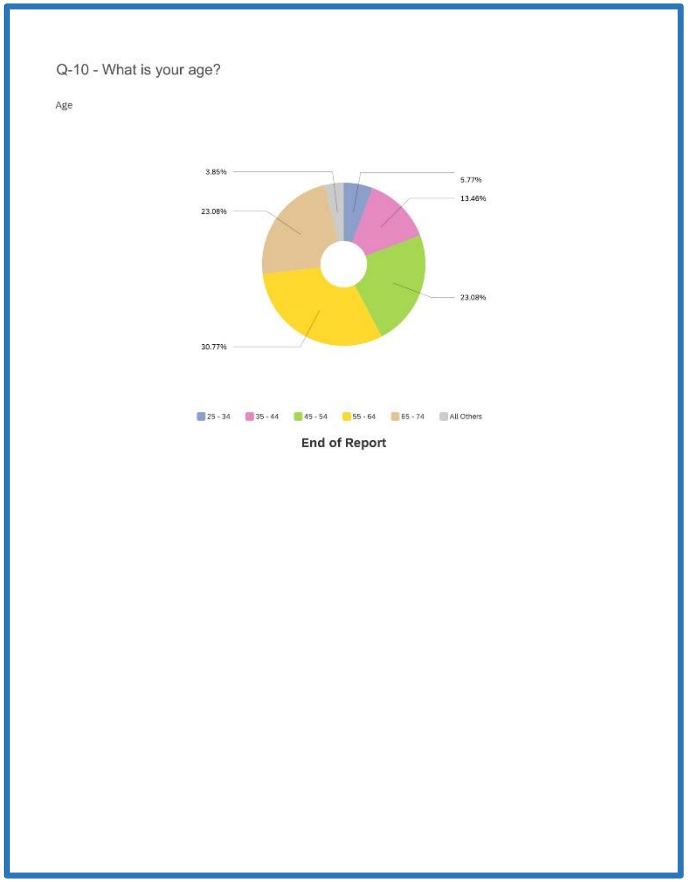


Q-8 - Select ALL options which apply to yourself.



Q-9 - How long have you resided or did reside in Fitchburg, MA?

Residency Years VS Number of People

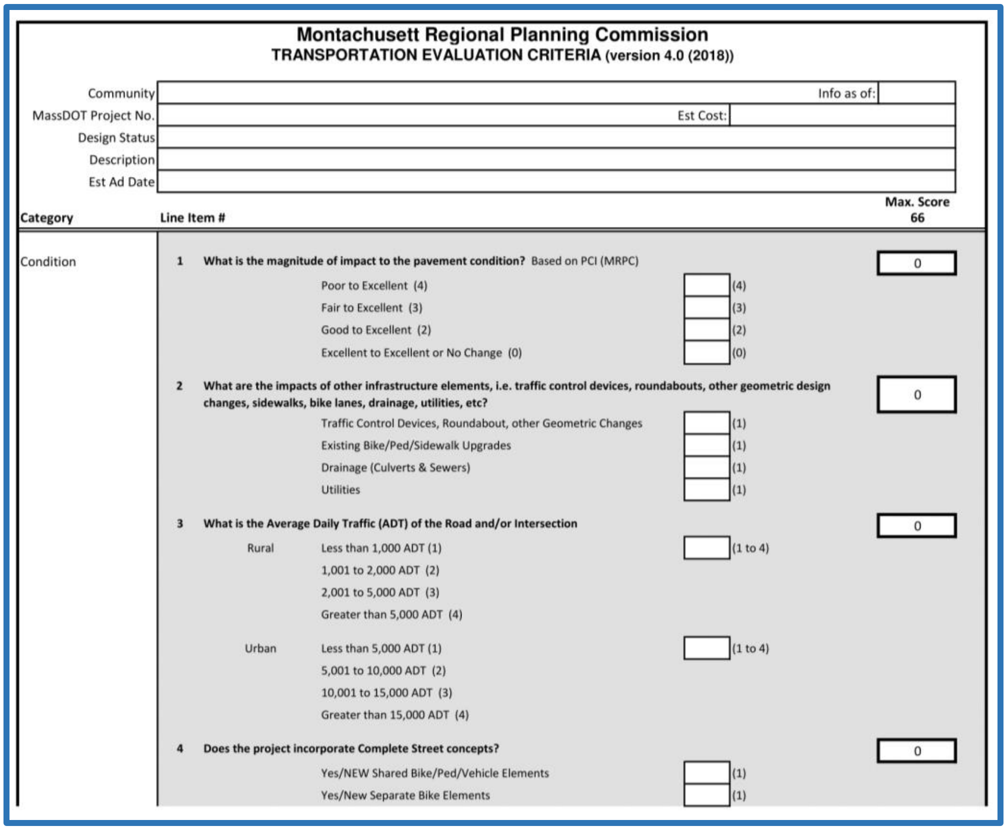


Q-10 - What is your age?

Age

End of Report

Appendix E: Full Transportation Evaluation Criteria Empty Template



Montachusett Regional Planning Commission

TRANSPORTATION EVALUATION CRITERIA (version 4.0 (2018))

Community: Info as of:

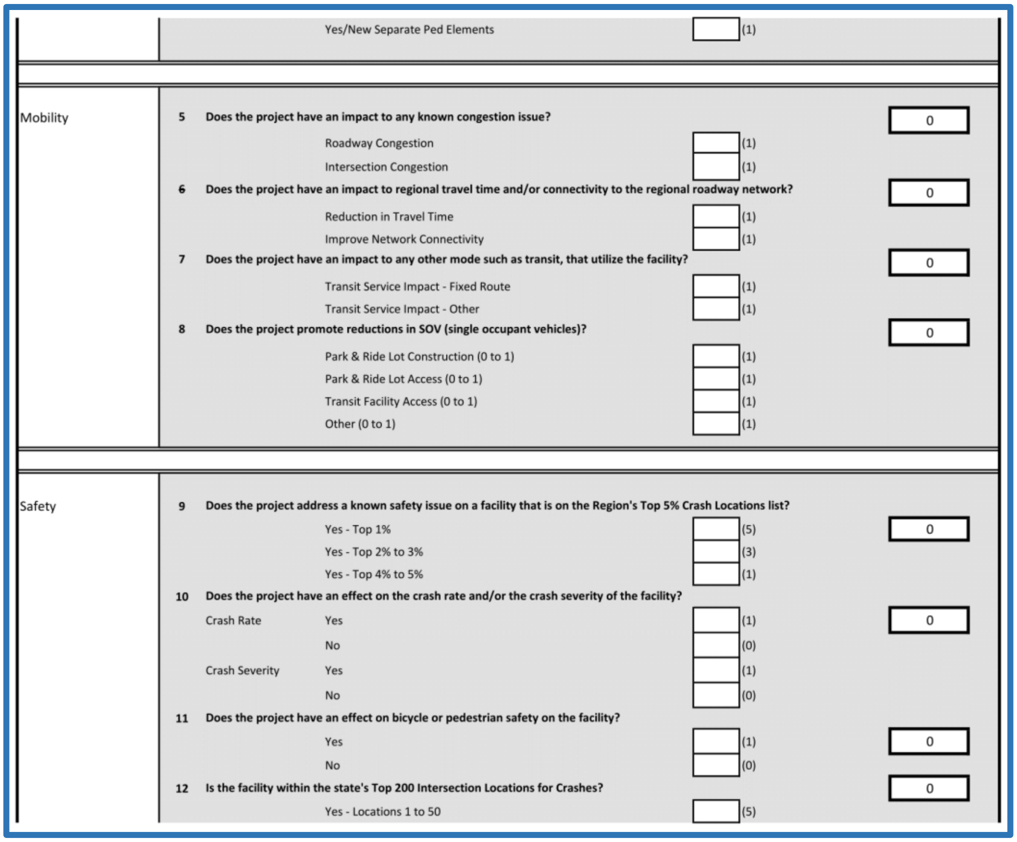
MassDOT Project No.: Est Cost:

Design Status:

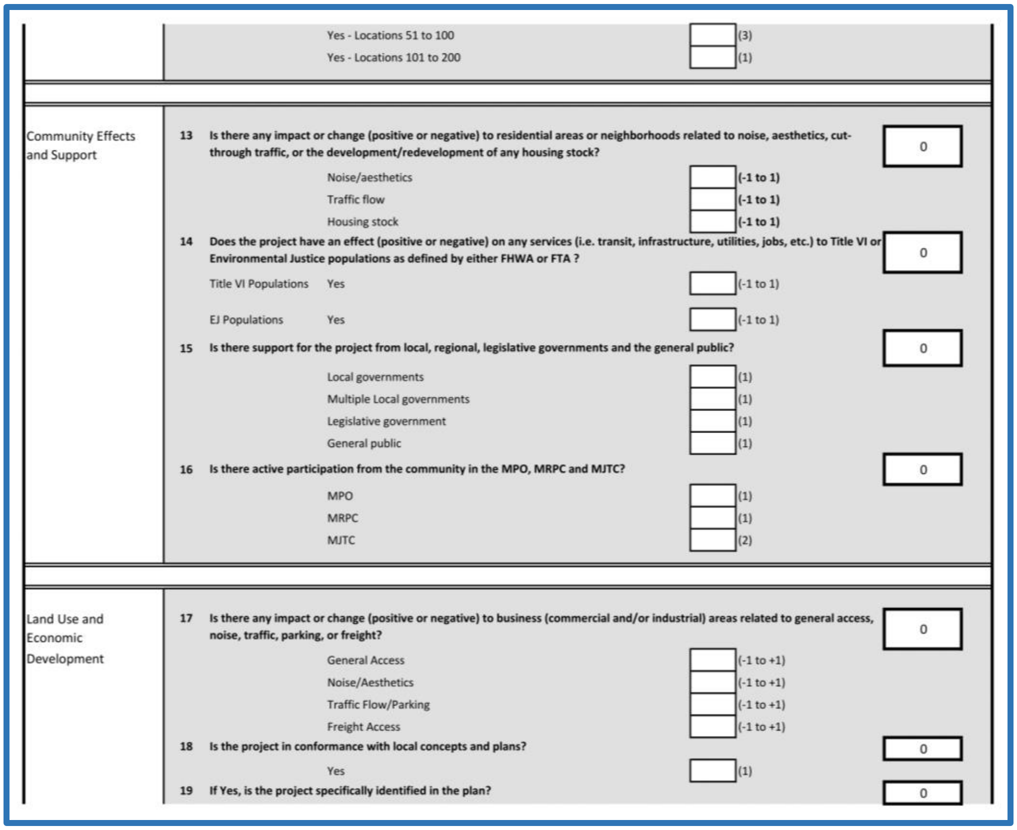
Description:

Est Ad Date:

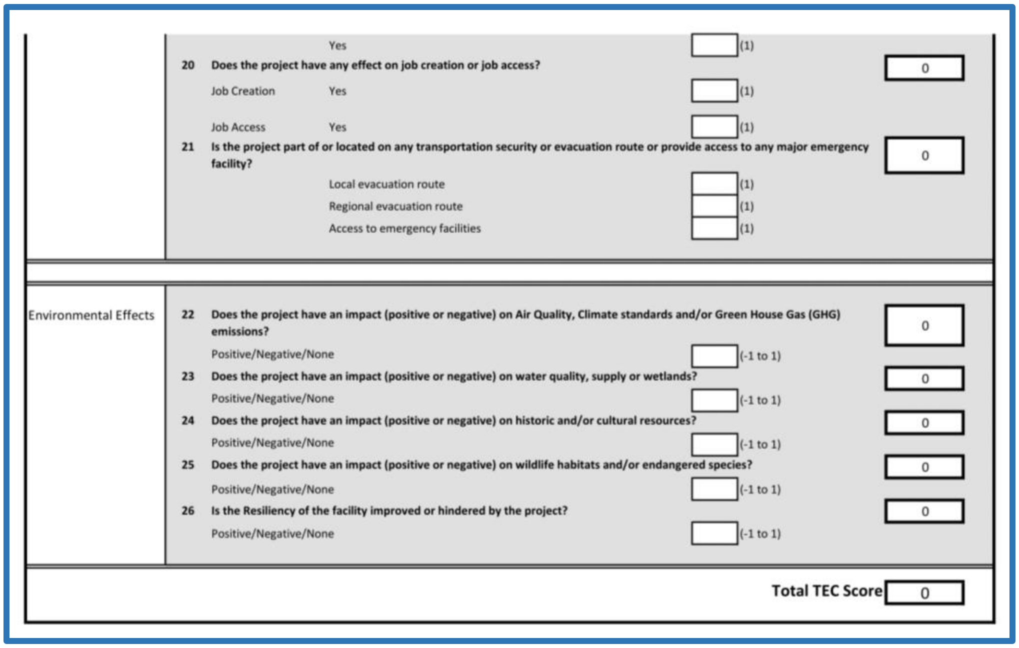
Category	**Line Item #**	**Max. Score** **66**
Condition	**1 What is the magnitude of impact to the pavement condition?** Based on PCI (MRPC)	0
	Poor to Excellent (4) ☐ (4)	
	Fair to Excellent (3) ☐ (3)	
	Good to Excellent (2) ☐ (2)	
	Excellent to Excellent or No Change (0) ☐ (0)	
	2 What are the impacts of other infrastructure elements, i.e. traffic control devices, roundabouts, other geometric design changes, sidewalks, bike lanes, drainage, utilities, etc?	0
	Traffic Control Devices, Roundabout, other Geometric Changes ☐ (1)	
	Existing Bike/Ped/Sidewalk Upgrades ☐ (1)	
	Drainage (Culverts & Sewers) ☐ (1)	
	Utilities ☐ (1)	
	3 What is the Average Daily Traffic (ADT) of the Road and/or Intersection	0
	Rural: Less than 1,000 ADT (1) ☐ (1 to 4)	
	1,001 to 2,000 ADT (2)	
	2,001 to 5,000 ADT (3)	
	Greater than 5,000 ADT (4)	
	Urban: Less than 5,000 ADT (1) ☐ (1 to 4)	
	5,001 to 10,000 ADT (2)	
	10,001 to 15,000 ADT (3)	
	Greater than 15,000 ADT (4)	
	4 Does the project incorporate Complete Street concepts?	0
	Yes/NEW Shared Bike/Ped/Vehicle Elements ☐ (1)	
	Yes/New Separate Bike Elements ☐ (1)	



			Yes/New Separate Ped Elements	(1)	
Mobility	5	Does the project have an impact to any known congestion issue?			0
			Roadway Congestion	(1)	
			Intersection Congestion	(1)	
	6	Does the project have an impact to regional travel time and/or connectivity to the regional roadway network?			0
			Reduction in Travel Time	(1)	
			Improve Network Connectivity	(1)	
	7	Does the project have an impact to any other mode such as transit, that utilize the facility?			0
			Transit Service Impact - Fixed Route	(1)	
			Transit Service Impact - Other	(1)	
	8	Does the project promote reductions in SOV (single occupant vehicles)?			0
			Park & Ride Lot Construction (0 to 1)	(1)	
			Park & Ride Lot Access (0 to 1)	(1)	
			Transit Facility Access (0 to 1)	(1)	
			Other (0 to 1)	(1)	
Safety	9	Does the project address a known safety issue on a facility that is on the Region's Top 5% Crash Locations list?			
			Yes - Top 1%	(5)	0
			Yes - Top 2% to 3%	(3)	
			Yes - Top 4% to 5%	(1)	
	10	Does the project have an effect on the crash rate and/or the crash severity of the facility?			
		Crash Rate	Yes	(1)	0
			No	(0)	
		Crash Severity	Yes	(1)	
			No	(0)	
	11	Does the project have an effect on bicycle or pedestrian safety on the facility?			
			Yes	(1)	0
			No	(0)	
	12	Is the facility within the state's Top 200 Intersection Locations for Crashes?			0
			Yes - Locations 1 to 50	(5)	

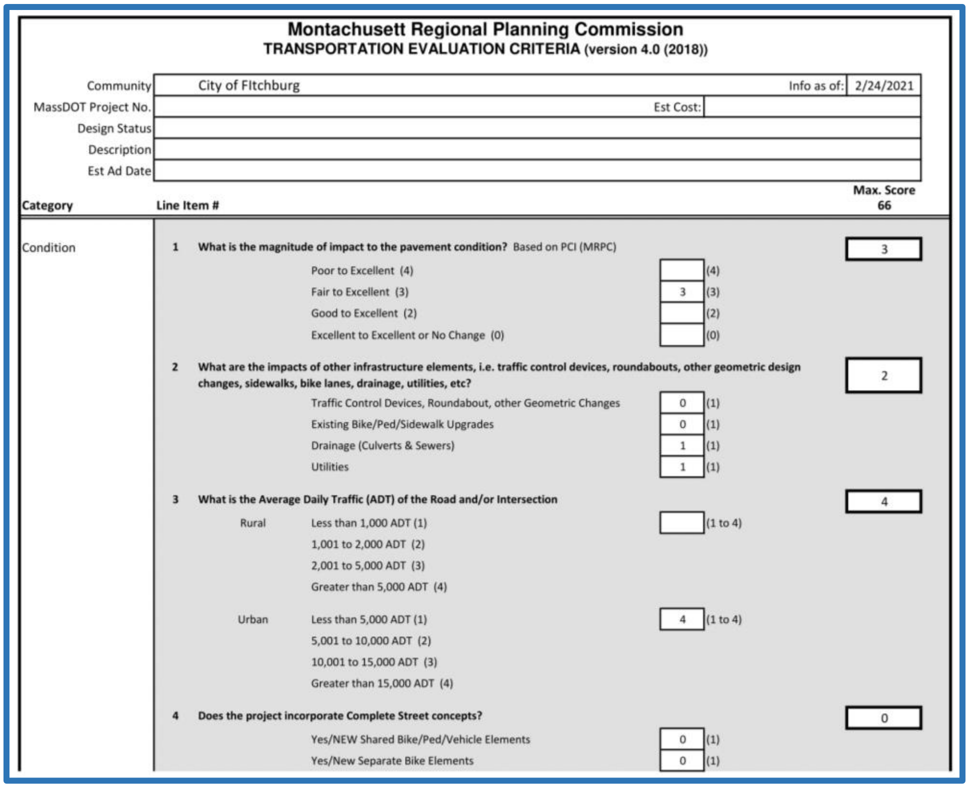


			Yes - Locations 51 to 100	(3)	
			Yes - Locations 101 to 200	(1)	
Community Effects and Support	13	Is there any impact or change (positive or negative) to residential areas or neighborhoods related to noise, aesthetics, cut-through traffic, or the development/redevelopment of any housing stock?			0
			Noise/aesthetics	**(-1 to 1)**	
			Traffic flow	**(-1 to 1)**	
			Housing stock	**(-1 to 1)**	
	14	Does the project have an effect (positive or negative) on any services (i.e. transit, infrastructure, utilities, jobs, etc.) to Title VI or Environmental Justice populations as defined by either FHWA or FTA ?			0
		Title VI Populations	Yes	(-1 to 1)	
		EJ Populations	Yes	(-1 to 1)	
	15	Is there support for the project from local, regional, legislative governments and the general public?			0
			Local governments	(1)	
			Multiple Local governments	(1)	
			Legislative government	(1)	
			General public	(1)	
	16	Is there active participation from the community in the MPO, MRPC and MJTC?			0
			MPO	(1)	
			MRPC	(1)	
			MJTC	(2)	
Land Use and Economic Development	17	Is there any impact or change (positive or negative) to business (commercial and/or industrial) areas related to general access, noise, traffic, parking, or freight?			0
			General Access	(-1 to +1)	
			Noise/Aesthetics	(-1 to +1)	
			Traffic Flow/Parking	(-1 to +1)	
			Freight Access	(-1 to +1)	
	18	Is the project in conformance with local concepts and plans?			0
			Yes	(1)	
	19	If Yes, is the project specifically identified in the plan?			0



			Yes	(1)	
	20	**Does the project have any effect on job creation or job access?**			0
		Job Creation	Yes	(1)	
		Job Access	Yes	(1)	
	21	**Is the project part of or located on any transportation security or evacuation route or provide access to any major emergency facility?**			0
			Local evacuation route	(1)	
			Regional evacuation route	(1)	
			Access to emergency facilities	(1)	
Environmental Effects	22	**Does the project have an impact (positive or negative) on Air Quality, Climate standards and/or Green House Gas (GHG) emissions?**			0
		Positive/Negative/None		(-1 to 1)	
	23	**Does the project have an impact (positive or negative) on water quality, supply or wetlands?**			0
		Positive/Negative/None		(-1 to 1)	
	24	**Does the project have an impact (positive or negative) on historic and/or cultural resources?**			0
		Positive/Negative/None		(-1 to 1)	
	25	**Does the project have an impact (positive or negative) on wildlife habitats and/or endangered species?**			0
		Positive/Negative/None		(-1 to 1)	
	26	**Is the Resiliency of the facility improved or hindered by the project?**			0
		Positive/Negative/None		(-1 to 1)	
				Total TEC Score	0

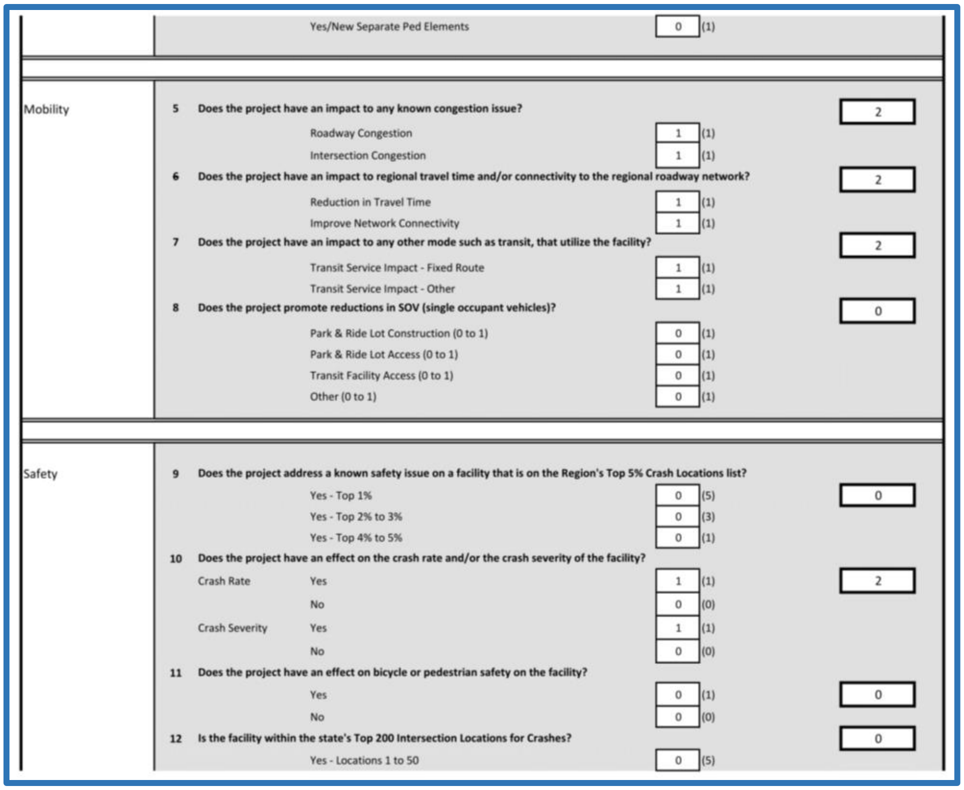
Appendix F: Bump out TEC Score Result



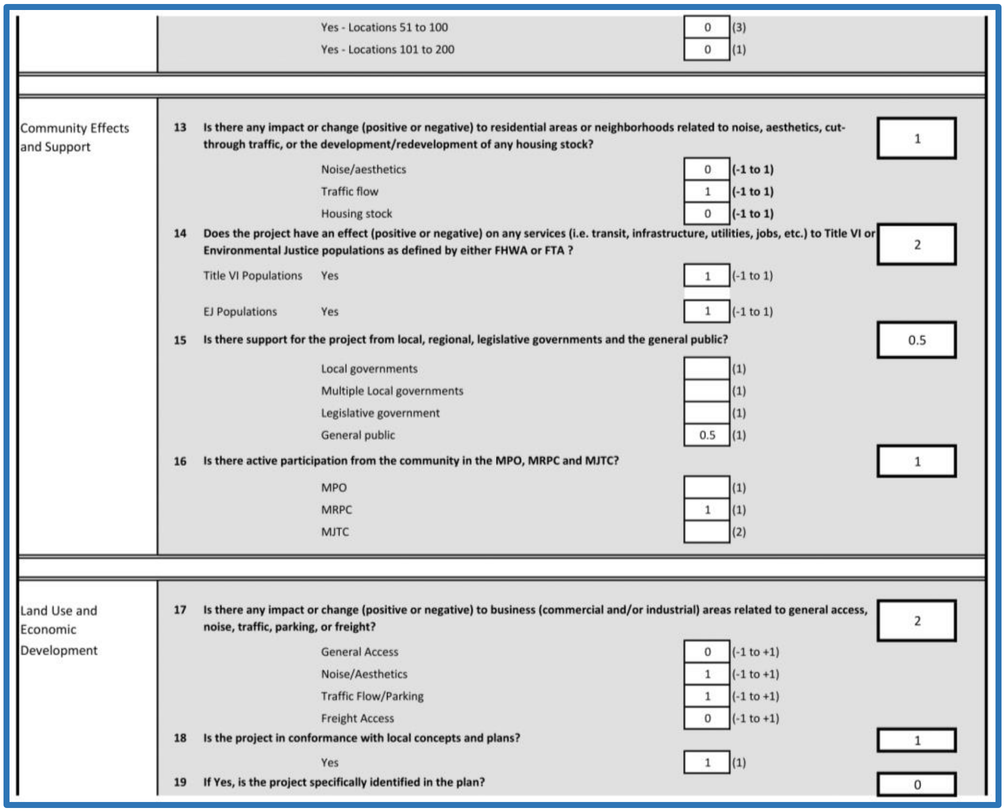
Montachusett Regional Planning Commission
TRANSPORTATION EVALUATION CRITERIA (version 4.0 (2018))

Community: City of FItchburg — Info as of: 2/24/2021
MassDOT Project No.: — Est Cost:
Design Status:
Description:
Est Ad Date:

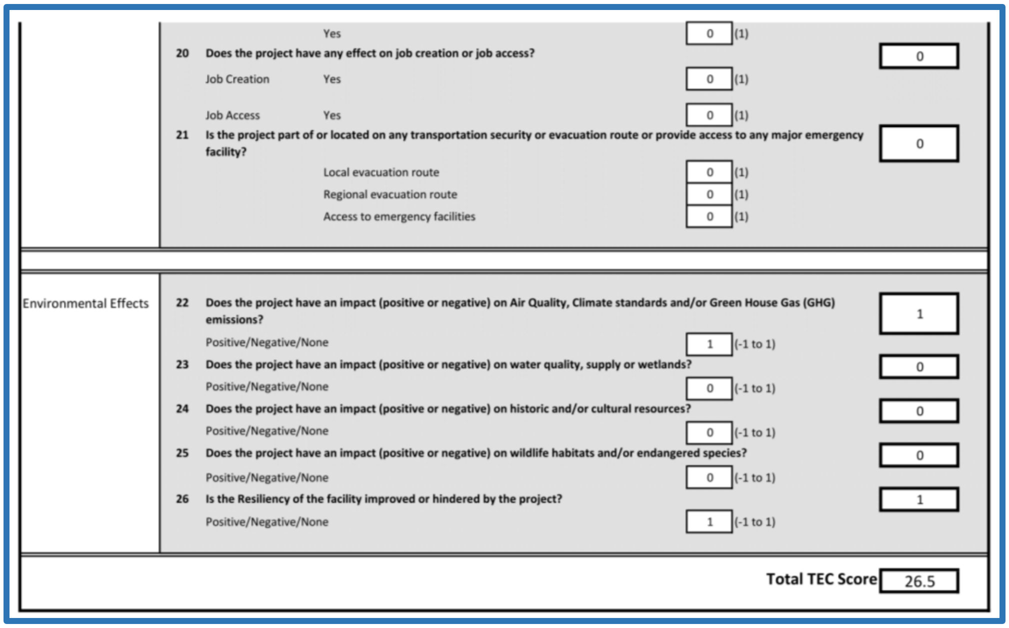
Category	Line Item #					Max. Score 66
Condition	1	**What is the magnitude of impact to the pavement condition?** Based on PCI (MRPC)				3
			Poor to Excellent (4)		(4)	
			Fair to Excellent (3)	3	(3)	
			Good to Excellent (2)		(2)	
			Excellent to Excellent or No Change (0)		(0)	
	2	**What are the impacts of other infrastructure elements, i.e. traffic control devices, roundabouts, other geometric design changes, sidewalks, bike lanes, drainage, utilities, etc?**				2
			Traffic Control Devices, Roundabout, other Geometric Changes	0	(1)	
			Existing Bike/Ped/Sidewalk Upgrades	0	(1)	
			Drainage (Culverts & Sewers)	1	(1)	
			Utilities	1	(1)	
	3	**What is the Average Daily Traffic (ADT) of the Road and/or Intersection**				4
		Rural	Less than 1,000 ADT (1)		(1 to 4)	
			1,001 to 2,000 ADT (2)			
			2,001 to 5,000 ADT (3)			
			Greater than 5,000 ADT (4)			
		Urban	Less than 5,000 ADT (1)	4	(1 to 4)	
			5,001 to 10,000 ADT (2)			
			10,001 to 15,000 ADT (3)			
			Greater than 15,000 ADT (4)			
	4	**Does the project incorporate Complete Street concepts?**				0
			Yes/NEW Shared Bike/Ped/Vehicle Elements	0	(1)	
			Yes/New Separate Bike Elements	0	(1)	



			Yes/New Separate Ped Elements	0	(1)	
Mobility	5	**Does the project have an impact to any known congestion issue?**				2
			Roadway Congestion	1	(1)	
			Intersection Congestion	1	(1)	
	6	**Does the project have an impact to regional travel time and/or connectivity to the regional roadway network?**				2
			Reduction in Travel Time	1	(1)	
			Improve Network Connectivity	1	(1)	
	7	**Does the project have an impact to any other mode such as transit, that utilize the facility?**				2
			Transit Service Impact - Fixed Route	1	(1)	
			Transit Service Impact - Other	1	(1)	
	8	**Does the project promote reductions in SOV (single occupant vehicles)?**				0
			Park & Ride Lot Construction (0 to 1)	0	(1)	
			Park & Ride Lot Access (0 to 1)	0	(1)	
			Transit Facility Access (0 to 1)	0	(1)	
			Other (0 to 1)	0	(1)	
Safety	9	**Does the project address a known safety issue on a facility that is on the Region's Top 5% Crash Locations list?**				0
			Yes - Top 1%	0	(5)	
			Yes - Top 2% to 3%	0	(3)	
			Yes - Top 4% to 5%	0	(1)	
	10	**Does the project have an effect on the crash rate and/or the crash severity of the facility?**				2
		Crash Rate	Yes	1	(1)	
			No	0	(0)	
		Crash Severity	Yes	1	(1)	
			No	0	(0)	
	11	**Does the project have an effect on bicycle or pedestrian safety on the facility?**				0
			Yes	0	(1)	
			No	0	(0)	
	12	**Is the facility within the state's Top 200 Intersection Locations for Crashes?**				0
			Yes - Locations 1 to 50	0	(5)	

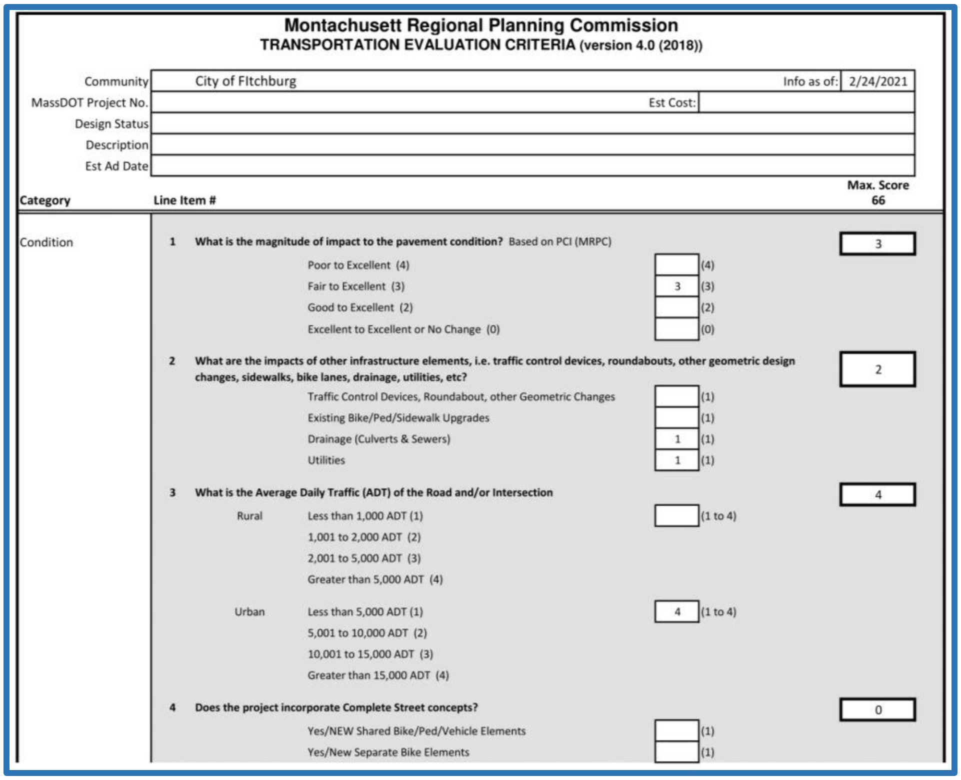


			Yes - Locations 51 to 100	0	(3)	
			Yes - Locations 101 to 200	0	(1)	
Community Effects and Support	13	**Is there any impact or change (positive or negative) to residential areas or neighborhoods related to noise, aesthetics, cut-through traffic, or the development/redevelopment of any housing stock?**				1
			Noise/aesthetics	0	**(-1 to 1)**	
			Traffic flow	1	**(-1 to 1)**	
			Housing stock	0	**(-1 to 1)**	
	14	**Does the project have an effect (positive or negative) on any services (i.e. transit, infrastructure, utilities, jobs, etc.) to Title VI or Environmental Justice populations as defined by either FHWA or FTA ?**				2
		Title VI Populations	Yes	1	(-1 to 1)	
		EJ Populations	Yes	1	(-1 to 1)	
	15	**Is there support for the project from local, regional, legislative governments and the general public?**				0.5
			Local governments		(1)	
			Multiple Local governments		(1)	
			Legislative government		(1)	
			General public	0.5	(1)	
	16	**Is there active participation from the community in the MPO, MRPC and MJTC?**				1
			MPO		(1)	
			MRPC	1	(1)	
			MJTC		(2)	
Land Use and Economic Development	17	**Is there any impact or change (positive or negative) to business (commercial and/or industrial) areas related to general access, noise, traffic, parking, or freight?**				2
			General Access	0	(-1 to +1)	
			Noise/Aesthetics	1	(-1 to +1)	
			Traffic Flow/Parking	1	(-1 to +1)	
			Freight Access	0	(-1 to +1)	
	18	**Is the project in conformance with local concepts and plans?**				1
			Yes	1	(1)	
	19	**If Yes, is the project specifically identified in the plan?**				0



			Yes	0	(1)	
	20	**Does the project have any effect on job creation or job access?**				0
		Job Creation	Yes	0	(1)	
		Job Access	Yes	0	(1)	
	21	**Is the project part of or located on any transportation security or evacuation route or provide access to any major emergency facility?**				0
			Local evacuation route	0	(1)	
			Regional evacuation route	0	(1)	
			Access to emergency facilities	0	(1)	
Environmental Effects	22	**Does the project have an impact (positive or negative) on Air Quality, Climate standards and/or Green House Gas (GHG) emissions?**				1
		Positive/Negative/None		1	(-1 to 1)	
	23	**Does the project have an impact (positive or negative) on water quality, supply or wetlands?**				0
		Positive/Negative/None		0	(-1 to 1)	
	24	**Does the project have an impact (positive or negative) on historic and/or cultural resources?**				0
		Positive/Negative/None		0	(-1 to 1)	
	25	**Does the project have an impact (positive or negative) on wildlife habitats and/or endangered species?**				0
		Positive/Negative/None		0	(-1 to 1)	
	26	**Is the Resiliency of the facility improved or hindered by the project?**				1
		Positive/Negative/None		1	(-1 to 1)	
					Total TEC Score	26.5

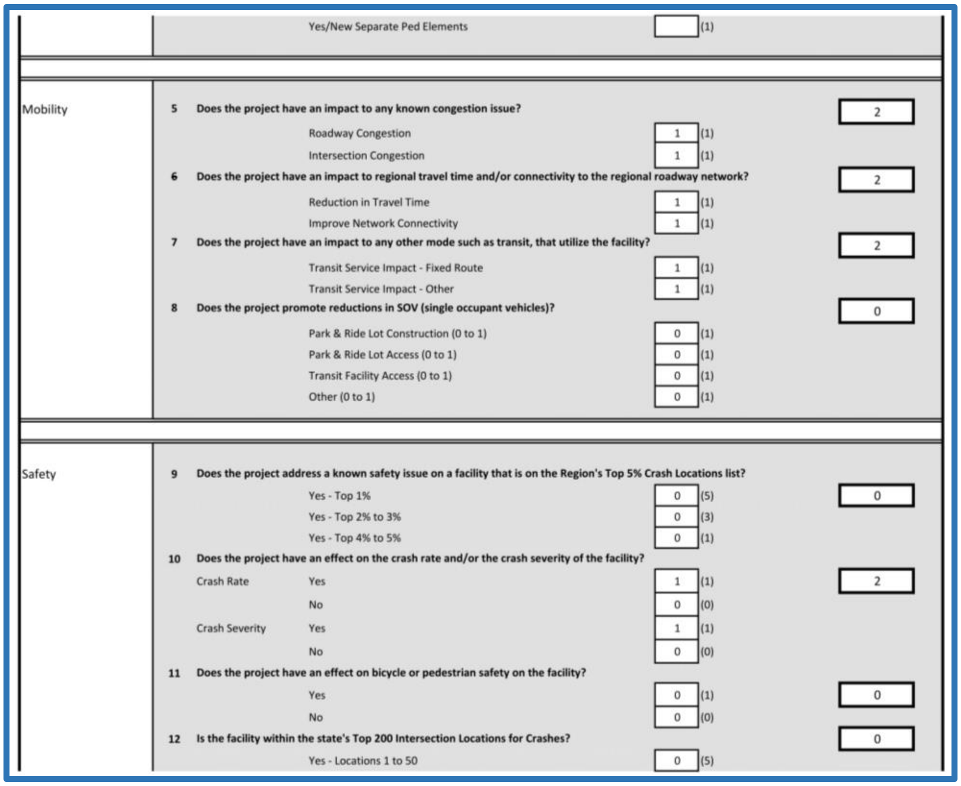
Appendix G: Island TEC Score Results



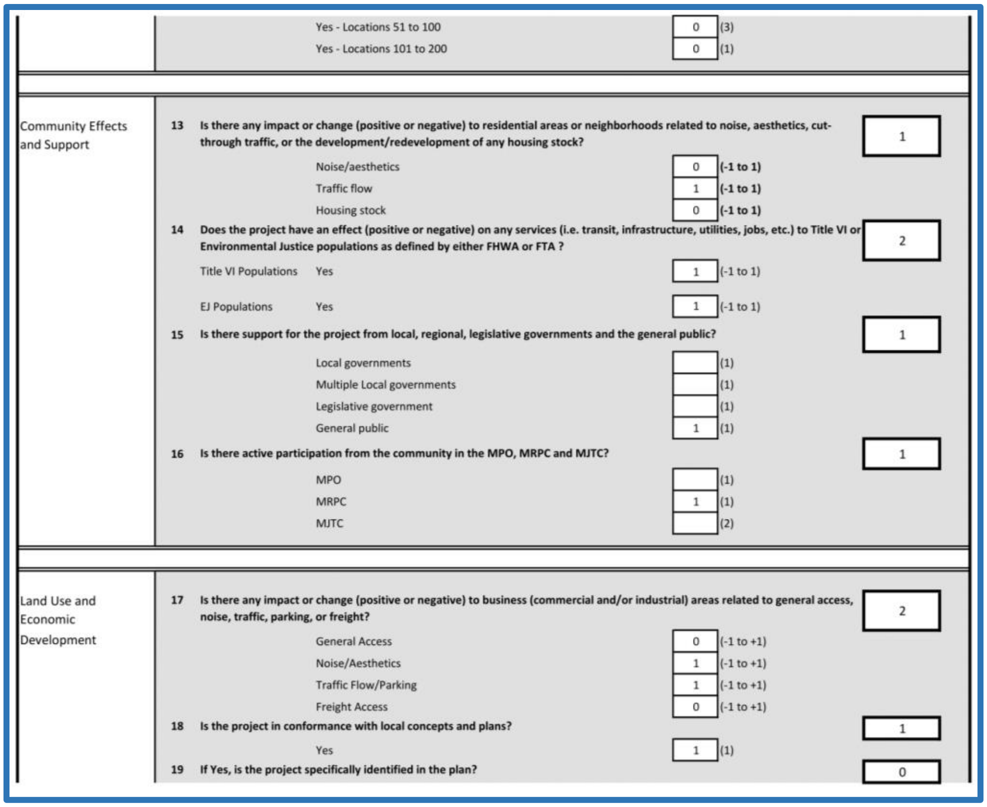
Montachusett Regional Planning Commission
TRANSPORTATION EVALUATION CRITERIA (version 4.0 (2018))

Community: City of FItchburg — Info as of: 2/24/2021
MassDOT Project No.: — Est Cost:
Design Status:
Description:
Est Ad Date:

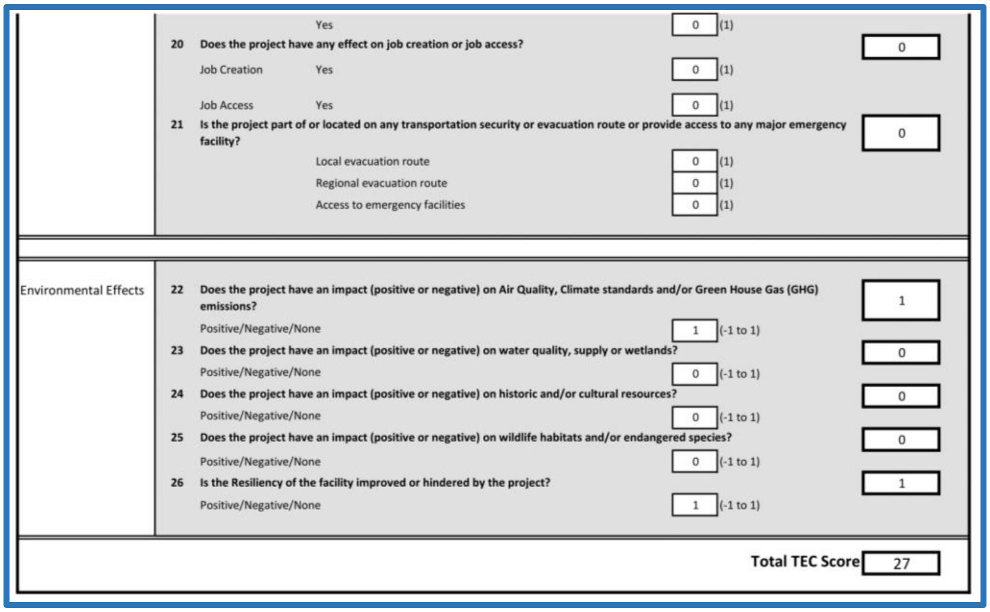
Category	Line Item #				Max. Score 66
Condition	1	**What is the magnitude of impact to the pavement condition?** Based on PCI (MRPC)			3
		Poor to Excellent (4)		(4)	
		Fair to Excellent (3)	3	(3)	
		Good to Excellent (2)		(2)	
		Excellent to Excellent or No Change (0)		(0)	
	2	**What are the impacts of other infrastructure elements, i.e. traffic control devices, roundabouts, other geometric design changes, sidewalks, bike lanes, drainage, utilities, etc?**			2
		Traffic Control Devices, Roundabout, other Geometric Changes		(1)	
		Existing Bike/Ped/Sidewalk Upgrades		(1)	
		Drainage (Culverts & Sewers)	1	(1)	
		Utilities	1	(1)	
	3	**What is the Average Daily Traffic (ADT) of the Road and/or Intersection**			4
		Rural: Less than 1,000 ADT (1)		(1 to 4)	
		1,001 to 2,000 ADT (2)			
		2,001 to 5,000 ADT (3)			
		Greater than 5,000 ADT (4)			
		Urban: Less than 5,000 ADT (1)	4	(1 to 4)	
		5,001 to 10,000 ADT (2)			
		10,001 to 15,000 ADT (3)			
		Greater than 15,000 ADT (4)			
	4	**Does the project incorporate Complete Street concepts?**			0
		Yes/NEW Shared Bike/Ped/Vehicle Elements		(1)	
		Yes/New Separate Bike Elements		(1)	



Category	Line Item #				
		Yes/New Separate Ped Elements		(1)	
Mobility	5	**Does the project have an impact to any known congestion issue?**			2
		Roadway Congestion	1	(1)	
		Intersection Congestion	1	(1)	
	6	**Does the project have an impact to regional travel time and/or connectivity to the regional roadway network?**			2
		Reduction in Travel Time	1	(1)	
		Improve Network Connectivity	1	(1)	
	7	**Does the project have an impact to any other mode such as transit, that utilize the facility?**			2
		Transit Service Impact - Fixed Route	1	(1)	
		Transit Service Impact - Other	1	(1)	
	8	**Does the project promote reductions in SOV (single occupant vehicles)?**			0
		Park & Ride Lot Construction (0 to 1)	0	(1)	
		Park & Ride Lot Access (0 to 1)	0	(1)	
		Transit Facility Access (0 to 1)	0	(1)	
		Other (0 to 1)	0	(1)	
Safety	9	**Does the project address a known safety issue on a facility that is on the Region's Top 5% Crash Locations list?**			
		Yes - Top 1%	0	(5)	0
		Yes - Top 2% to 3%	0	(3)	
		Yes - Top 4% to 5%	0	(1)	
	10	**Does the project have an effect on the crash rate and/or the crash severity of the facility?**			
		Crash Rate: Yes	1	(1)	2
		No	0	(0)	
		Crash Severity: Yes	1	(1)	
		No	0	(0)	
	11	**Does the project have an effect on bicycle or pedestrian safety on the facility?**			
		Yes	0	(1)	0
		No	0	(0)	
	12	**Is the facility within the state's Top 200 Intersection Locations for Crashes?**			0
		Yes - Locations 1 to 50	0	(5)	

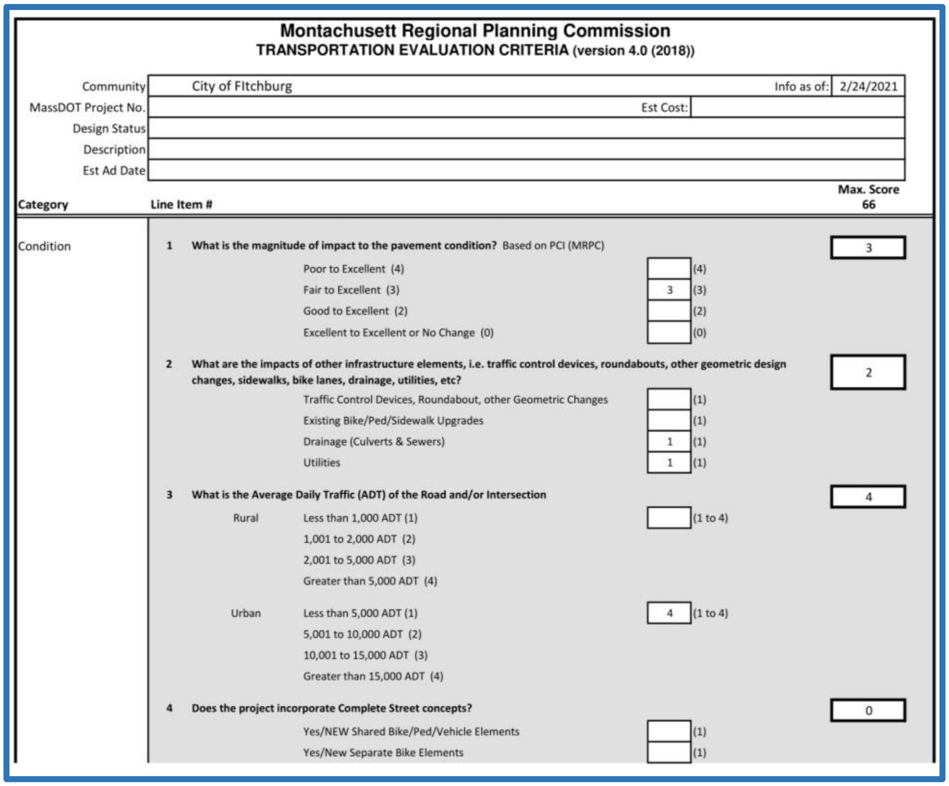


		Yes - Locations 51 to 100	0	(3)	
		Yes - Locations 101 to 200	0	(1)	
Community Effects and Support	13	**Is there any impact or change (positive or negative) to residential areas or neighborhoods related to noise, aesthetics, cut-through traffic, or the development/redevelopment of any housing stock?**			1
		Noise/aesthetics	0	**(-1 to 1)**	
		Traffic flow	1	**(-1 to 1)**	
		Housing stock	0	**(-1 to 1)**	
	14	**Does the project have an effect (positive or negative) on any services (i.e. transit, infrastructure, utilities, jobs, etc.) to Title VI or Environmental Justice populations as defined by either FHWA or FTA ?**			2
		Title VI Populations Yes	1	(-1 to 1)	
		EJ Populations Yes	1	(-1 to 1)	
	15	**Is there support for the project from local, regional, legislative governments and the general public?**			1
		Local governments		(1)	
		Multiple Local governments		(1)	
		Legislative government		(1)	
		General public	1	(1)	
	16	**Is there active participation from the community in the MPO, MRPC and MJTC?**			1
		MPO		(1)	
		MRPC	1	(1)	
		MJTC		(2)	
Land Use and Economic Development	17	**Is there any impact or change (positive or negative) to business (commercial and/or industrial) areas related to general access, noise, traffic, parking, or freight?**			2
		General Access	0	(-1 to +1)	
		Noise/Aesthetics	1	(-1 to +1)	
		Traffic Flow/Parking	1	(-1 to +1)	
		Freight Access	0	(-1 to +1)	
	18	**Is the project in conformance with local concepts and plans?**			1
		Yes	1	(1)	
	19	**If Yes, is the project specifically identified in the plan?**			0



		Yes	0	(1)	
	20	**Does the project have any effect on job creation or job access?**			0
		Job Creation Yes	0	(1)	
		Job Access Yes	0	(1)	
	21	**Is the project part of or located on any transportation security or evacuation route or provide access to any major emergency facility?**			0
		Local evacuation route	0	(1)	
		Regional evacuation route	0	(1)	
		Access to emergency facilities	0	(1)	
Environmental Effects	22	**Does the project have an impact (positive or negative) on Air Quality, Climate standards and/or Green House Gas (GHG) emissions?**			1
		Positive/Negative/None	1	(-1 to 1)	
	23	**Does the project have an impact (positive or negative) on water quality, supply or wetlands?**			0
		Positive/Negative/None	0	(-1 to 1)	
	24	**Does the project have an impact (positive or negative) on historic and/or cultural resources?**			0
		Positive/Negative/None	0	(-1 to 1)	
	25	**Does the project have an impact (positive or negative) on wildlife habitats and/or endangered species?**			0
		Positive/Negative/None	0	(-1 to 1)	
	26	**Is the Resiliency of the facility improved or hindered by the project?**			1
		Positive/Negative/None	1	(-1 to 1)	
				Total TEC Score	27

Appendix H: Signal TEC Score Results



Montachusett Regional Planning Commission
TRANSPORTATION EVALUATION CRITERIA (version 4.0 (2018))

Community: City of FItchburg
Info as of: 2/24/2021
MassDOT Project No.:
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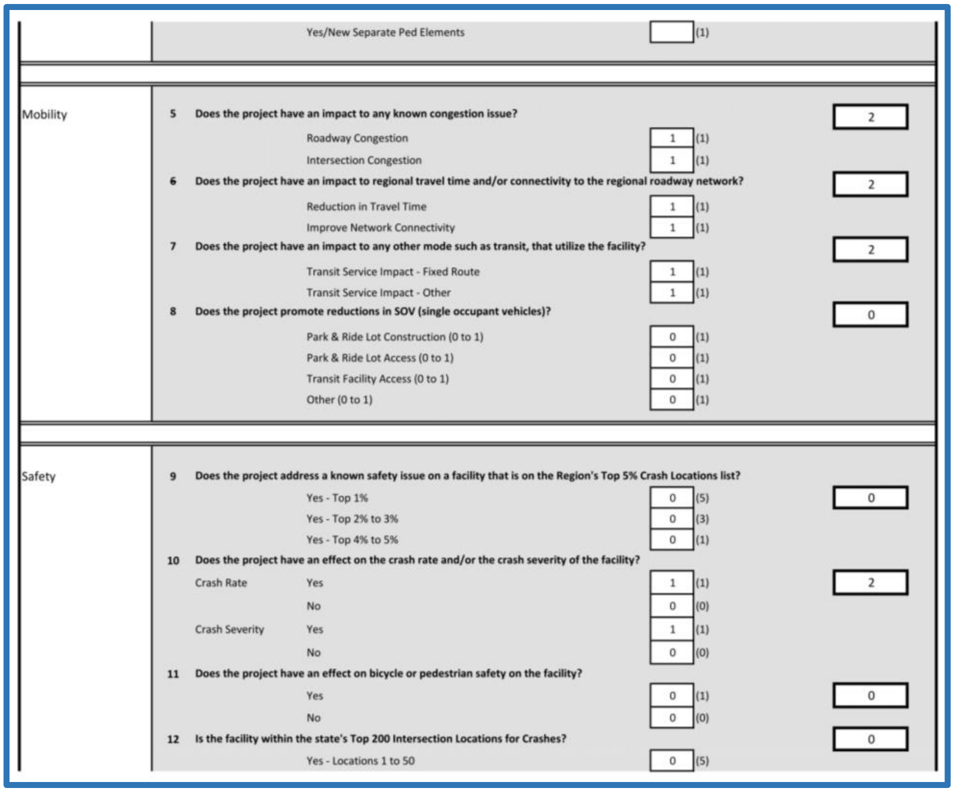
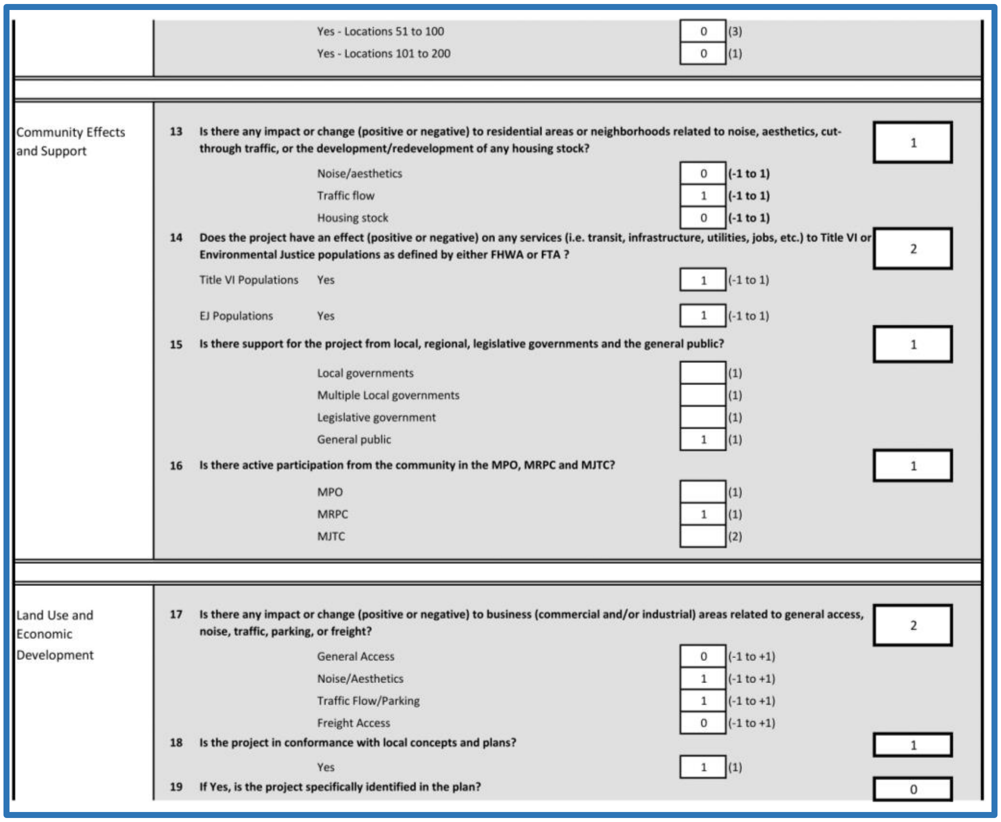
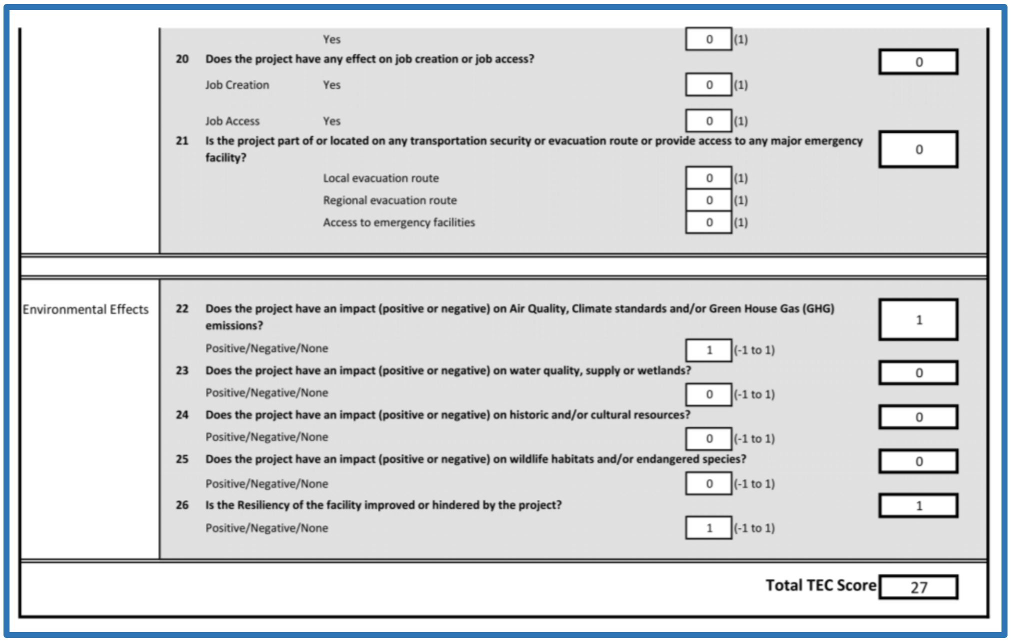
Category	**Line Item #**					**Max. Score** **66**
Condition	1	**What is the magnitude of impact to the pavement condition?** Based on PCI (MRPC)				3
			Poor to Excellent (4)		(4)	
			Fair to Excellent (3)	3	(3)	
			Good to Excellent (2)		(2)	
			Excellent to Excellent or No Change (0)		(0)	
	2	**What are the impacts of other infrastructure elements, i.e. traffic control devices, roundabouts, other geometric design changes, sidewalks, bike lanes, drainage, utilities, etc?**				2
			Traffic Control Devices, Roundabout, other Geometric Changes		(1)	
			Existing Bike/Ped/Sidewalk Upgrades		(1)	
			Drainage (Culverts & Sewers)	1	(1)	
			Utilities	1	(1)	
	3	**What is the Average Daily Traffic (ADT) of the Road and/or Intersection**				4
		Rural	Less than 1,000 ADT (1)		(1 to 4)	
			1,001 to 2,000 ADT (2)			
			2,001 to 5,000 ADT (3)			
			Greater than 5,000 ADT (4)			
		Urban	Less than 5,000 ADT (1)	4	(1 to 4)	
			5,001 to 10,000 ADT (2)			
			10,001 to 15,000 ADT (3)			
			Greater than 15,000 ADT (4)			
	4	**Does the project incorporate Complete Street concepts?**				0
			Yes/NEW Shared Bike/Ped/Vehicle Elements		(1)	
			Yes/New Separate Bike Elements		(1)	



			Yes/New Separate Ped Elements		(1)	
Mobility	5	**Does the project have an impact to any known congestion issue?**				2
			Roadway Congestion	1	(1)	
			Intersection Congestion	1	(1)	
	6	**Does the project have an impact to regional travel time and/or connectivity to the regional roadway network?**				2
			Reduction in Travel Time	1	(1)	
			Improve Network Connectivity	1	(1)	
	7	**Does the project have an impact to any other mode such as transit, that utilize the facility?**				2
			Transit Service Impact - Fixed Route	1	(1)	
			Transit Service Impact - Other	1	(1)	
	8	**Does the project promote reductions in SOV (single occupant vehicles)?**				0
			Park & Ride Lot Construction (0 to 1)	0	(1)	
			Park & Ride Lot Access (0 to 1)	0	(1)	
			Transit Facility Access (0 to 1)	0	(1)	
			Other (0 to 1)	0	(1)	
Safety	9	**Does the project address a known safety issue on a facility that is on the Region's Top 5% Crash Locations list?**				
			Yes - Top 1%	0	(5)	0
			Yes - Top 2% to 3%	0	(3)	
			Yes - Top 4% to 5%	0	(1)	
	10	**Does the project have an effect on the crash rate and/or the crash severity of the facility?**				
		Crash Rate	Yes	1	(1)	2
			No	0	(0)	
		Crash Severity	Yes	1	(1)	
			No	0	(0)	
	11	**Does the project have an effect on bicycle or pedestrian safety on the facility?**				
			Yes	0	(1)	0
			No	0	(0)	
	12	**Is the facility within the state's Top 200 Intersection Locations for Crashes?**				0
			Yes - Locations 1 to 50	0	(5)	

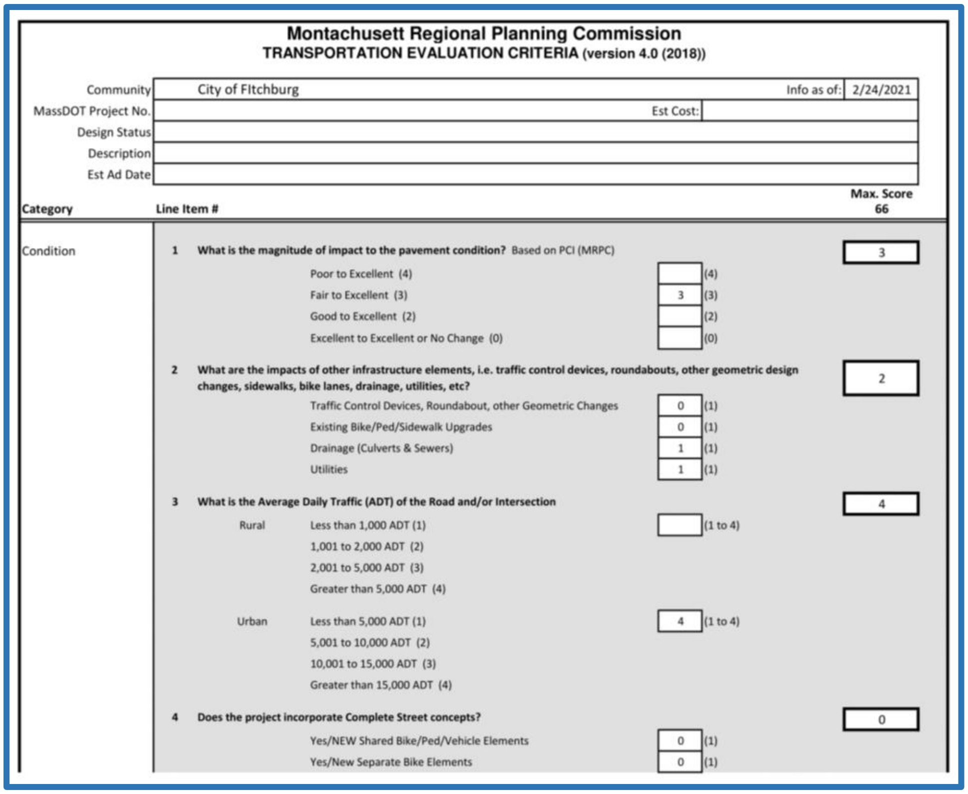


			Yes - Locations 51 to 100	0	(3)	
			Yes - Locations 101 to 200	0	(1)	
Community Effects and Support	13	Is there any impact or change (positive or negative) to residential areas or neighborhoods related to noise, aesthetics, cut-through traffic, or the development/redevelopment of any housing stock?				1
			Noise/aesthetics	0	(-1 to 1)	
			Traffic flow	1	(-1 to 1)	
			Housing stock	0	(-1 to 1)	
	14	Does the project have an effect (positive or negative) on any services (i.e. transit, infrastructure, utilities, jobs, etc.) to Title VI or Environmental Justice populations as defined by either FHWA or FTA ?				2
		Title VI Populations	Yes	1	(-1 to 1)	
		EJ Populations	Yes	1	(-1 to 1)	
	15	Is there support for the project from local, regional, legislative governments and the general public?				1
			Local governments		(1)	
			Multiple Local governments		(1)	
			Legislative government		(1)	
			General public	1	(1)	
	16	Is there active participation from the community in the MPO, MRPC and MJTC?				1
			MPO		(1)	
			MRPC	1	(1)	
			MJTC		(2)	
Land Use and Economic Development	17	Is there any impact or change (positive or negative) to business (commercial and/or industrial) areas related to general access, noise, traffic, parking, or freight?				2
			General Access	0	(-1 to +1)	
			Noise/Aesthetics	1	(-1 to +1)	
			Traffic Flow/Parking	1	(-1 to +1)	
			Freight Access	0	(-1 to +1)	
	18	Is the project in conformance with local concepts and plans?				1
			Yes	1	(1)	
	19	If Yes, is the project specifically identified in the plan?				0



			Yes	0	(1)	
	20	Does the project have any effect on job creation or job access?				0
		Job Creation	Yes	0	(1)	
		Job Access	Yes	0	(1)	
	21	Is the project part of or located on any transportation security or evacuation route or provide access to any major emergency facility?				0
			Local evacuation route	0	(1)	
			Regional evacuation route	0	(1)	
			Access to emergency facilities	0	(1)	
Environmental Effects	22	Does the project have an impact (positive or negative) on Air Quality, Climate standards and/or Green House Gas (GHG) emissions?				1
		Positive/Negative/None		1	(-1 to 1)	
	23	Does the project have an impact (positive or negative) on water quality, supply or wetlands?				0
		Positive/Negative/None		0	(-1 to 1)	
	24	Does the project have an impact (positive or negative) on historic and/or cultural resources?				0
		Positive/Negative/None		0	(-1 to 1)	
	25	Does the project have an impact (positive or negative) on wildlife habitats and/or endangered species?				0
		Positive/Negative/None		0	(-1 to 1)	
	26	Is the Resiliency of the facility improved or hindered by the project?				1
		Positive/Negative/None		1	(-1 to 1)	
					Total TEC Score	27

Appendix I: Bump Out with Signal TEC Results



Montachusett Regional Planning Commission

TRANSPORTATION EVALUATION CRITERIA (version 4.0 (2018))

Community: City of Fitchburg — Info as of: 2/24/2021

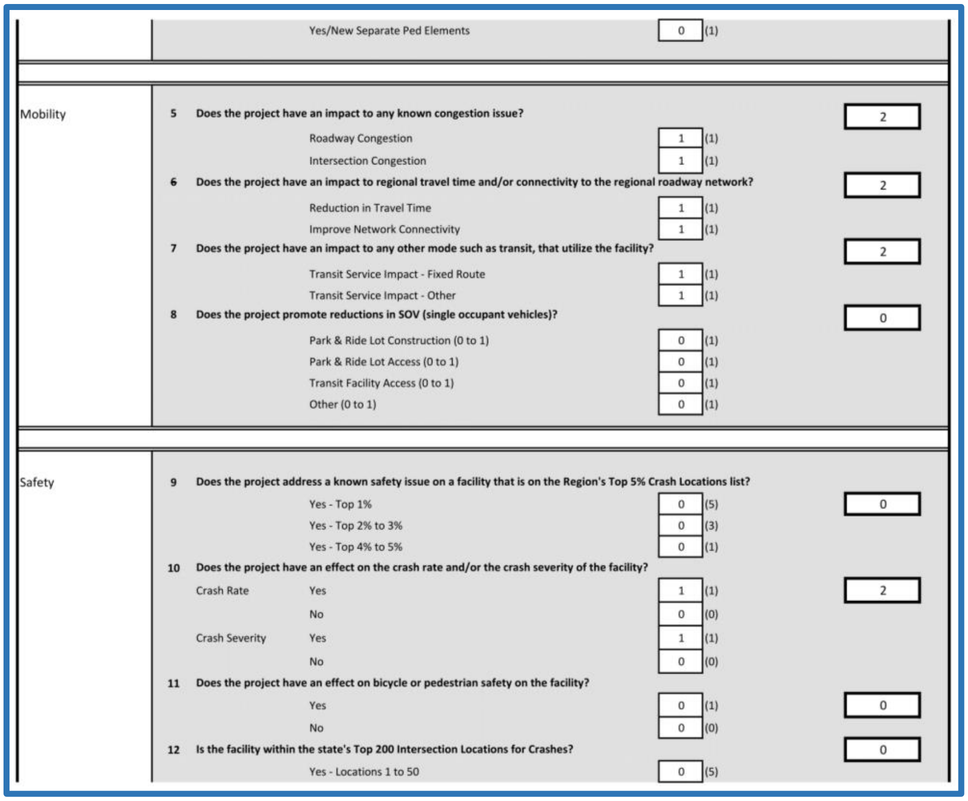
MassDOT Project No.: — Est Cost:

Design Status:

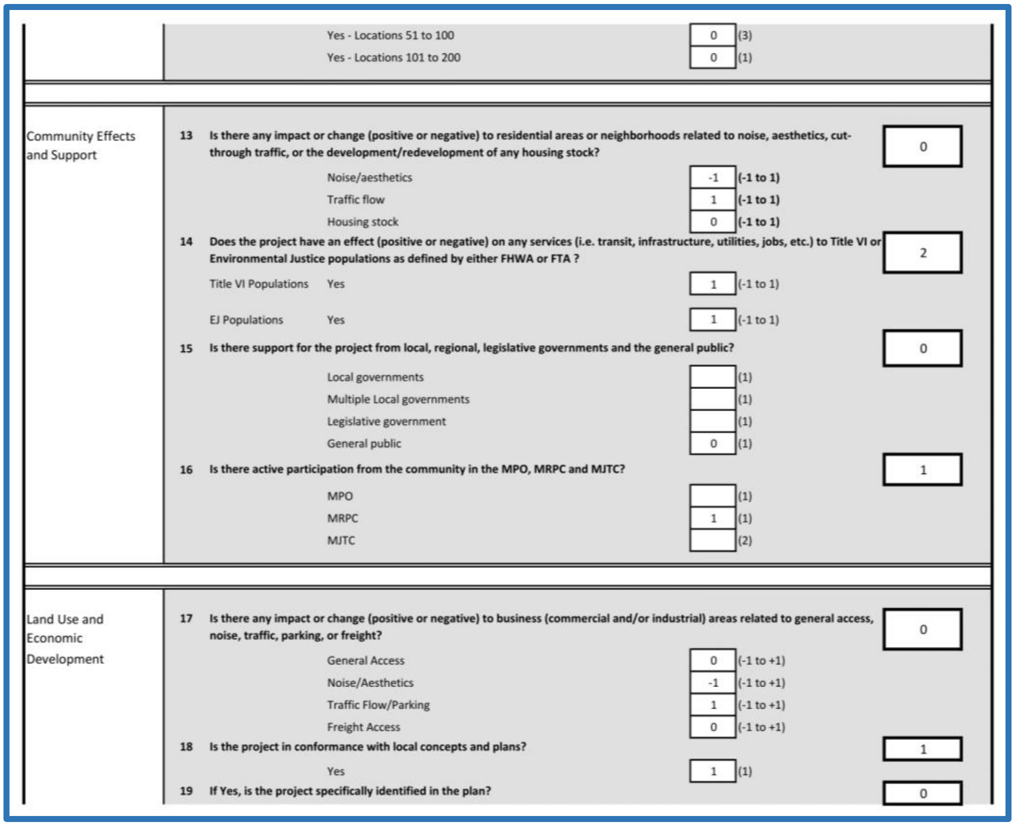
Description:

Est Ad Date:

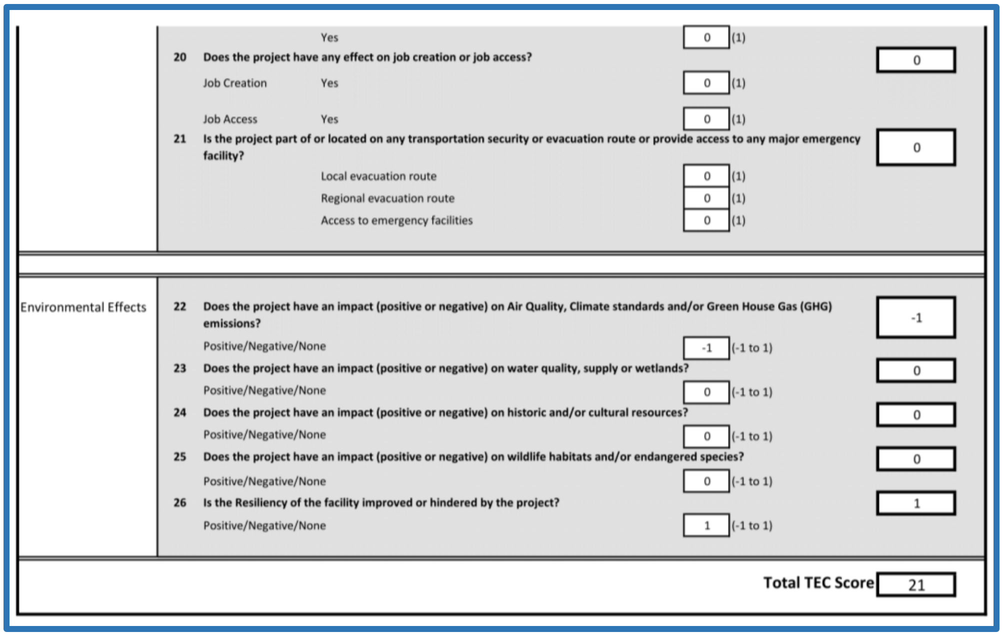
Category	**Line Item #**				**Max. Score** **66**
Condition	1	**What is the magnitude of impact to the pavement condition?** Based on PCI (MRPC)			3
		Poor to Excellent (4)		(4)	
		Fair to Excellent (3)	3	(3)	
		Good to Excellent (2)		(2)	
		Excellent to Excellent or No Change (0)		(0)	
	2	**What are the impacts of other infrastructure elements, i.e. traffic control devices, roundabouts, other geometric design changes, sidewalks, bike lanes, drainage, utilities, etc?**			2
		Traffic Control Devices, Roundabout, other Geometric Changes	0	(1)	
		Existing Bike/Ped/Sidewalk Upgrades	0	(1)	
		Drainage (Culverts & Sewers)	1	(1)	
		Utilities	1	(1)	
	3	**What is the Average Daily Traffic (ADT) of the Road and/or Intersection**			4
		Rural — Less than 1,000 ADT (1)		(1 to 4)	
		1,001 to 2,000 ADT (2)			
		2,001 to 5,000 ADT (3)			
		Greater than 5,000 ADT (4)			
		Urban — Less than 5,000 ADT (1)	4	(1 to 4)	
		5,001 to 10,000 ADT (2)			
		10,001 to 15,000 ADT (3)			
		Greater than 15,000 ADT (4)			
	4	**Does the project incorporate Complete Street concepts?**			0
		Yes/NEW Shared Bike/Ped/Vehicle Elements	0	(1)	
		Yes/New Separate Bike Elements	0	(1)	



		Yes/New Separate Ped Elements	0	(1)	
Mobility	5	**Does the project have an impact to any known congestion issue?**			2
		Roadway Congestion	1	(1)	
		Intersection Congestion	1	(1)	
	6	**Does the project have an impact to regional travel time and/or connectivity to the regional roadway network?**			2
		Reduction in Travel Time	1	(1)	
		Improve Network Connectivity	1	(1)	
	7	**Does the project have an impact to any other mode such as transit, that utilize the facility?**			2
		Transit Service Impact - Fixed Route	1	(1)	
		Transit Service Impact - Other	1	(1)	
	8	**Does the project promote reductions in SOV (single occupant vehicles)?**			0
		Park & Ride Lot Construction (0 to 1)	0	(1)	
		Park & Ride Lot Access (0 to 1)	0	(1)	
		Transit Facility Access (0 to 1)	0	(1)	
		Other (0 to 1)	0	(1)	
Safety	9	**Does the project address a known safety issue on a facility that is on the Region's Top 5% Crash Locations list?**			
		Yes - Top 1%	0	(5)	0
		Yes - Top 2% to 3%	0	(3)	
		Yes - Top 4% to 5%	0	(1)	
	10	**Does the project have an effect on the crash rate and/or the crash severity of the facility?**			
		Crash Rate — Yes	1	(1)	2
		No	0	(0)	
		Crash Severity — Yes	1	(1)	
		No	0	(0)	
	11	**Does the project have an effect on bicycle or pedestrian safety on the facility?**			
		Yes	0	(1)	0
		No	0	(0)	
	12	**Is the facility within the state's Top 200 Intersection Locations for Crashes?**			0
		Yes - Locations 1 to 50	0	(5)	



		Yes - Locations 51 to 100	0	(3)	
		Yes - Locations 101 to 200	0	(1)	
Community Effects and Support	13	**Is there any impact or change (positive or negative) to residential areas or neighborhoods related to noise, aesthetics, cut-through traffic, or the development/redevelopment of any housing stock?**			0
		Noise/aesthetics	-1	**(-1 to 1)**	
		Traffic flow	1	**(-1 to 1)**	
		Housing stock	0	**(-1 to 1)**	
	14	**Does the project have an effect (positive or negative) on any services (i.e. transit, infrastructure, utilities, jobs, etc.) to Title VI or Environmental Justice populations as defined by either FHWA or FTA ?**			2
		Title VI Populations Yes	1	(-1 to 1)	
		EJ Populations Yes	1	(-1 to 1)	
	15	**Is there support for the project from local, regional, legislative governments and the general public?**			0
		Local governments		(1)	
		Multiple Local governments		(1)	
		Legislative government		(1)	
		General public	0	(1)	
	16	**Is there active participation from the community in the MPO, MRPC and MJTC?**			1
		MPO		(1)	
		MRPC	1	(1)	
		MJTC		(2)	
Land Use and Economic Development	17	**Is there any impact or change (positive or negative) to business (commercial and/or industrial) areas related to general access, noise, traffic, parking, or freight?**			0
		General Access	0	(-1 to +1)	
		Noise/Aesthetics	-1	(-1 to +1)	
		Traffic Flow/Parking	1	(-1 to +1)	
		Freight Access	0	(-1 to +1)	
	18	**Is the project in conformance with local concepts and plans?**			1
		Yes	1	(1)	
	19	**If Yes, is the project specifically identified in the plan?**			0



		Yes	0	(1)	
	20	**Does the project have any effect on job creation or job access?**			0
		Job Creation Yes	0	(1)	
		Job Access Yes	0	(1)	
	21	**Is the project part of or located on any transportation security or evacuation route or provide access to any major emergency facility?**			0
		Local evacuation route	0	(1)	
		Regional evacuation route	0	(1)	
		Access to emergency facilities	0	(1)	
Environmental Effects	22	**Does the project have an impact (positive or negative) on Air Quality, Climate standards and/or Green House Gas (GHG) emissions?**			-1
		Positive/Negative/None	-1	(-1 to 1)	
	23	**Does the project have an impact (positive or negative) on water quality, supply or wetlands?**			0
		Positive/Negative/None	0	(-1 to 1)	
	24	**Does the project have an impact (positive or negative) on historic and/or cultural resources?**			0
		Positive/Negative/None	0	(-1 to 1)	
	25	**Does the project have an impact (positive or negative) on wildlife habitats and/or endangered species?**			0
		Positive/Negative/None	0	(-1 to 1)	
	26	**Is the Resiliency of the facility improved or hindered by the project?**			1
		Positive/Negative/None	1	(-1 to 1)	
				Total TEC Score	21