A Bikeway Network for the City of Worcester

An Interactive Qualifying Project Report
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Abstract

The past decade has brought about a period of revitalization for the City of Worcester. A number of projects, including the CSX expansion and the redevelopment of the Worcester Common Outlets, illustrate the increased investment into the downtown area. The increase in population has caused the amount of congestion to increase. The addition of bicycle lanes to the city would help reduce congestion, while providing an inexpensive and efficient personal transportation system for the city. The addition of bicycle lanes to urban areas currently in redevelopment have been shown to complement the improvements made. Bikeways have been shown to decrease vehicle congestion in urban areas as well increase the health of its citizens and the economic value of the area. Bikeways have been shown to increase migration to urban areas and reduce the cost of commuting. The addition of bikeways would increase the mobility options for many of the residents of a city that may not be able to afford their own automobile.

There are many factors to consider in developing a feasible bikeway system for the City of Worcester. The goal of this study is to determine what the government and the population of Worcester will approve as a viable means of alternative transportation. This project provides a cost benefit analysis showing that long term benefits of increased ridership greatly outweigh the initial costs of building infrastructure, and that state and federal funding will drastically decrease the cost of the system. Most importantly we will demonstrate how to construct a path that will be of use to the greatest number of people, while providing a number of options to balance the cost. This will be achieved using a combination of survey results from the general public as well as elevation changes, traffic, road conditions, and access to important locations in Worcester.

The proposed system of bikeways will stand to revitalize Worcester and improve the method of transportation in the city. A new, efficient network of bikeways, following the lead of cities such as Boston and Providence, increases the usability and attraction of the city. Worcester as the heart of Massachusetts could surpass other cities in New England to lead the way for ridership and efficient multi-modal transportation.

Executive Summary

Currently the City of Worcester is in a period of revitalization. Through this period of revitalization, the city could only benefit from additional improvements, such as constructing a bikeway network. This Interactive Qualifying Project explored the feasibility of creating bikeways in Worcester and developed a proposal plan for the city. It explored the need for a bikeway, possible bike routes, what type of bikeways could be implemented, previous initiatives, case studies of similar cities, possible funding sources, and a suggested plan of action.

Before the rise of automobile transportation, bicycles were the principle form of inexpensive travel. With the rise of automobile production, bicycle travel became less of an everyday form of transportation. Recently as the price of gasoline has been increasing, bicycle travel once again became more popular. With the ever increasing population size in Worcester, urban transportation has become a challenge for city planners and residents. The increase in household sizes and number of cars on the road has become a great challenge for keeping traffic density levels low. Building a bikeway in any city especially Worcester, would remove some of the city's traffic load by providing alternate transportation to a substantial portion of local traffic. Implementing bikeways would increase the appeal to the city, thus attracting more residents and increasing the tax revenue. The long term benefits of having a bikeway are a decrease in the CO2 output along with the decreased amount of space bikes take up for parking. Biking can also greatly increase the health of the rider making the average bicycle commuter healthier, seen in study done in Denmark and further discussed in the proposal.

The City of Worcester currently has over 180,000 residents with numerous parks, shops, and schools spread throughout the forty square miles of city are connected through buses and taxis. Taking the buses from the ten mile north to south route will generally take an hour and cost the rider at least $1.50 each way. Taking a bike would only be a onetime cost to the rider for the purchase of a bike. The cost of the bike would pay off in about one year for a mid-range new bicycle, taking into account some rainy days where bus travel is inevitable. Many residents still choose to take their cars for shorter trips throughout the city, causing an increase in congestion and causing many chokepoints throughout Worcester. One of these streets is Salisbury Street west of Park Avenue during rush hour. Adding a bikeway to the city would remove much of this local traffic allowing bikers an alternative route to the congested roads.

The addition of a bikeway in an urban environment cannot happen overnight. Some of the best bikeways in the world were created in a slow, but constant manner. Copenhagen is one of the most prominent bicycling cities with a nice flat terrain and full government support for a bikeway. The city began adopting bikeways in the 1970s when an environmental movement began to call for a decrease in automobile traffic. Demonstrations were held to fight for the rights for cyclists to use the major roads in the Copenhagen. With this increase in bikers, there was a call for better bicycle safety as many people began having accidents with the motor vehicles. More recently, the government has been implementing bikeways to cover the many roads with traffic lights changing with priority to the bikers. Today, Copenhagen is one of the most biker friendly cities in the world attracting many tourists and allowing for everyday commuters to take their bicycles to work. Many types of these bikeways exist and can be implemented into the cityscape.

In general there are three types of bikeway styles. Class I, Class II and Class III bikeways. Class I bikeways are completely separated from the road and usually meant for multiple uses excluding cars. Class II

bikeways are on the road or separated by pavement markings or barriers off the roadway or shoulder. These types of bikeways have been used in many cities such as New York. The main concern with this type of bikeway is that vehicular traffic is allowed to cross and turn within the bikeway posing safety concerns. Class III bikeways are generally shared lanes designated by signs put up along the roads. One of the benefits of these bikeways is that the motorists are able to easily see the bikers, however there is little to no protection for the biker from the motor vehicles. Class III bikeways are also common choices for bike implementation in cities where space is limited.

In the past Worcester has experienced several initiatives to implement bikeways. One of the most prominent has been Alan Gordon's bikeways in the early 1990's. The project was funded in part by ISTEA, a federal transportation planning policy and connected the Blackstone River Bikeway to Institute Park and Salisbury Street. These first attempts at these bikeways faded in popularity and are now physically faded and underutilized. Later on in 2003, the Blackstone Valley Chamber of Commerce conducted their own set of case studies with VHB contractors for the feasibility of implementing a bikeway connecting the Blackstone River Bikeway to Union Station. Again in 2004 the Blackstone Valley Chamber of Commerce conducted a feasibility study for connecting an off road bikeway to connect a bikeway on Millbury street to the future Blackstone River Northern Gateway Visitors Center. These bikeways would connect to many of the major parks and points of interest to attract the most users as possible. These previous initiatives were a great attempt at improving Worcester. The benefits that community would receive from adding to these bikeways currently and in the future outweighs the idea of letting them fade from sight. Looking at these previous initiatives, Worcester has a desire to implement bike paths, but the network needs to be better implemented, so that everyone in the city has the opportunity to use if for commuting and recreation.

Some of the challenges which may emerge from creating a bikeway would fall under the following categories: Engineering, Encouragement, Education, Enforcement, and (Freedman, 2011). The engineering challenges would require tedious route planning, and what type of bikeways should be implemented. Public opinion should be put into consideration to attract the largest number of the population. Safety will also have to be taken into account like how the bikeway will interact with tuning traffic at intersections. The next challenge will be encouragement. Public support for the bikeways will need to be made public to show the government officials that a need is there for bikeways in Worcester. People will also have to be encouraged to go out on the road and use the bikeways once they are implemented showing that the routes are safe. The public will also have to be educated on how to share the road with bicyclists and bicyclists will have to be taught the rules of the roads such as riding on sidewalks and wearing helmets. The Worcester police will have to enforce the new rules of driving on sidewalks and wearing helmets along with cars parking in the bike lanes. Finally the bikeways will need to be evaluated. There has to be some type of monitoring put in place to show that the bikeways are being put to use and how many cars have been removed from the roads in order to show the government that the bikeways were effective and should be maintained.

Implementing a bikeway in any city will have many social impacts. One of the social impacts of a bikeway is the diffusion of centrally located crime near the path. The greater traffic near the path will make the targeting of individuals more difficult. A bikeway connecting the consortium colleges will also allow for students to attend other classes, which they cannot otherwise take in the current college. With a bikeway connecting the many places of worship, community centers, museums and other points of interest, more people will be able to participate in activities bringing the community closer together. Finally, getting more people to commute with bicycles will benefit people’s health as well as their ability to participate in being an active citizen of Worcester.

To determine the need for the bikeways a survey was developed to poll the many Worcester students and residents. The survey asked if the respondents thought that Worcester needed a bikeway, how they envisioned it, what and why they would use it etc. The results of the survey concluded that Worcester would benefit from a bikeway and would use it in everyday commuting. It also helped plan a proposed route as to where the bikeways could go. The proposed routes would potentially connect a major gap in the East Coast Greenway, which will complete the Maine to Florida trail. The proposed routes will also create a web of bikeways emanating from the center of Worcester to the outskirts connecting major parks and points of interest.

Funding for the bikeways could be partially contributed through federal funds such as SAFETEA-LU, ICETEA, or safe routes to school. Another option for funding could be fundraising during public awareness events. The Safe Routes to School program requires that the bikeway provide a route to schools for non-motorized vehicles, which could be fulfilled by connecting the consortium colleges. Through our cost-benefit analysis we found that using these sources of funding, we found that the cost of phase I of our plan to be $250,000. This represents the cost of constructing on road bikeways which cross the city connecting many of the parks, schools and other points on interest that highly rated on our survey.

Upon completion of this IQP, it was discovered that Worcester has a need for bikeways. In order to suit the needs of the majority of Worcester residents and commuters, the bikeways would have to run through major points of interest. These points of interest include parks, schools, city hall, bike paths outlying the city, etc. If the routes were to go through Worcester connecting the north, south, east and west, the bikeways could offer an alternative means of transportation to the bus routes. If these changes were incorporated in the city, Worcester would become more attractive to outside residents and provide its residents with another alternative means of transportation.

Table of Contents

List of Figures

List of Tables

1 Introduction

Fast and efficient transportation is an important consideration for everyone residing in an urban environment. Many current urban transportation systems have become outdated and require modernization. Keeping a city's public transportation modern and efficient increases its value and attraction to more citizens. Without updates to modes of transportation, population increases may result in further system failure such as gridlock or over filled public transportation. If the transportation issue is not dealt with, the city may lose its attractiveness. This could result in a reduction of the quality of life, and potentially residents leaving the city.

Despite previous attempts to introduce alternative means of transportation, the current system in most cities would benefit from a revival and addition of bikeways by reducing congestion and marginalizing urban sprawl. Ideally college campuses would be united through this effort as well as parks, major transportation hubs, and shopping centers.

Much like the other major cities, Worcester's urban transportation would benefit from a bikeway by allowing citizens an inexpensive and healthy way to travel. In order to make bikeways worthwhile, they must be developed to provide transportation for the largest portion of people commuting within Worcester. Connecting the universities would provide an alternative means of transportation for the 16% of students that use the consortium system between colleges in the city of Worcester as well as staff, faculty, and administrators(City of Worcester, 2011) . Also by adding a bikeway connecting the colleges and major points of interest, a large number of the Worcester population's need for alternative routes would be addressed.

The City of Worcester has previously developed a plan for a series of bikeways throughout the city as shown above in Figure 63(Gordon, 2011). The plan included a phased development process. However the City never completed later phases of the project after political changes. A bikeway system in Worcester should be built upon this already existing infrastructure and plan, making additions and improvements to account for the way the community has changed since the plans introduction. By building on existing infrastructure, the city will be able to reduce the overall costs for implementing the system, given that the existing paths connect a number of desirable destinations. The goals of the bikeway system should include increasing awareness of the existing paths while extending the paths to new destinations. This would improve the public transportation and value of the city making it a better place to live while also connecting to major bikeways outside of the city such as the Blackstone River Bikeway. The Blackstone River Bikeway is a current project aiming to follow the Blackstone River from Worcester all the way to Rhode Island. At this time it has two and a half miles constructed in Worcester with ten miles built in Rhode Island. Connecting to this bikeway would open provide a bicycle connection from the city of Worcester to outside paths, and ultimately to the entire East Coast Greenway. In order to make these improvements, the current needs of the community will be analyzed, along with the changes in traffic patterns, and points of interest, in order to ensure a safe and attractive bicycle way.

This project also conducted a survey to determine the public's desire for a bikeway, along with their desired points of interest and the concerns of the city's population. In addition, the project examined the bicycle routes in similar cities around the country and the world, taking into consideration Worcester's unique layout. This data was collected from published case studies, interviews, surveys, and observations taken throughout the city. The observations, surveys, and interviews have provided a

unique, up-to-date perspective on possible obstacles and attractions throughout the city. This data allowed for the development of a path to meet the needs of the greatest portion of the population.

This document explores the benefits of bikeways for the City of Worcester, having taken into account the current modes of transportation available to residents. The goals and benefits of having alternative travel for urban transportation within a city are detailed as well. The benefits and downsides of different bikeway styles are also considered. Case studies of cities similar to Worcester and previous attempts of bikeways being implemented in the City of Worcester were also explored. Project challenges and possible solutions to these were broken down along with the social impact of bikeways within Worcester. Finally, a proposed approach is given describing a possible phased implementation and routes for creating the bikeway. Possible funding options were also investigated and a cost benefit analysis was performed. Finally the results of the findings are summarized with conclusions and recommendations for the City of Worcester.

2 The Benefits of Bikeways

Cycling has existed as an efficient means of transportation for almost 200 years (Herlihy, 2004). Generally, popularity of cycling as a means of transportation declined as the automobile became more available, though it is currently becoming a more popular option with the increasing cost of fuel, and the desire to be environmentally friendly. This chapter will introduce the concept of bikeways as a means of urban transportation, and how they could benefit the City of Worcester.

2.1 Modern Society and Urban Transportation

The exponential increase in global population presents a daunting challenge for urban transportation. Despite the increasing efficiency provided by technological advances the current population of seven billion people, which is expected to reach nine billion in the next 40 years, is putting a significant strain on the transportation infrastructure. (UN Department of Economic and Social Affairs, 2009) It is expected that many cities will continue to grow at an exponential rate, resulting in the challenge of having to design a system that is both cost efficient and effective. The increased amount of cars on the road creates the challenge to design infrastructure that will mediate the amount of cars on the road.

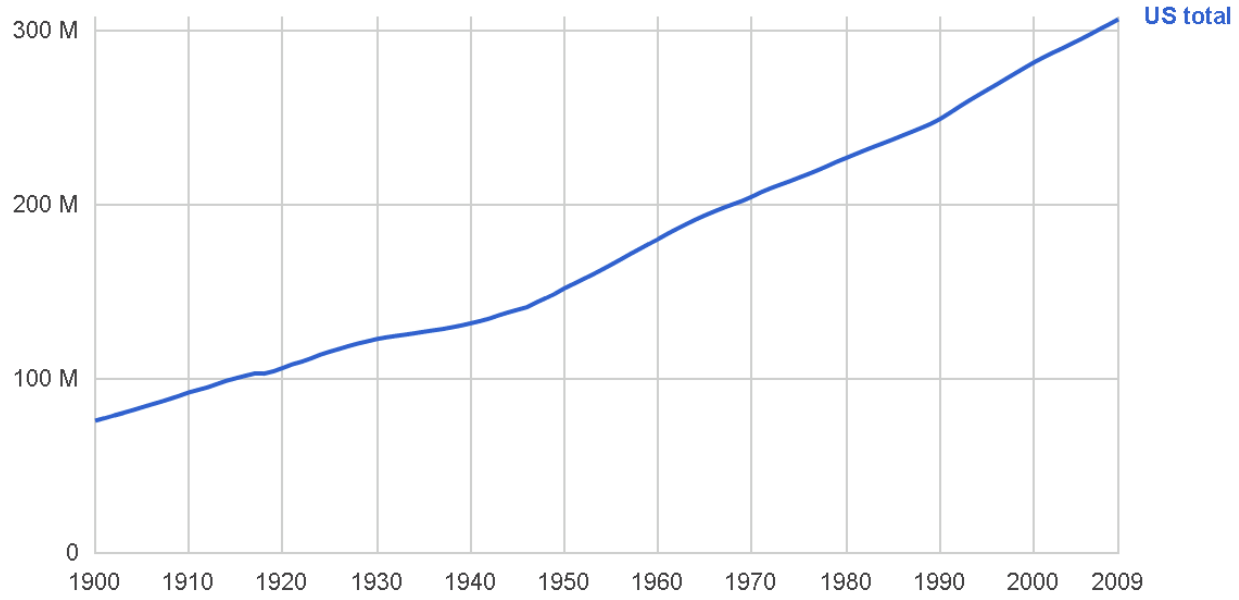

Figure 1: Total US population from 1900 to Present(FHWA, 2012)

Despite planning for population growth, such as the rapidly growing US population shown in Figure 1, unexpected rises in cars can cause roads to be plagued by congestion, such as this congestion on Main Street in Worcester shown in Figure 2. Traffic congestion wastes the time of commuters, and increases pollution, as the majority of cars stuck in traffic are idling, and wasting fuel.(USDOT, 2006)

Figure 2: Congestion on Main Street in Worcester, MA (Worcester Mag., 2012)

For cities and municipalities around the world urban transportation is a necessity, but they struggle to try to bring the best system, while still remaining within their budgets. Building up infrastructure remains expensive and it is one of the biggest expenses that a city has, as shown in Figure 3 roads are built slowly in comparison to population growth. Making changes in a system that is already in place can be challenging, which is why it is important to plan to ensure that small modifications in the design of streets can greatly benefit multi-modal transportation.

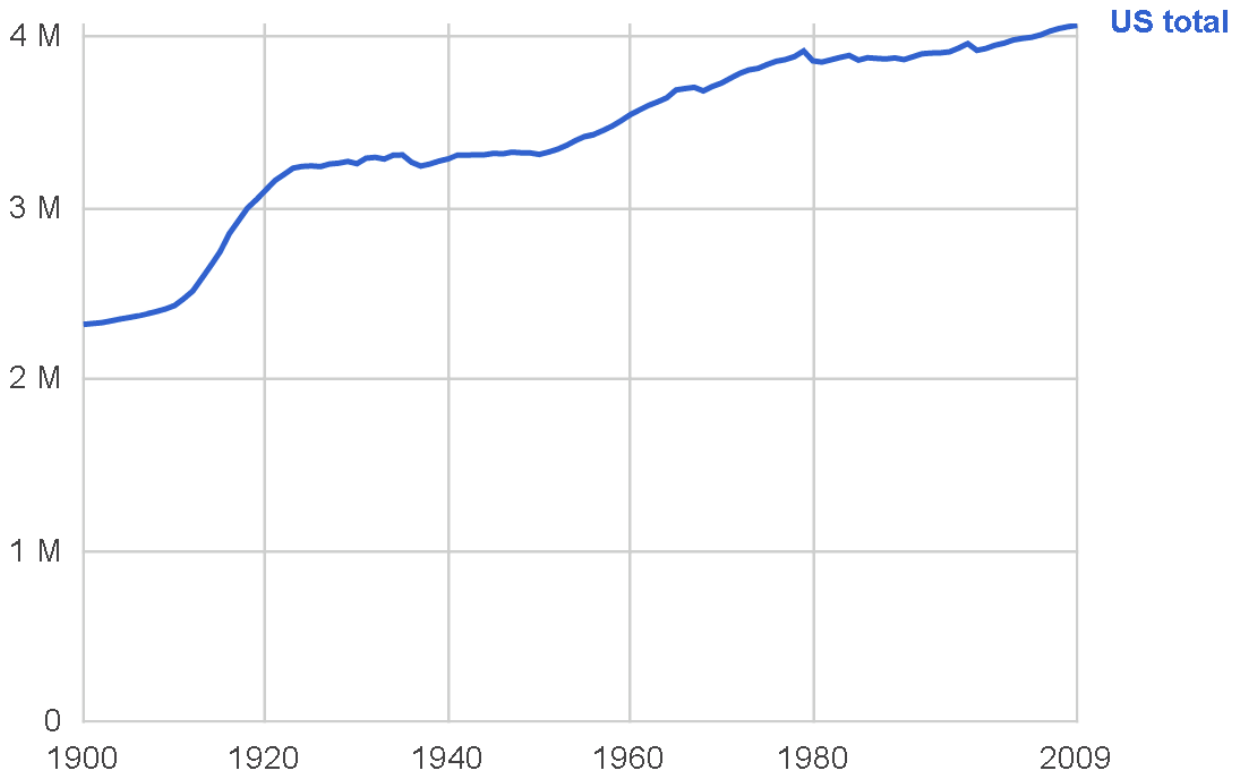

Figure 3: Total miles of road in the US (FHWA, 2012)

The department of transportation has goals, for transportation, in five strategic areas(USDOT, 2006):

1. Safety
2. Reduced Congestion
3. Global Connectivity
4. Environmental Stewardship, and Security
5. Preparedness and Response

A bikeway benefits the infrastructure because of the way it can supplement unnecessary urban vehicle travel, by reducing congestion and having no emissions from fossil fuels.

Urban transportation is a continually evolving, ever changing system that can be altered by the smallest ripple. A car crash in a high volume location can result in hours of delays. The addition of new roads does not solve the problem of congestion, but allows people to live farther away from the city. After 100 years of automobile production, the car has completely changed transportation. The graphs below show a correlation between population and the amount of vehicles and the amount of miles driven. The figures show the trend of the addiction to automobiles with almost exponential growth. The problem is that even though fuel supply factors are scalable, the infrastructure needed to support them is not.

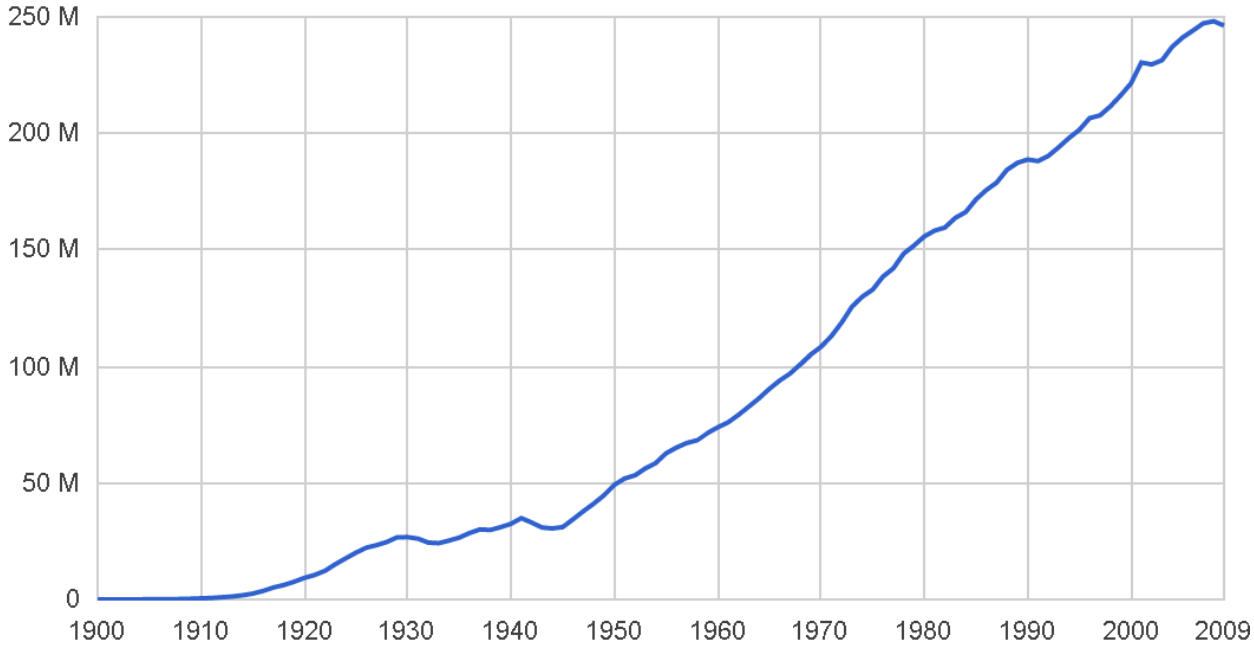

Figure 4: Graph of the number of vehicles in the US from 1900 to present.(FHWA, 2012)

The time and cost of building roads is extremely high and at some point the cost of our driving tendencies will at some point There is evidence of this where we see dips in Figure 5 when World War II occurred, when the gas crises in the 1970's occurred and most recently in 2009 when markets collapsed.

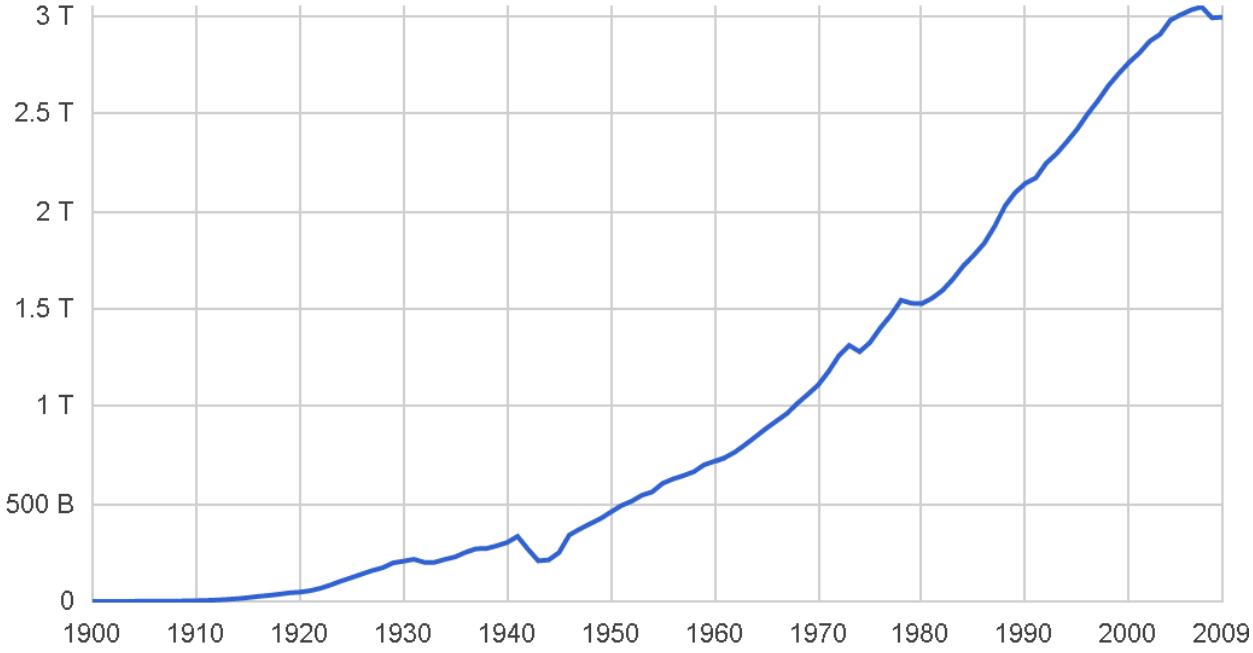

Figure 5: Graph of vehicle miles traveled from 1900 to present.(FHWA, 2012)

2.1.1 Transportation Goals

In the United States, the Department of Transportation (USDOT) is the agency responsible for ensuring a fast, safe, efficient, accessible and convenient transportation system.(USDOT, 2011) With the USDOT's guidance the best system of transportation is measured by its adherence to the goals. Systems of transportation until this point have been widely automobile-centric in the United States. The cost of vehicles and fuel are expected by the user, but the social cost of roads, emissions, and accidents are hidden, which creates a gap between the perceived cost and the actual cost. The increased use of multimodal transportation can vastly increase the efficiency of the system and decrease the amount of waste.

Public transportation increases the appeal of city life, attracting more residents, and creating a system with increased choice. When traveling during the day there are "People who choose to drive rather than walk or cycle a short distance do so not merely for convenience, but also to insulate themselves from the harshness of a street ruled by the motor vehicle." (Lowe, 1989)

When considering major changes to its transportation infrastructure, it is important for a city to consider not only the short term changes in system efficiency, but the long term goals of the system and its effects on the environment. Automobiles have multiple conveniences and advantages over other forms of transportation because of what has already been instituted. However the current state of congestion and the current global increase in CO_2, as seen in This figure shows the history of atmospheric carbon dioxide concentrations as directly measured at Mauna Loa, Hawaii. This curve is known as the Keeling curve, and is an essential piece of evidence of the man-made increases in greenhouse gases that some

believe to be the cause of global warming. The longest such record exists at Mauna Loa, but these measurements have been independently confirmed at many other sites around the world.
Figure 6, requires a critical rethinking in the way we value our forms of transportation. This has to include not only the cost to the consumer, but the social cost as well, cars have an enormous social cost that includes the roads and parking required to make cars so convenient. When comparing the cost to the cost of cycling or walking there requires a system wide reassessment of the ways that we use vehicles.

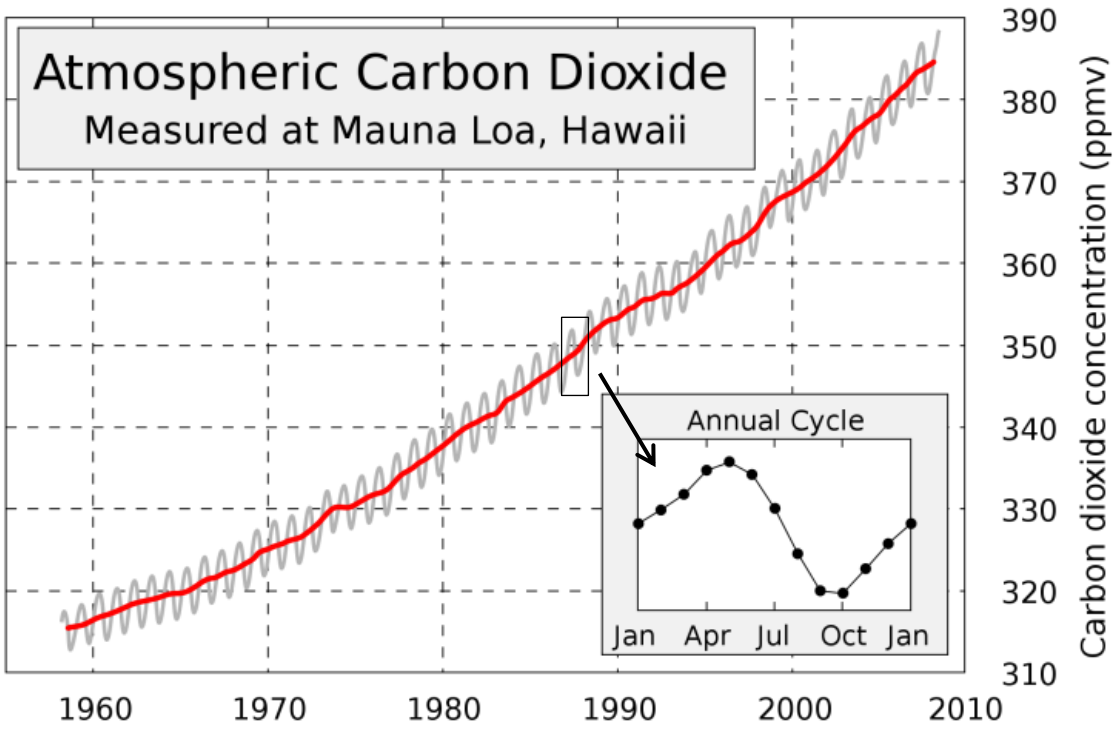

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Figure 6 Atmospheric carbon dioxide concentrations(Rohde, 2008).

The time it takes to get from home to work also plays a factor in the efficiency of the worker as a whole. If someone arrives late to work every day because of the road congestion there is a significant problem. In addition any impact on the sleeping habits of the worker will decrease their overall working capability. Cycling can increase the health of the rider and in addition to the health aspects there are several incentive programs, such as NuRide to get commuters to start cycling.

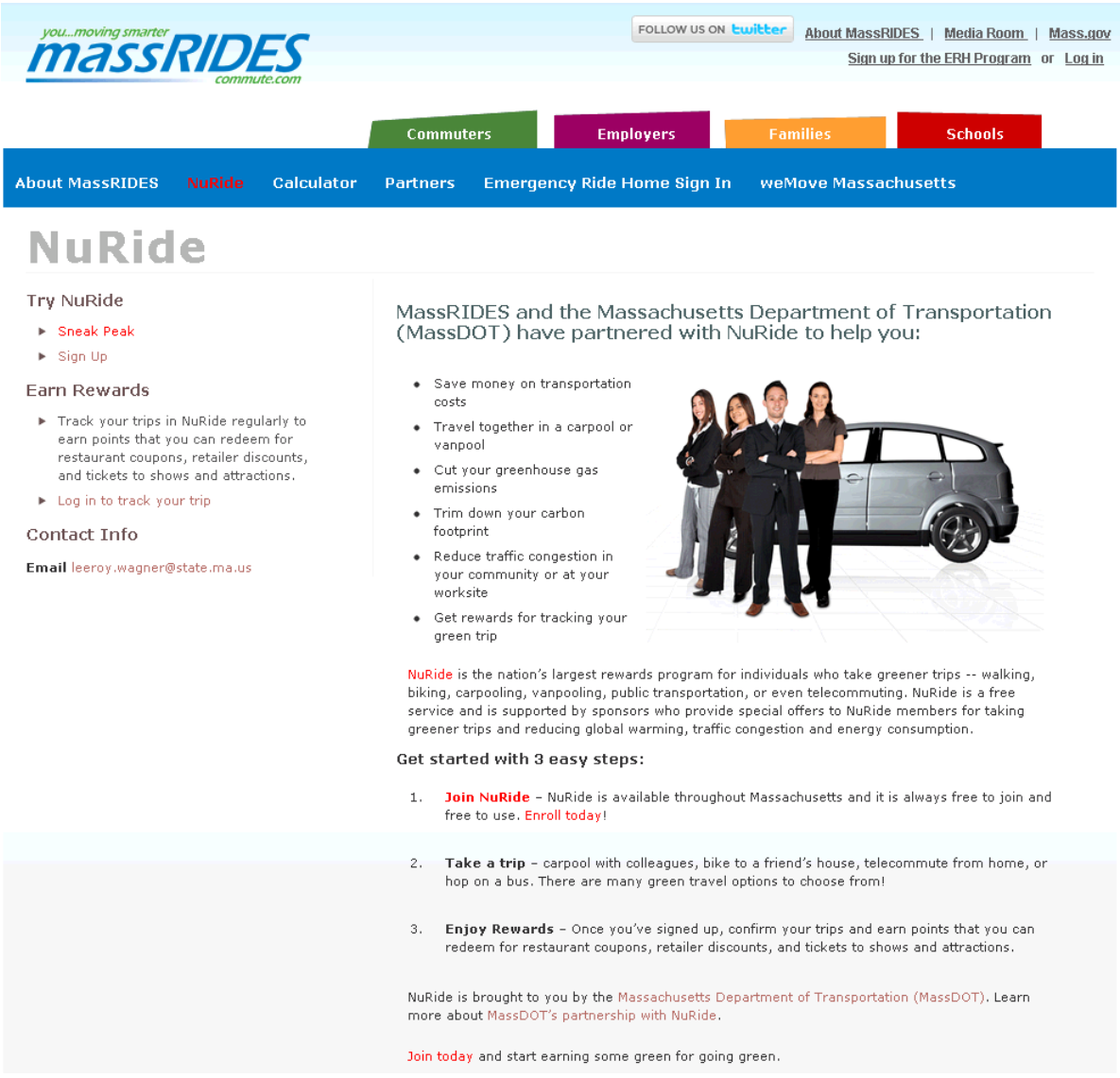

Figure 7 : NuRide website, this service pays for commuters to cycle or walk to work. The service is sponsored by MassRIDES

NuRide is a program that rewards members for commuting in a way that they define as green. This includes rewards for carpooling, taking public transit, biking and walking. The way it works is by having members sign up online and input how they commuted that day to accumulate reward miles. The rewards are sponsored by the government, employers, or local business. (Nuride, 2012) In the state of Massachusetts the program is sponsored by MassRIDES a division of massDOT and they make it easy to sign up and earn rewards as seen in Figure 7.

When considering other forms of transportation, the bicycle comes into effect as an efficient way to reexamine the infrastructure. One of the major concerns with commuting by bicycle is the safety associated with riding side by side with cars. When considering the difference between instituting bikeways and the absence of designated space for bikeways, there is a major gap between them. Noland and Kunreuther stated that when considering the perceived safety of a bikeway drastically increases ridership especially in the long run. He estimates that in the short run a bikeway, with no perceived safety risks, would increase ridership by 196% in the short run and in the long run it would increase by 754%(Noland & Kunreuther, 1996). Furthermore "the results show that users are willing to pay the highest price for designated bike-lanes, followed by the absence of parking on the street and by taking a bike-lane facility off-road." (Tilahun, Levinson, & Krizek, 2007) In order to get the maximum increase in ridership there needs to be a bikeway designed where car traffic safety concerns are minimized.

2.2 Bicycle Path Styles

Throughout the United States there are a multitude of bikeway styles that go by a multitude names and use different terminology. In the next section these bikeways will be broke down into three general styles. Each requiring different road rules which can be found in the national standards of the American Association of State Highway and Transportation Officials (AASHTO, 2010)and that of the Manual on Uniform Traffic Control Devices (Manual on Uniform Traffic Control Devices, 2009). These standards help create a clear definition as to what is required for each style, such as the different types of signage on the road, or what needs to be addressed for cars sharing the road.

Bicycle lanes are one of the major umbrella terms used to describe a separate lane from traffic that is designated specifically for bicycles. Within this term there are typically three ways to designate it as a separate lane: the use of thermoplastic lane painting; a solid blockage i.e. gate; raising a segment of the area. A simplified overhead view of what a bike lane consists of can be seen in Figure 8: Typical Bike Lane. By separating the lane with a simple painted lane allows for more cars to pass over the lane or park within it, but it does designate it just for cyclists. Adding the protection of a gate allows for a much larger visual reminder for motorists and cyclists alike to stay in their appropriate lane. The raised barrier or area for these bike lanes can also classify these bike lanes as cycle tracks. A very well done example of painted lanes can be found within the city of Boston, through the dedicated work of one, Nicole Freedman(Freedman, 2011). The following Figure 9: Mass Ave Bike Lane is a photograph of one of the newer bike lanes added to Massachusetts Avenue in Boston.

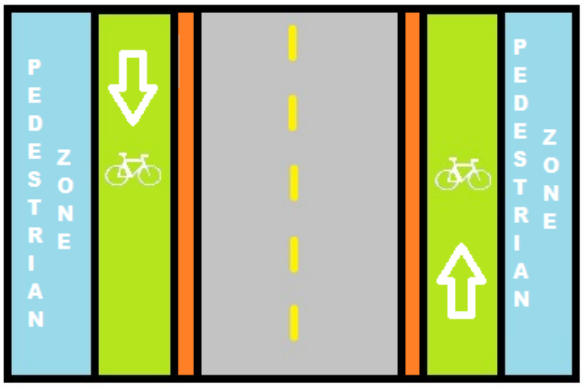

Figure 8: Typical Bike Lane

Figure 9: Mass Ave Bike Lane (Douglas, 2009)

Another type of bikeway is where the roads are intended to be shared. This means that there is no segregation for cyclists from the motorists, but there is signage to designate the specific areas and build awareness of the possibility of a bicycle being on the road. Signage on the road can also be used seen in the following Figure 10: Chevron from Salisbury Street, Worcester, MA is a typical chevron found in Worcester. These can be seen currently around the city of Worcester on streets like Chandler Street or Green Street. This type of bikeway is best served in a community that has narrower streets or cannot necessarily give up some parking space.

Figure 10: Chevron from Salisbury Street, Worcester, MA (Martin)

A final type of bikeway is that one that covers most of the rural or wooded paths is known as bike path. Typically this is a route that has taken and renovated outdated rail road tracks or trails through national parks and open areas for the specific use of bicycles or hikers. Quite a few of these exist on the outskirts of the greater Worcester area, such as the Blackstone Valley trail. Work is constantly being done by the department of the Greater Worcester Land Trust. (Novick, 2011)Another path that has come a great way in the past years is the East Coast Greenway, which is a path stretching from Maine to Florida. There are a few obvious gaps still remaining, including a section that starts at the north of Worcester and ends at the south. (Weis, 2011)

Typically bikeways could be implemented in any area within cities, suburbs or rural areas. Suburban communities are generally great for quiet bike lanes because they have wide streets, and are generally flat with no real through traffic. A successful implementation of bikeway could be in the surrounding communities of the Worcester and the consortium colleges. They're of moderate density and have local service centers like groceries stores and libraries. There are no traffic roads which are ideal for bikeways, since they have very little protection between the motorists and cyclists. Therefore shared lanes and similar programs would be essential in the implementation of any bike plan for the city.

2.3 The City of Worcester

The City of Worcester is home to over 180,000 people with numerous parks, shops, and schools spread across almost forty square miles. The considerable distance between a resident of the city and some desirable destination often leaves very few options for reasonable travel, namely taking a city bus, a taxi, or a private automobile. These options can be both expensive and slow, and all contribute to the congestion and pollution of the city. Worcester is an ideal candidate for the development of a system of bikeways, as Worcester's size is small enough that cycling to any point in the city is within the capabilities of most people, yet large enough that walking is prohibitively slow. Worcester provides a number of transit options for its residents, and adding a bicycle path is a simple step towards making Worcester a greener, better place to live.

2.3.1 Worcester Transportation Options

The Worcester Regional Transit Authority bus system consists of 23 routes with one hour between each bus at any stop and a one way fare of $1.50. The system is current centered around City Hall, with all but two peripheral routes having City Hall as the end of the line (Worcester Regional Transit Authority, 2012). This service is provided to approximately 3.1 million passengers annually by way of 46 buses and 10 minibuses. The city is also currently considering plans to provide more bus service, specifically providing more links to Union Station and area colleges (VHB/Vanasse Hangen Brustlin, Inc., 2011). This system is very convenient for residents wishing to travel into the center of the city from the fringes, and back to their homes, but other trips may be more difficult.

As an example of this difficulty, a commuter wishing to travel across the widest point of the city would require at least one transfer (at City Hall) as well as waiting for the bus, and paying two bus fares. A Bikeway throughout the city would provide an alternative to this, allowing the cyclist to travel directly across the city, without having to delay his trip, or pay anything other than the initial cost of the bicycle. The bikeway could also be used to extend the reach of the existing bus infrastructure, allowing passengers to take a bus that takes them from their home to the bicycle path, finishing their trip on a bicycle, or allowing them to bike to a bus stop that was farther away in order to avoid having to change buses at City Hall. The two systems could also provide weather dependent alternatives for intra-city trips, allowing the enjoyment of the ride in pleasant weather, or the shelter of the bus when it is required.

Automobile Travel

Many residents of the City of Worcester, as well as United States in general, opt to use their personal automobiles for many short trips which might otherwise make use of mass transit, or a bicycle. This reliance on the automobiles has resulted in automobile traffic greater than what was anticipated when existing roads were planned. The City of Worcester has approximately 75 thousand residents who commute to work, with 70% of these trips ending within a nearby town, and 57% of these trips ending within the city of Worcester. Additionally, 95 thousand people commute into Worcester daily, with 67% of these commuters having a trip beginning in one of the neighboring towns (VHB/Vanasse Hangen Brustlin, Inc., 2011). These trips represent a significant portion of the automobile traffic through the city of Worcester, many of which representing travel between towns that are only 10-15 miles from the Worcester City Center. The increased traffic and congestion from the large number of cars has created a situation where traveling by bicycle may actually be faster than driving to a particular destination, with increase cycle use also reducing congestion for those who travel via automobile.

The significant amount of commuter traffic through the City of Worcester results in a number of chokepoints during the morning and evening rush hours. A perfect example of a chokepoint in Worcester is Salisbury Street, west of Park Avenue. During the morning rush hour in Worcester, traffic heading east can back up from Forest St, almost as far as Assumption College, with over 10,000 people traveling south on Salisbury from Moreland St., and an additional 7600 traveling from Flagg St., for a total of almost 18,000 cars daily traveling through a section of road with one lane in each direction, making it one of the busiest streets in the City of Worcester (massDOT, 2012)A bicycle way constructed along this route would allow for cyclists to safely pass the stopped automobiles, allowing them to reach their destinations more rapidly. In addition, the availability of a bicycle way might persuade those who make frequent short trips through this point to switch from their cars to bicycles, reducing the existing automobile traffic.

The Salisbury Street traffic is only an example of a number of places where such traffic chokepoints exist. During various hours of the day, many other streets within the city, including Highland Street, and West Street, experience similar traffic jams, due to the over 20,000 people daily that travel through the intersection, that might be mitigated by the addition of bicycle ways, or the increased use of bicycles as an alternative to automobile travel(massDOT, 2012)

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Bicycle Ways

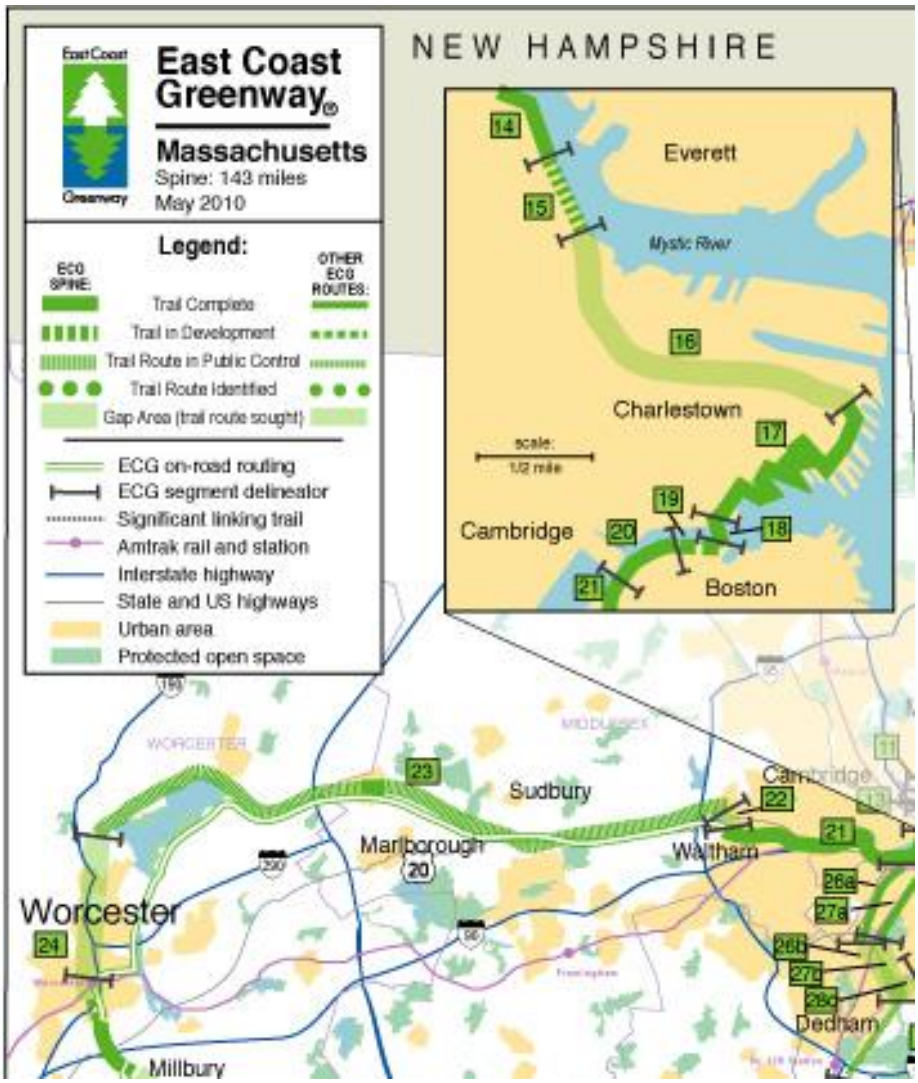


Figure 13: The East Coast Greenway (Massachusetts and Rhode Island Sections)

The development of a system of bicycle ways would allow Worcester residents greater mobility at a low cost, while reducing congestion. It would also allow residents to take advantage of many of the public parks, shops, and city services that are outside of walking distance from their homes. This can provide a boost to local businesses, in addition to making residential areas farther from these services more desirable. By providing a bicycle lane as a connection from "remote" residential areas to central city services, the stresses placed on city resources such as fire and police from crowded central areas may be reduced. Such a system was attempted by the City of Worcester in the late 1990s, with minimal interest, but recent systems such as those in Boston, and New York show that now may be a better time to try again. The previous Worcester system is discussed in depth in Section 3.3.1.

2.4 Case Studies

The installation of bicycle paths has become common in cities worldwide as a means of reducing pollution, and providing greater mobility for people. These new installations combined with places with a much older cycling culture provide a useful resource for implementing a successful bikeway system in Worcester. Cities like Copenhagen (see Figure 14) have had dedicated cycling programs stretching back almost a century and is one of the cities that most people consider very innovative of its bicycle facilities. By studying cities with similar problems and solutions a bikeway in Worcester has a better chance of success by studying other successful bikeways.

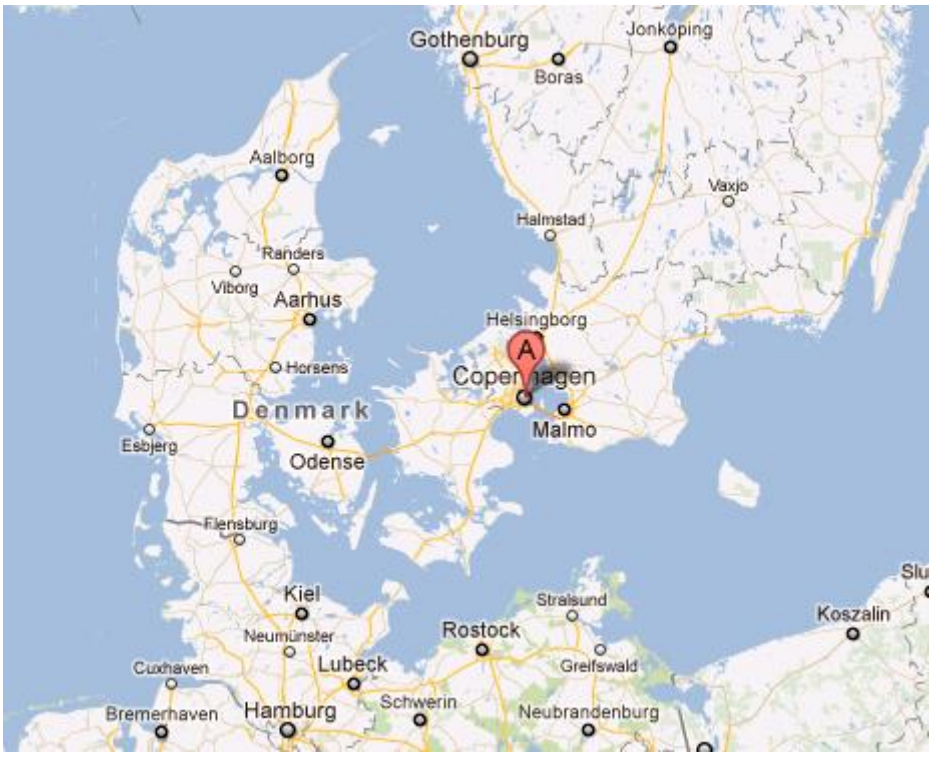


Figure 14: Map of Copenhagen

2.4.1 Copenhagen Case Study

Copenhagen is one of the foremost cities for cycling in the world. Copenhagen has the several advantages that make it a unique player for bicycle paths including its terrain, size and population. In addition the government fully supports the widespread use of cycling through funding and publicity. Through the steps that the government has taken citizens and visitors to Copenhagen enjoy a safe, well designed system that allows the user to efficiently get to where they wish to go.

The main cycling organization responsible for pushing Denmark ahead of the world is the Danish Cycling Foundation, or Dansk CyklistForbund. The Danish Cycling Foundation is a non-governmental organization that is responsible for increasing rider interest, lobbying for increased government funding and providing references for cycling. They organization was started in 1905 with the goal to increase regulations for traffic.

The Danish citizens have biked 4.4 million kilometers (2.7 million miles)(City of Copenhagen, 2011) as they continue to support and enjoy cycling. This is especially important when considering the important

factors that attribute to higher ridership. First and foremost are the convenience of the mode and then the safety of the rider and the bike.

Figure 15: Danish Cyclists (City of Copenhagen, 2011). Cyclists waiting at a light are provided a foot rest as an added convenience, in order that they do not have to leave their bicycles.

History

Copenhagen has a very long history of cycling dating back to the late nineteenth century. The number of bicycles from 1890 to 1934 increased from 3,000 to 400,000(Cycling Embassy of Denmark, 2002). The effect of the exponential increase in bicycles caused Copenhagen to be built to have a dense city center to keep transportation to a minimum.(Cycling Embassy of Denmark, 2002)

The first separate bicycle paths were established in Copenhagen around the lakes in 1910 and as the existing bridle paths were converted into isolated Cycle. Presently there are more than 350 km of bicycle paths in and around Copenhagen and since the first few bicycles were introduced on the street in 1890s. Nearly every Copenhagener owns a cycle today. (COPENHAGEN PORTAL, 2002)

During the German occupation of Denmark from 1940 to 1945 fuel rationing caused citizens to switch from automobiles to bicycles to reduce fuel consumption. The increased bicycle use remained constant until the 1950s when the automobile traffic began to increase again.

In the 1970s the environmental movement began to call for decreased automobile use and increased emphasis on cycling. Demonstrations were held in cities all over Denmark to fight for the right for cyclists to use major streets in Denmark. They were also calling for increased safety, because in the late 1960s there were roughly 300 cyclist deaths(Copenhagenize, 2011).

Figure 16
Cyclist Demonstration for the right to use major streets in Denmark for cycling. Gatherings such as this one were held annually in major cities throughout Denmark.(Cycling Embassy of Denmark, 2002)

Copenhagen started multiple infrastructure projects throughout the beginning of the 21st century; including the Øresund Bridge and the Copenhagen metro that opened in 2002.

The Øresund Bridge was finished in the year 2000 to connect Malmö, in Sweden, to Copenhagen in Denmark. The first part of the structure is a bridge that extends from Malmö to an artificial island 7,845m (25,738 ft.) away. The bridge then descends below the water and joins with the Drogden Tunnel, connecting at the artificial island Peberholm. This project was shared between Sweden and Denmark and cost a total of DKK 30.1 billion (~US$5.7bn). The structure also includes two rail lines for trains, which complete the journey from Malmo to Copenhagen in about an hour. Some citizens use this to commute, living in Sweden to avoid the cost of living in Copenhagen.(OECD, 2003)

Another addition to Copenhagen's infrastructure is its metro system. The metro system was planned from 1992, with its first section opened in October 2002. In total the Metro now runs through 21 kilometers of Copenhagen and Frederiksberg, calling at 22 stations en route. At five stations (Vanløse, Flintholm, Nørreport, Ørestad and Lufthavnen) there are connections to the S-Train and regional rail networks.

A completely new Metro extension, called Cityringen, is now under way. The route will run underground and will have 17 stations and will cover major parts of the city center as well as the Østerbro, Nørrebro, and Vesterbro districts and the Municipality of Frederiksberg currently not covered by S-train or Metro line service. The circle line is due for completion in 2018, by then it is estimated that a round trip is expected to take approximately 23 minutes. (Metroselskabet, 2012)

The additional improvements in infrastructure by the government create an opportunity for increased use of different modes of transportation like trains, buses and bicycles. Part of what made Copenhagen the worlds leading bicycle city were the innovations that it created to increase safety and convenience for riders. A big hurdle that many cities, including Copenhagen are having is the transition from a bike to a train. This configuration will serve as an interesting example of interaction between bicycle and train commuters.

Cycling Data

Copenhagen has data traffic data for the volume of cyclists that have been riding since the 1970's, with more complete data from 1995 onward. The following figures show how the number of cyclists has increased remarkably.

Figure 17 shows how the number of cyclists from the mid 1970's to the present has increased, albeit with the ups and downs that the changing seasons bring. Despite this increase from roughly 100,000 to over 150,000, the goal is to increase the percent of the population that bike to 35% from 30% today. The traffic flow map in Figure 17 shows how there are many people using cycling as a means for transportation.

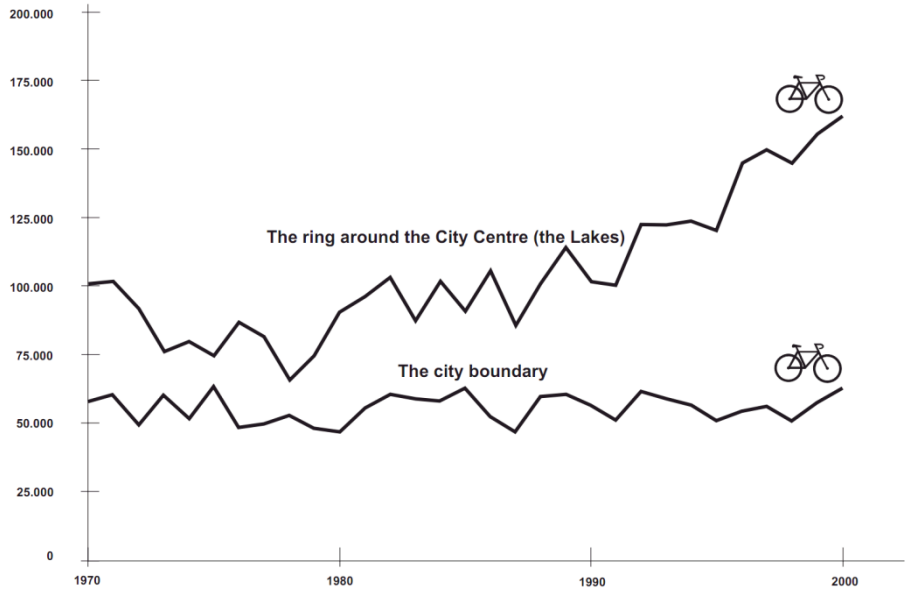


Figure 17:
Bicycle traffic trends: Since the mid-1970s, when cycling in Copenhagen was at a minimum, bicycle traffic has grown, especially in the City Centre and in the residential areas around the City Centre. The figure shows the sum of cycle traffic moving in both directions registered at the ring around the City Centre and the city boundary between 6 am - 6 pm(City of Copenhagen, 2002)

At the city center, the volume of cyclists is indicative of how many people are replacing short car trips with a bike trip. The most popular reason for why commuters in Copenhagen use bikes is that it is faster (City of Copenhagen, 2012).

This is a mindset problem that Copenhagen has pushed for by increasing its bicycle facilities and educating people that biking safely is more efficient, healthier and more productive. The three goals that Copenhagen strives for is to make more convenient, faster, and safer bicycle facilities.

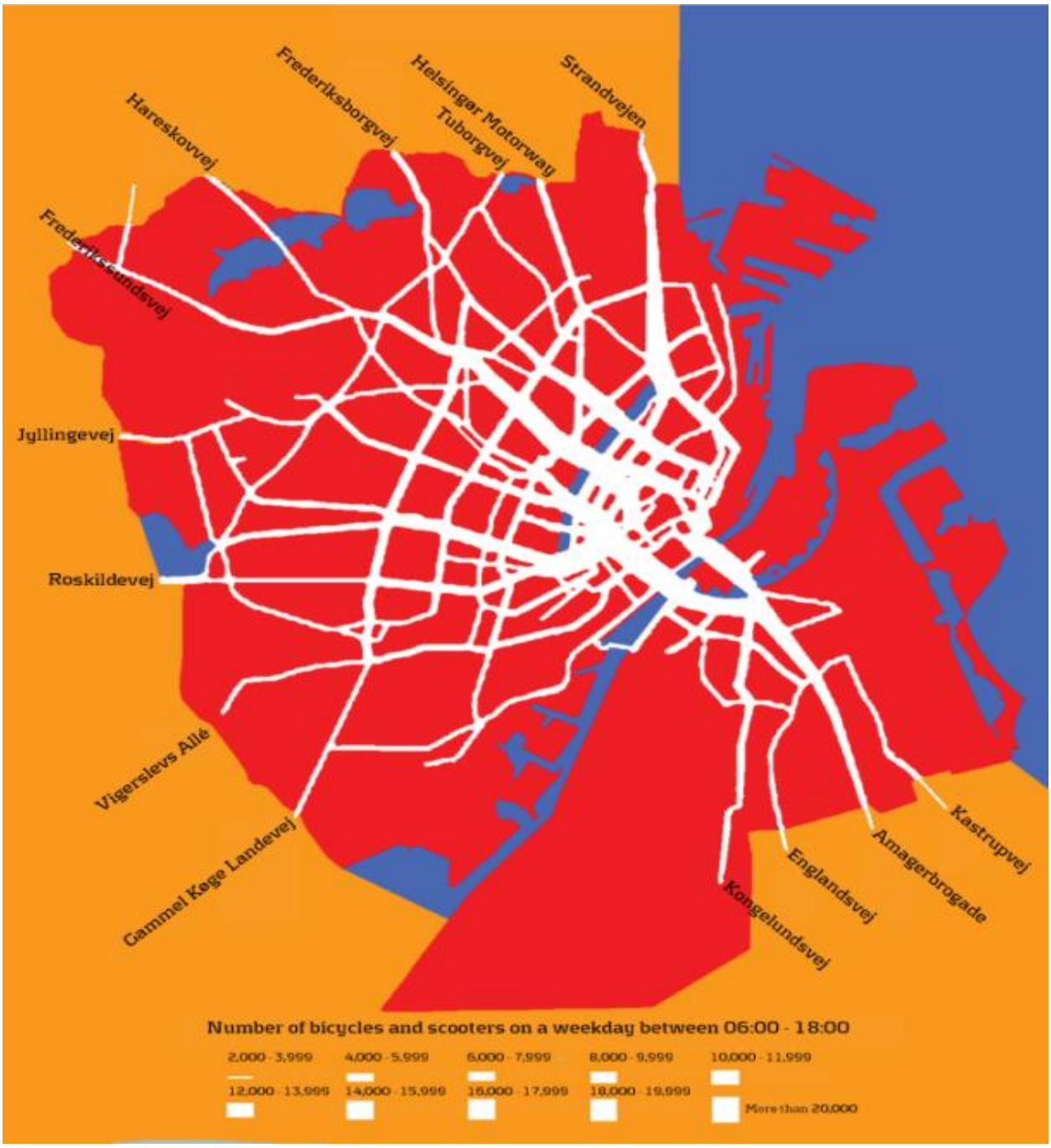


Figure 18: Bicycle Traffic Flow
The white lines represent bikers traveling down certain streets. The thicker the lines are the more cyclists travel in that area. The range of cyclists is a minimum of 2000 at the edges of the city and more than 20,000 cyclists in one day near the middle of the map. (Copenhagen, 2007)

Infrastructure

The pure size of the investment in infrastructure over the past 12 years is a monumental achievement and one of the reasons that Copenhagen is known as the best city for biking in the world. The total cost of the Nørrebro route came out to be about $886 million. In addition Copenhagen is also committed

enticing more cyclists to use its paths, with its target for 2015 being to bring the percentage of cyclists from 35% to 50%. (City of Copenhagen, 2011)

Copenhagen, like many cities, has a river that runs right through the middle of it. To provide cyclists with a safe path for crossing from Ørestad and Vesterport, behind the Fisketorvet Shopping Center, the Bryggebroen Bridge was created in 2006. The bridge has one lane for cyclists and another for pedestrians(Smith, 2011).

Figure 19: Side view of the Bryggebroen Bike bridge. It spans 190 meters. The design of the bridge was meant to complement the modern area where it was placed.

Figure 20: View of the Bryggebroen bridge from the prospective of a cyclist.(Smith, 2011)

The increase in the percentage of cyclists equates to a bigger change then is immediately apparent. While the percentage is increasing so is the total population. The population in Copenhagen and the surrounding area is 1.174 million, which equates to about a quarter of the population of Denmark. With the current percentage of people who cycle at about 35% that equates to about 410,000 people who cycle. It is because of this popularity that the current and future infrastructure of Copenhagen is created around cycling.

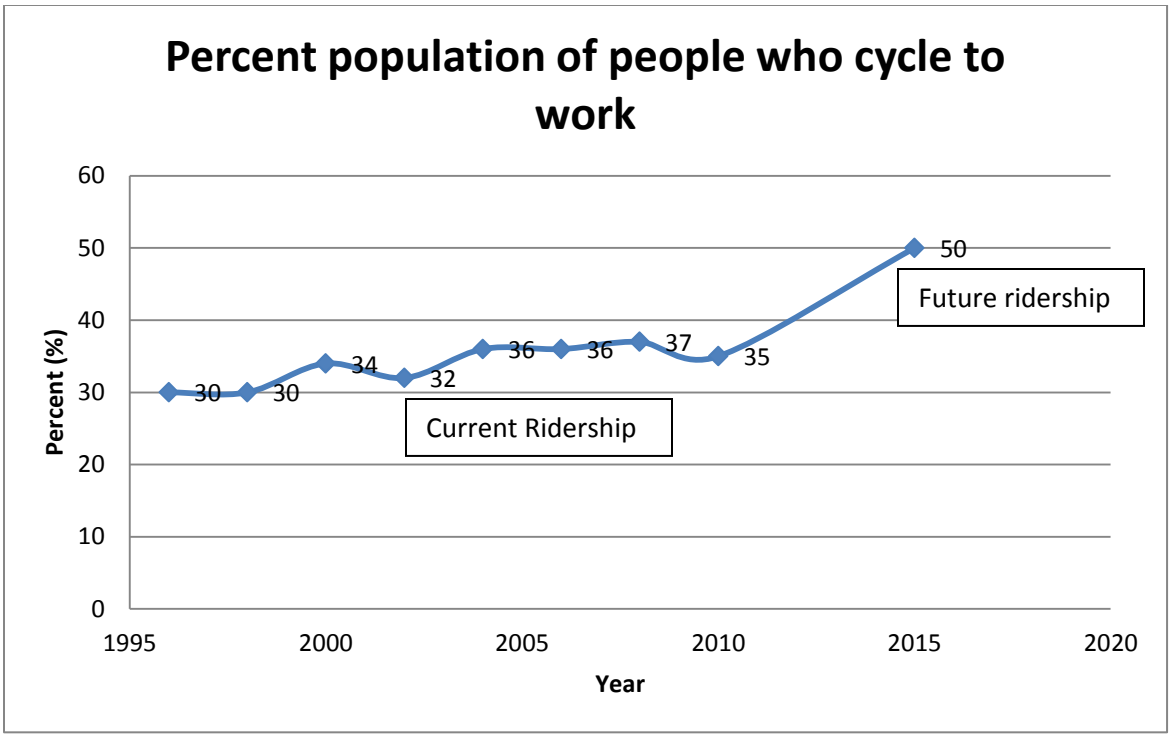


Figure 21: Population Commuting by Bicycle: The City of Copenhagen releases its data and projections of the percentage of the population who cycle. Their goal is to have 50% of the population cycling by 2015. If they accomplish their goal almost 587,000 people will participate(City of Copenhagen, 2011).

Conclusions

Copenhagen is the leading cycling city in the world, established by the way it has developed key ways to incorporate cycling into its transportation system, that cities around the world are adopting. One of the biggest problems, yet to be solved, is the multi-modal transportation procedure, which would involve a combination of bikes and public transit. Currently the challenge stands that public transportation was not build to support more than a small amount of bikes and cannot handle the extra volume of bicycles during rush hours.

Copenhagen cites three benefits of endorsing cycling facilities for its city. First environmentally bicycles decrease traffic noise, air pollution and CO_2 emissions. Second, socially cycling ensures that the population is healthier, reducing health care costs. Third, economically cycling provides a low cost form of transport and increases economic productivity by decreasing commuting times and congestion(City of Copenhagen, 2012).

The current model of the Copenhagen system has been ported to other cities including Melbourne, Australia and New York City. The design of the bike network in Copenhagen, including the lights for cyclists and the unique street designs, serve as an inspiration for Worcester and other cities. Copenhagen, because of its climate, has to deal with winter weather, which might otherwise cause people to abandon their bikes for the season, but they plow the roads in the winter and allow people to use the bicycle path year round.

2.4.2 New York case study

New York City is the largest and most populated city on the East Coast. Starting in 1997 their department of planning began to endorse and plan for bike routes. Like Boston they have recently started a pilot program where businesses will operate bike share programs. The city's commitment to cycling since has been astronomical; they plan to have 1800 miles of bike lanes by 2030, according to PlaNYC.

History

New York City consists of five boroughs; the Bronx, Brooklyn, Manhattan, Queens, and Staten Island, see Figure 22. The city presently has over 8 million people over a land area of 305 square miles (US Census Bureau, 2011). This number of people makes the usage of space paramount to the success of the city. However while there may have been cyclists the city of New York did not have a network of bikeways.

Figure 22: New York City divided up by boroughs. 1: Manhattan2: Brooklyn 3: Queens 4: The Bronx 5: Staten Island (Schorzman, 2005)

Early in the millennia New York did not have an especially aggressive bicycle agenda. The nominal bike routes that had to be developed through federal and state funding were there, but it was not the focus of New York's mayor or their Commissioner of Public Works.

The key point for most cities to decide whether they are going to become automobile-centric came in the 1950's for America. The period of the 1950 was when suburbanization was growing after World War II. Suburbanization becomes a key transition length of time people are willing to travel into and out of the city each day.

The government in New York chose to build a massive new thruway system, which we now know as highways. This system of roads allowed suburban communities to be further reliant to automobiles to combat the sprawl created.

Crime in New York City was high from the 1980's through the 1990's. Mayor Rudolph Giuliani became mayor in 1994 and during his first term there was a steady drop in crime that has lasted until the present. The drop in crime rates throughout the decade is enormously important to the growth of cycling in New York City. With decreased crime comes increased safety, which is cited as the main reason not to bike in Copenhagen(Copenhagen, 2007).

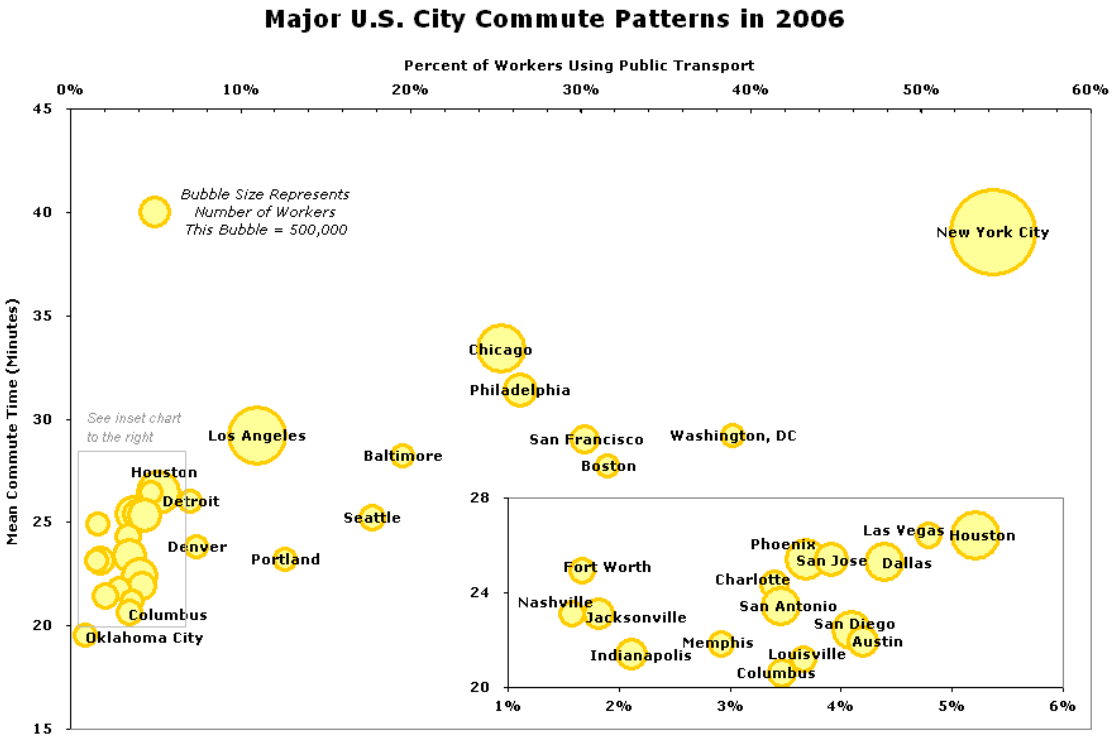


Figure 23: United States Commute Patterns for Major Cities including mean travel time. The chart shows how much new Yorkers rely on the public transportation for their travel throughout the city(Ramos, 2008).

In addition to the thruway system there is the NYC subway operated by the MTA 24 hours per day 365 days per year. The reason why New York has not put its resources into cycling; there was not enough of a demand for it.

The number of annual riders on the metro from 2007 to 2010 was 1.6 billion; Figure 23 shows that percentage wise New York City has far higher ridership on its public transportation system. The sheer number of people that use the transit system is reason enough why an enormous amount of people going from one place to another, but they do it through an increasingly safe and inexpensive form of transportation.(Metropolitan Transit Authority, 2010)

The MTA has, in the past, faced budget problems; requiring fare hikes every year starting in 2007. There are many implications of this, but one major one is the MTA's ability to update and upgrade current systems. Looking forward New York might try to relieve overcrowded subways by transferring some of the riders to cycling, which is less costly. The operating loss of the MTA annually is about $10 billion with revenues being $5 billion, where the taxpayers subsidize the loss.(Metropolitan Transportation Authority, 2011)

Starting in 2006 New York City DOT made a plan to construct 200 miles of bike lane in just 3 years, which was just completed in 2009. Because of this increase in the infrastructure of bicycle facilities the DOT projected that commuter cycling increased 35% from 2007 to 2008 as seen in Table 1.

Table 1: Data from New York City's cycling data showing the number of cyclists and the percent change from the previous year (Sadik-Khan, 2011)

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
cyclists	4839	5631	7667	7340	7090	8649	9327	12328	15495	17491	18846
percent change	12%	16%	36%	-4%	-3%	22%	8%	32%	26%	13%	8%

Corresponding to the number of miles of bikeways built the number of people who are riding in New York City has also increased. New York created PlaNYC to determine what they want the city to become by 2030. The overall goal of the transportation in New York is to reduce congestion and increase safety. Cycling does both of those things, which is why Janett Sadik-Kahn, the Commissioner of the NYC DOT, is aggressively pursuing all available option for new miles of bikeways

Current Facilities

New York City currently has over 250 miles of bike trails on the road as of 2011. They have 20 miles of bike protected bicycle paths, 185 miles of exclusive bicycle lanes, shared bicycle lanes. The numbers in Table 2 illustrate how the city went about increasing their total bicycle way mileage. The majority of the miles over the first 3 year were exclusive bike lane. This type of bikeway will encourage bikers to commute by bicycle and proves there is a demand for the path. In 2010 and 2011 there was more focus on protected bikeways which will encourage beginner cyclists to take up cycling in a comfortable atmosphere, away from cars.

Miles by Type	FY07	FY08	FY09	3 yr. Subtotal	Percent	FY10	FY11	Total	Percent of Total
Protected Bicycle Path	0	0.8	4.1	**4.9**	**2%**	9.9	6.1	**20.9**	**7%**
Exclusive Bicycle Lane	35.8	54.4	60.2	**150.4**	**73%**	16.2	18.3	**184.9**	**64%**
Shared Bicycle Lane	6.2	18.9	24.4	**49.5**	**24%**	24.4	8.7	**82.6**	**29%**
Total	**42**	**74.1**	**88.7**	**204.8**		**50.5**	**33.1**	**288.4**	

Table 2: Bicycle lanes in New York City by year and by type of path (New York City DOT, 2011)

For those who do not own bikes or prefer to use multi-modal commuting, bike sharing is becoming very popular in cities like Boston, Paris, and Washington DC. The bike share program is going to be launched in New York in the summer of 2012, by Alta Bicycle Share. This same company launched its bike share program in Washington DC in 2010 and in Boston, MA in 2011. The system will have over 10,000 (Boston only has 600) at over 600 station and they will be available 24/7. The bike share program is not going to be funded by the taxpayers, but by private business.

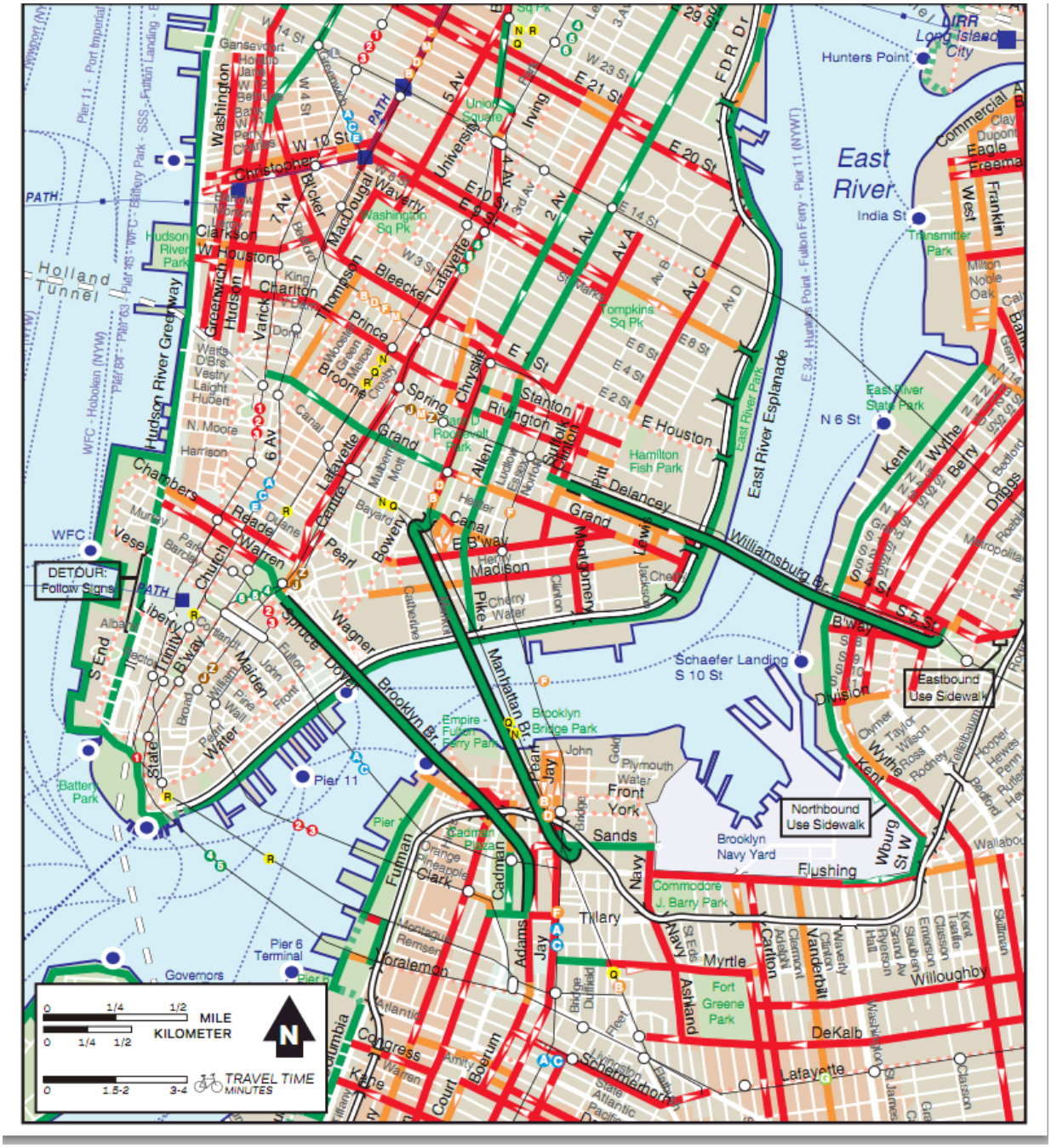


Figure 24: Bike map of lower Manhattan(New York City DOT, 2011)

In 2008 New York City launched the sustainable streets program to create safe streets for everyone, whether they are pedestrians, cyclists, or drivers. The plan introduces the idea of the “complete street”, which is the idea that streets are things that aid in transportation. The “complete street” encompasses all modes of transportation to create the most efficient system possible. This means also that specifically for bikeways and lanes in the city that they are everywhere and go everywhere so that the lanes are fast, convenient and safe.

New bike and pedestrian construction and rehabilitation of streetscapes and other reconstruction projects associated with the greenway around Hunt’s Point were constructed with American recovery

and Re-investment act funds of $ 37million(Budget, 2011). Waterfronts are a very valuable resource that should be shared with the community. In Figure 25 we can see the paths in green and blue that represents the web of new bike paths in the Bronx.

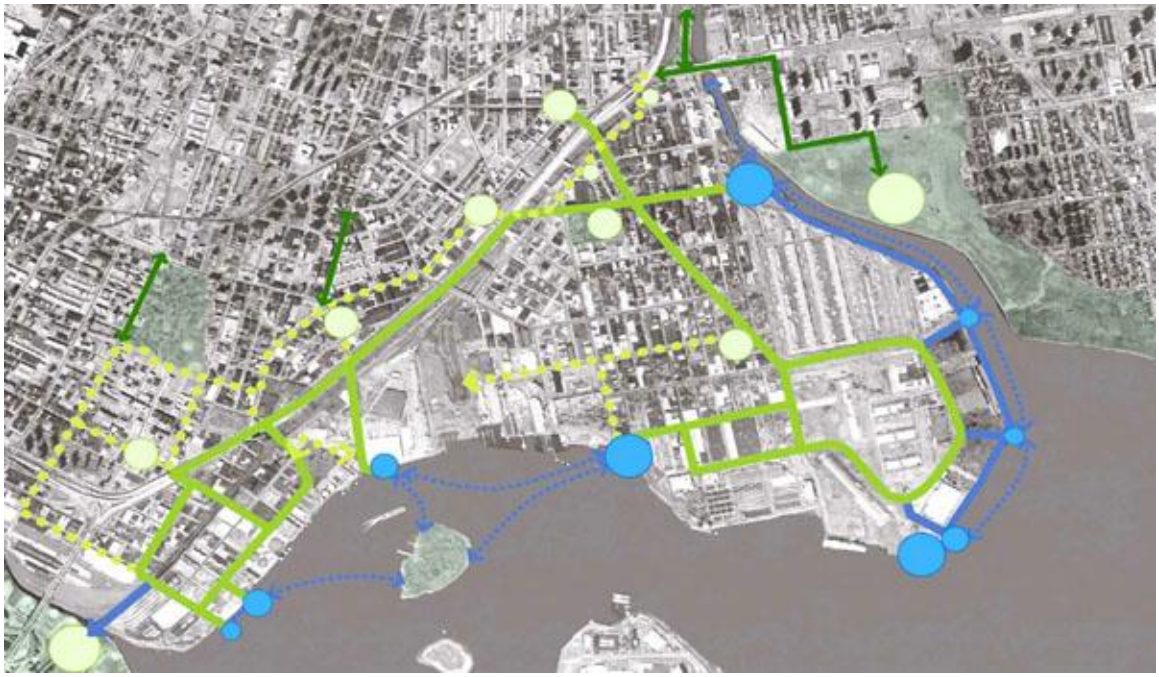


Figure 25: The route of the South Bronx Greenway is overlaid on a satellite image of the South Bronx (The Hunt's Point Express, 2009)

Conclusions

The interest in cycling within the city of New York has increased greatly in the past 5 years. Their experience of rapid expansion of its cycling program has many lessons embedded in its success. One thing that is important is that a person in the transportation department that has a passion for bikes. This has been seen in Boston with Nicole Freedman, also known as the bike czar and in New York Ms. Sadik-Kahn has fought for New York's bicycle program(Viser, 2007). In both cases the mayor hired someone directly to advance cycling in their city and in both cases it has worked.

The way that New York City is rolling out its bikeways is an important factor to its success as well. The majority of the first phase consisted of painted lines exclusive for cyclists, which are relatively inexpensive and easy to implement when compared to protected bikeways. Painted lines present a commitment to cyclists in that they give cyclists their own piece of the road. Then phase two consisted of the protected bicycle lanes, which will draw more new cyclists.

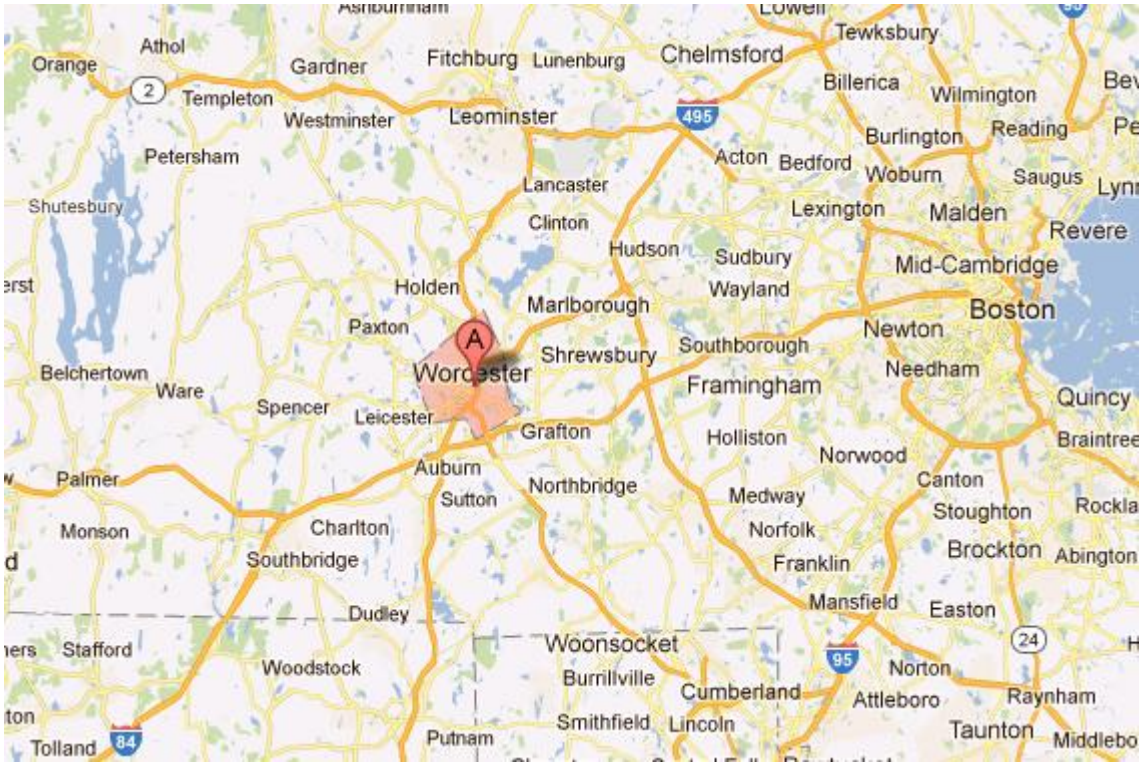


Figure 26: Map of Worcester

2.4.3 Worcester Bikeway Case study

Worcester (See Figure 26), being one of the five largest cities in New England, makes a great candidate for the implementation of bikeways. It is in the center of Massachusetts and has East Coast Greenway to the north and south of it. Connecting these bikeways would provide bikers with numerous options to commute outside of Worcester with the bike. With its population being so high and the city so large, it is clear that other transportation options are needed for people to get around. People also want to enjoy the city they live in and ride around it going to major parks or recreational centers, leading to these destinations being included in the original bikeway layout.

History

The city of Worcester first began implementing its bike lane system interest in the early 1990's. The project headed by Alan Gordon was funded in part by ISTEA; a Federal transportation planning policy established providing funding for non-motorized trails between 1991 and 1993. The bike lane project was initiated in order to improve Worcester's transportation efficiency and provide a recreational bikeway for the general public. It was started right around the time where many of the nearby major cities were also beginning to implement bikeways as a result of the new ICETEA act. The bike lanes were chosen based upon where the most people would need to get to and historical sites in Worcester, e.g. the major transportation hubs and parks.

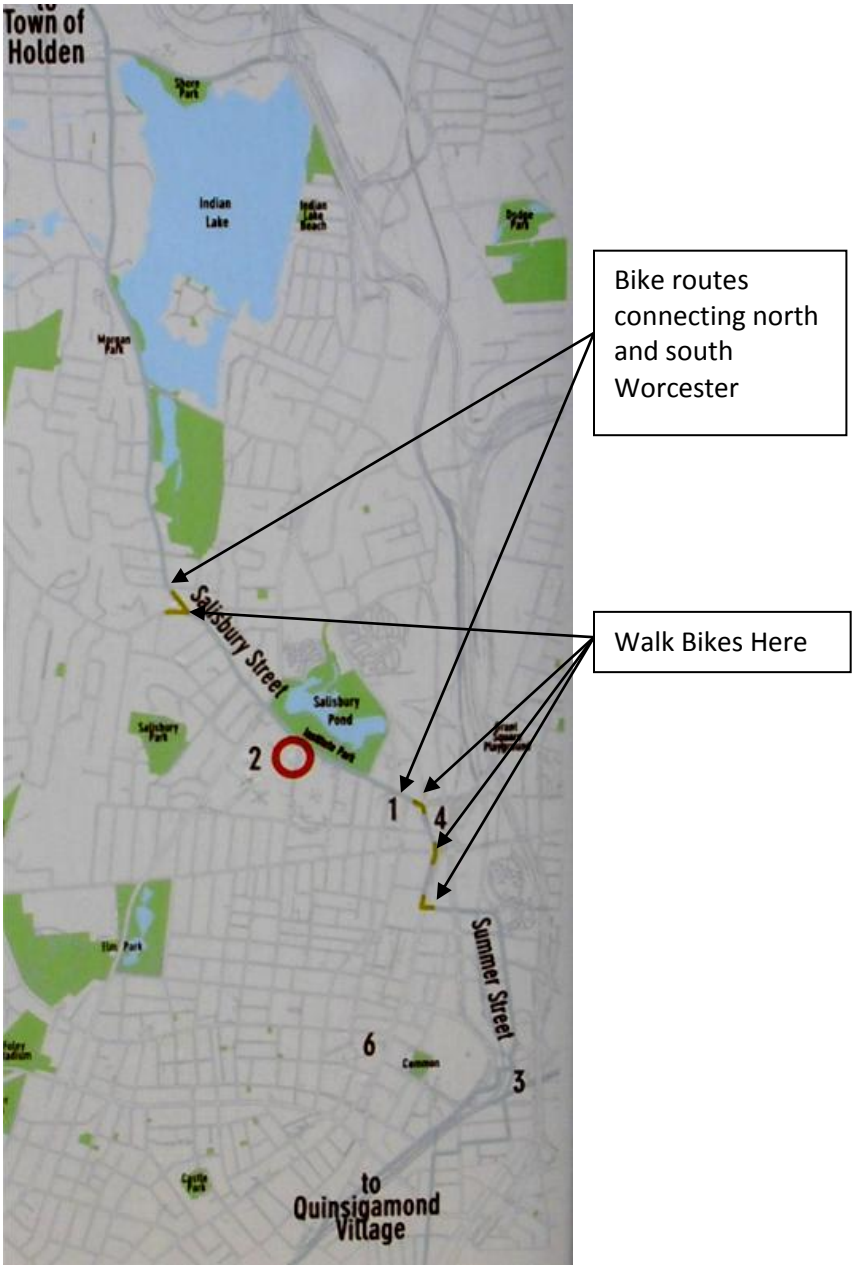


Figure 27: Kiosks at Institute Park (See appendices for other Kiosk Image Figure 78)

Upon completion of the project, ten thousand brochures of the route for the bike lanes were printed and distributed to increase public awareness and attract bikers. Kiosks were put up on parks near the bike lanes such as the ones shown above on Institute Park. The bike lanes were effective at bringing the users to some of the parks located in Worcester along with the bus stops and train station. The Bike lanes also managed to connect to the Blackstone river bikeway allowing uses to continue biking outside of the Worcester area.

Later on in 2003 the Blackstone Valley Chamber of Commerce conducted a case study for the feasibility of implementing a bikeway connecting the Blackstone River Bikeway to Union Station(VHB/ Vanasse

hangen Brustlin, Inc., 2003). This study conducted by VHB looked into the different possible paths and the estimated cost associated with each one. This feasibility study also looked into options for connecting to facilities and resources to enhance the bikeway. It specifically looked into options for connecting to existing places and routes such as ones in Millbury and the Rhode Island section of the Northern Blackstone River Bikeway. The study also looked into options for making the bikeway available to the largest number of users. Finally it looked into making the bikeway easy to build upon and a success for the public use.

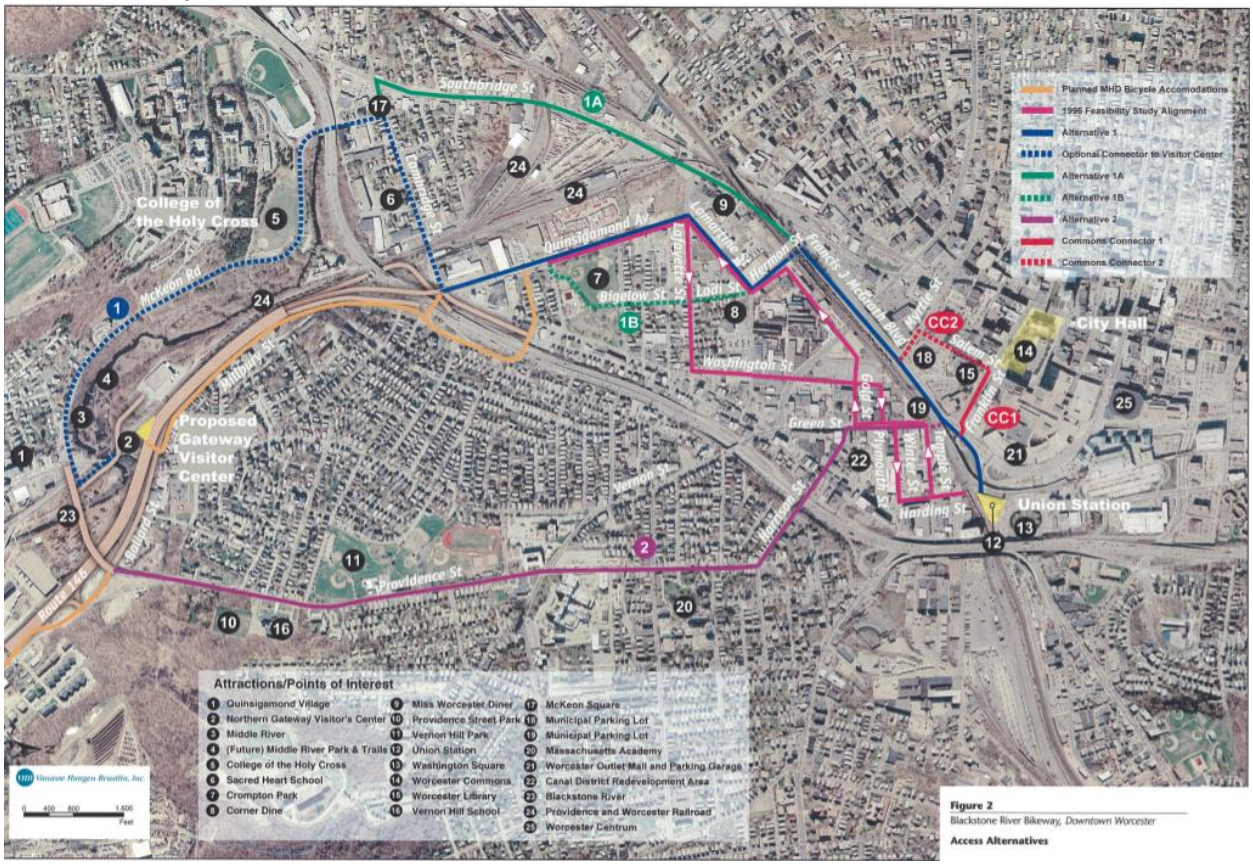


Figure 28: VHB 2003 Feasibility Study-Possible Routes (See Appendix 7.1 for a larger image)

Some of the proposed routes as seen in Figure 28 (See Appendix 7.1 for a larger image) were McKeon Rd which would connect to Holy Cross, Southbridge St, or even off-road on RT 146 where a visitors center could be built. Most of the proposed paths would go by the major areas of interest for the general public such as Union station and City Hall. Unfortunately, even though the proposed routes had high potential, there was not initiative to begin building these bikeways.

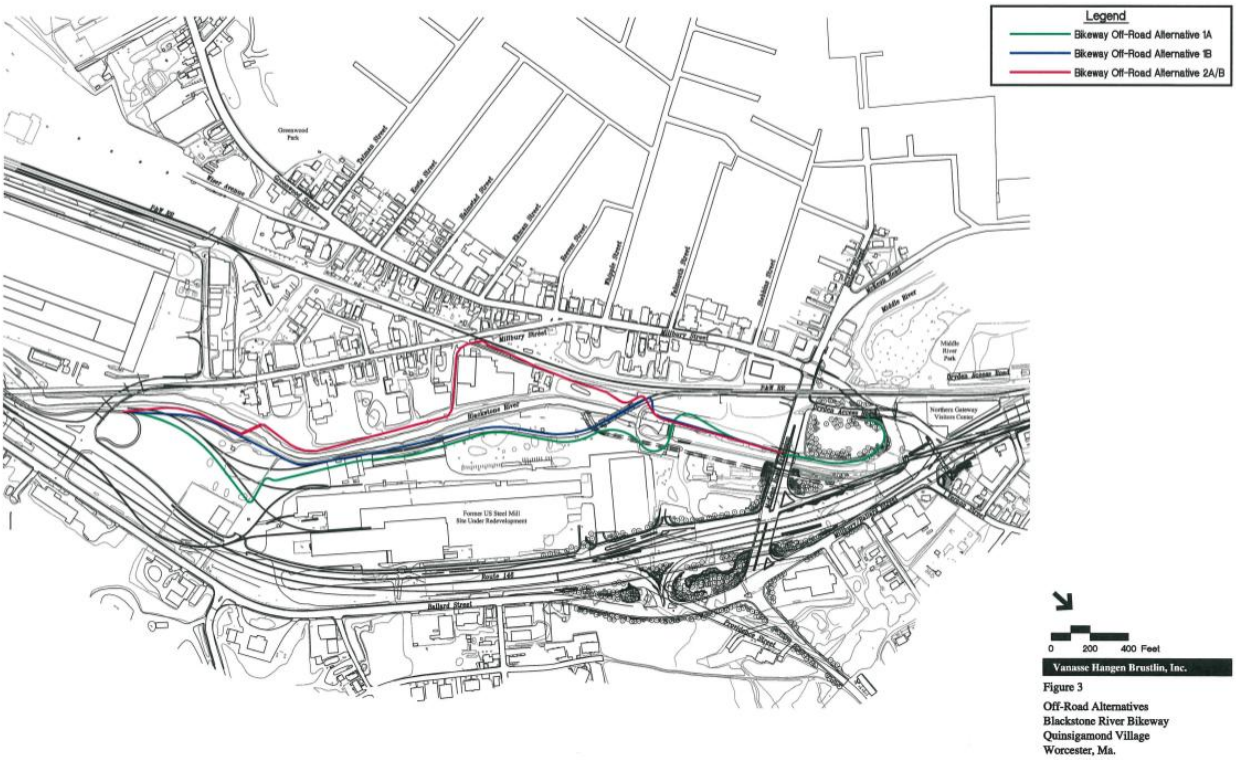


Figure 29: 2004 Feasibility Study of Blackstone River Bikeway Addition (See Appendix 7.1 for a larger image)

Again in 2004, the Blackstone Valley Chamber of Commerce had VHB conduct a feasibility study. This study was for an off-road bikeway to connect to the current on-road bikeway on Millbury Street to the future Blackstone River Northern Gateway Visitors Center. Its goal was to farther develop the current bikeway ending in Worcester and connect it to the future visitor center. It looked to connect to major points of interest to get public interest. The feasibility study also attempted to create a bikeway which would be popular among users and easy to build upon in the future. The proposed bikeway would run alongside the Blackstone River and end at the proposed location of the visitor's center as seen in Figure 29 (See Appendix 7.1 for a larger image). This proposed bikeway would create a highly popular route among users especially since it is off-road(VHB/Vanasse Hangen Brustlin, Inc., 2004).

Current Bicycle Facilities

The current bicycle network in Worcester consists mostly of "Bike Lane signage like in Figure 30 and Figure 31. Worcester is starting to build on the previous bike lane system, by updating signage and widening roads and sidewalks as they are being repaired.

In addition there are plans to replace the Kenneth F. Burns Memorial Bridge, which spans Lake Quinsigamond and links Shrewsbury to Worcester, this construction will likely start early to mid-2012. The bridge will have bike lanes on both sides of the bridge along with large pedestrian sidewalks. This shows a level of commitment between MassDOT and the town planners that will hopefully continue into the future.(Janson, 2011)

Figure 30: New Bike Lane sign on Green Street in Worcester.

Figure 31: Bike sign on Salisbury Street in Worcester, saying that the lights will be changed by a cyclist.

More recently, in December 2009, MassDOT held a public hearing presenting plans for updating Green Street, Millbury Street, and Water Street. These plans included designs implementing painted bike lanes as can be seen in Figure 32, Figure 33 , and Figure 34. The funding for the $7.5 million project would be Enhancement Funding to provide more flexibility to the projects eighteen month schedule. At the meeting there was unanimous support for the project and it was decided that MassDOT would incorporate the public suggestions into their design plans (Michael O'Brian, 2010). Today if one were to drive down Green Street, it would be immediately apparent that these plans are now being implemented just two years after being proposed to the public. Projects like these to implement bikeways in road renewal construction projects will be something which will be seen more often in the near future. According to Robert Moylan, the City is required to look into the possibility of implementing

bikeways on state or federal funded road renewal projects. (Moylan, Robert Moylan Interview, 2012) This is the main reason why Worcester presented these plans to the public. For some of the projects, bikeways will be difficult to implement because the road size is too small. Commissioner Moylan suggested that roads under thirty five feet wide would be extremely difficult to add bikeways to with on street parking being included too. This sometimes causes the City to have to come to the conclusion that a bikeway is not possible to implement in the road renewal plans.

Illustration of Proposed Improvements on Water Street

Illustrative Cross-Section of Proposed Improvements at Neck-Down on Water Street

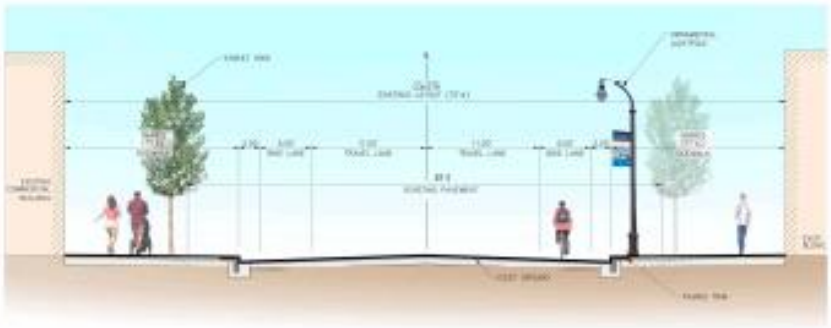
Figure 32: Water Street Streetscape Improvements

Illustration of Proposed Improvements in Millbury Street Commercial Area

Illustrative Cross-Section of Proposed Improvements in Millbury Street Commercial Area

Figure 33: Millbury Street Streetscape Improvements

Illustration of Proposed Improvements at Green Street at intersection with Winter Street



Illustrative Cross-Section of Proposed Improvements at Neck-Down on Green Street

Figure 34: Green Street Streetscape Improvements

Conclusions

The first initiative headed by Alan Gordon was a good start to implementing bike lanes in the city of Worcester as it gave residents a taste of some of the benefits of having a bikeway. The bikeway might not have been a great hit among some bikers though such as Tom Swenson of Boylston from the Seven Hills Wheelman who stated "There's more to being bicycle-friendly than putting up signs and painting a few lines ." The article also goes on to say that the bikeways just aren't great for everyone as most people do not enjoy biking on the roads with a painted line separating them from the cars(Tolman, 1996). In general, the bike trails would have to be separated from the road by more than just a painted line to please the public. Looking at the Worcester bike lane today, one can learn a few things for the next project to improve upon. One of the major improvements which will greatly increase the longevity of the bike lanes will be to maintain the lanes. If one were to follow the bike lanes in Worcester today, the painted lanes would be very difficult to see because they are all faded and the only thing stating that the path is there is a sign. Also printing out more maps of the bike lanes for the public to collect at kiosks would help keep the lanes active among the community.

Looking at the feasibility studies, it is clear that there is an interest in creating a bikeway in Worcester otherwise the Blackstone Valley Chamber of Commerce would not have called VHB to prepare a feasibility study for a bikeway. If Worcester would be able to implement even one of these proposed bikeways, the Blackstone River Bikeway would provide cyclists the option of biking all the way to Rhode Island. In the future plans could also be made to connect to various other bikeways north of the city, creating a sort of transportation hub out of Worcester. It is apparent that Worcester is considering adding bikeways to the city because of the initiatives on Green, Millbury, and Water Street. Because Worcester is already adding some bike lanes to its streets, the possibility of the previous bike lanes being implemented are pretty good.

2.4.4 Bicycle Rental Programs

Many cities throughout the world are going through transformations to become greener and to adapt to the increased cost of fuel. This trend towards greener transportation has created a higher demand for bicycles, and bikeways. Some cities such as Boston, New York, and Florence Italy, are beginning to implement bike sharing systems such as, Hubway, Bike Rental Central Park, and Mille E UnaBici. In Boston, Hubway bikes can be rented for as long as the customer requires, but the fees are based on a half hour schedule with the first half hour being free. The user is also required to pay a yearly membership fee on top of the hourly fee. There are also options of obtaining a three or seven day membership plan. The rental stations are located at many of the major T stations and public attractions(Graham, 2011). Should Worcester implement a bikeway in the future, a system similar to Hubway would be a great addition to major public places like Union Station and City Hall providing people without a bike with transportation for the bikeways.

Figure 35: Hubway Bike Rental (htt2)

Some of the universities in the Worcester area have also started to adopt bicycle sharing programs such as Clark and Assumption University.(Clark Bike Share, 2011) The bike sharing program at Clark has been implemented through student volunteers participation in the Cycles of Change organization, a program dedicated “to improve the health and sustainability of our neighborhoods by increasing the use of bicycles as transportation, connecting youth with the extraordinary living systems of our local area, and building a diverse community of visionary young leaders” (Cycles of Change, 2011) Obtaining a bike at Clark University's Bike Share is strictly for students studying at Clark University, by providing their student ID as collateral, students may rent the bikes for free.

Figure 36: Clark Bike Share (Clark Bike Share, 2011)

In the future, bike rentals in Worcester could be extended to the general public much like the Hubway program in Boston. The universities, as members of the Worcester Consortium, could also provide intercollegiate bike sharing or even open up the bike sharing programs to the public for a small fee or in exchange for collateral.

2.5 Project Challenges

In constructing a major bikeway, there are five main topics which need to be addressed, Engineering, Encouragement, Education, Enforcement, and Evaluation(Freedman, 2011). Each of these stages of the project needs to be addressed if the bikeway is going to be a success.

2.5.1 Engineering

The engineering portion of the project requires the construction and layout of the bikeway to be taken into account. One needs to determine what type of bike lanes should be used and where they should go. The public need will have to be addressed as to where the bikeway should go. The public opinion should be taken into consideration when determining the route for the bicycle path through surveys and traffic patterns. This will result in a path which addresses the needs of most citizens without causing undue disruption to the normative traffic flow. This bikeway will also have to maintain the building codes in order to be eligible for many of the funding opportunities and provide a safe environment for bikers. The types of bikeways being implemented will have to be taken into account as seen in the Section 2.2 Summary Bicycle. Once the style, need, and location for the bikeways have been determined, a construction company will have to create a document with all the proposed routes and prices. The document will then have to be presented to the City of Worcester to be voted on for approval.

The specifics of the bikeways will also need to be taken into account such as providing enough of a barrier between the cars and the bikers to keep a good safety cushion. The intersections will need to be carefully planned to prevent cars turning into the bike lanes and hitting bikers when turning. Untrained bikers often drive through intersections when they should wait for the signal to change. Changing the layout of the intersection by disallowing turns on red may also help with situations like this. Adding signs reminding car drivers about biker presence to each intersection can also increase the safety for bikers.

In creating a bikeway, the greatest obstacle may come from finding funding for the project. Even with overwhelming support for the path, there may be Worcester residents who are opposed to providing financial support. Special care will be needed to determine the possible funding sources. Finally bike parking will also have to be dealt with, as an increased number of bicycle users will create a need for more bicycle racks. The major public points of interest will have to become more biker friendly and provide bike racks for parking.

2.5.2 Encouragement

The project will also need to gather public support and encourage people to use the bikeway showing a need for one. This encouragement for using the bikeway could come from major biking events to get the public excited about the project and aware of the many benefits of a bikeway. To keep the bikeway in a positive light and public support up, it will have shown the public that the bikeway is a safe and crime free place.

The locations in a bikeway providing the highest risk to a biker are at the intersections in the roadway, so special attention should be paid to these crossings. Commuters driving in a car almost always get frustrated when waiting at a red light and adding a bikeway to the city of Worcester may increase the waiting time for drivers at traffic lights unless a good method can be implemented for giving commuters or bikers the right of way.

Crime is a significant issue for all cities to address. This is particularly relevant in the City of Worcester, as the city has ranked 10th for US cities with rising violent crime (Sauter & Stockdale, 2011). This rising crime rate may have an influence on people using bikeways, especially at night. This problem could be dealt with by adding safety call boxes or light posts along the bikeways much like the blue light system at major colleges. In some cases it may be possible that crime levels may go down due to the increased public presence on major streets adding witnesses to any possible crime incidents.

Currently America's culture promotes big cars and trucks. With all the advertisements seen on the television, the average American is being brought up wanting the biggest cars with the largest engines. This hurdle will have to be dealt with for promoting the new bikeways. People will have to be introduced to biking and shown that it is cool and fun. This could be done by creating public events where anybody can come by and meet with local biking clubs to show them they can be a part of a club themselves.

Finally, the increased use of bikes will require Worcester to upgrade some of the other modes of public transportation to give bikers who are stuck somewhere an alternative means of transportation. Currently Worcester has a bus transportation service for local area routes and a train station for long distance travel options. Some of the buses have a bike rack on the front for bicycle commuters, but with an increase in biker traffic, the bike rack will have to be expanded to support more biker commuters, especially on rainy days. The trains in Worcester may also have to adapt to more biker commuter traffic in allowing bikes to either be stored at the station or be brought on the train.

2.5.3 Education

Depending on which type of bikeway gets implemented, be it on road, or off road ways, drivers in the City of Worcester will need to learn to share the road. It will also take time before the commuters get used to seeing bikes on the road and how to act in the new conditions. Bus drivers will need to be

trained on how to respond to bikers using the bike racks on the bus. Kids riding bikes will have to be taught to wear a helmet and not ride on sidewalks. Police will have to be informed to keep a watch on people not obeying the laws such as riding on the sidewalk. Signs could be posted to make users aware of the rules of the road. Pamphlets with maps of the paths or posters could also display a few ground rules to using the bikeways. The city could also offer classes for beginners learning to ride about bicycle safety. As an alternative for a small fee, bike shops in Worcester could offer jumpstart programs for new bikers to educate them on safety.

2.5.4 Enforcement

In order to show that the city is serious about the bikeways, it will require some enforcement. The police will have to be on the lookout to ticket people obstructing the bikeways, not wearing helmets, running red lights, etc... Bus drivers should be lenient on allowing bikers to bring bikes on the bus bike racks and not deny them their right. By enforcing the rules, the city will make the bikeways safer for their users. It will also create a fun and attractive aspect of the city enticing visitors to come visit Worcester.

2.5.5 Evaluation

Upon completion of the bikeways, and even beforehand, there will have to be some monitoring done. The bikeway or planned bikeway should be monitored as to how many users use it along with the number of cars using adjacent roads. This will later show a trend of how many bikers use the bikeway and if it has an effect on the number of cars on the road. The data can be evaluated to show the success of a bike lane and how it affects the city.

Table 3: Summary of Project Challenges

Challenge	Description	Solutions
Funding	Obtaining funding for the project	Determine different funding options
Safety	Providing a safe environment for bikers	Create barriers
Crime	Keeping the bikeways free of crime	Police call boxes
Public Transportation	Allowing bikers to take bikes on busses and trains	Beefing up the transportation system
Location	Determining where the bikeway will go	Survey results and public awareness

2.6 Social Impact

Table 4: Cause and Effect of Bikeways

Reason	Cause	Effect
Crime Rate is high	Bikeway runs through high crime-rate area	Diffuses centrally located crime
Attending higher education classes	Bikeway connects the consortium therefor allowing for easier access for commuting	Betterment of oneself
Community Events	Bikeway connects churches, YMCA's, museums and so much more	Diverse community can participate in so many more activities
Obesity in America	Bikeway allows for exercise throughout the city	A leaner Worcester

Table 4: Cause and Effect of Bikeways, shown above, summarizes some of the potential benefits of implementing a bikeway. The benefits shown include uniting communities by providing easy access, as well as reducing crime and improving health. An interesting technique used to absolve crime has been demonstrated by Crime Prevention Through Environmental Design (CPTED).(Crowe & Zahm, 1994) If a bikeway is implemented through a rough neighborhood crimes may not be committed as easily and the crimes tend to shift locations. By taking the route of the Worcester bikeway through some of the lesser commuted areas, the project would be able to help squelch out some of the current problem areas. Properly maintain these paths would not only help ensure the success of this approach but extend the life of the project and prove the sustainability of it.

Sustainability has become a huge buzz word on the campuses as of recent years. Always a present idea, sustainable transportation has become a part of a larger, greener movement, as said by Mr. Carlos Balsas.(The Centre for Sustainable Transportation, 2002)As shown in Figure 37 below, the simplified interactions of economy, environment and society all overlap to show how comprehensive sustainability can be achieved. A fantastic example of society and environmental influences has been the college movement. These actions on campuses worldwide have been a big factor in these universities investing money into the integration of bikeways. The benefits are significantly less motor traffic from cars and buses, and healthier students. Locations across the world have started seeing significant trends of such benefits. Specified in the article, Sustainable Urban Transport Visioning in Central America – A Future without the Car, studies done in Central America have started seeing a way where cities can function without vehicular traffic. (Schreffler, Umaña, Moreno, & Mattsson, 2010) Although not feasible for Worcester, less congested streets and faster commutes are practical and could be in sight within the next 10 years.

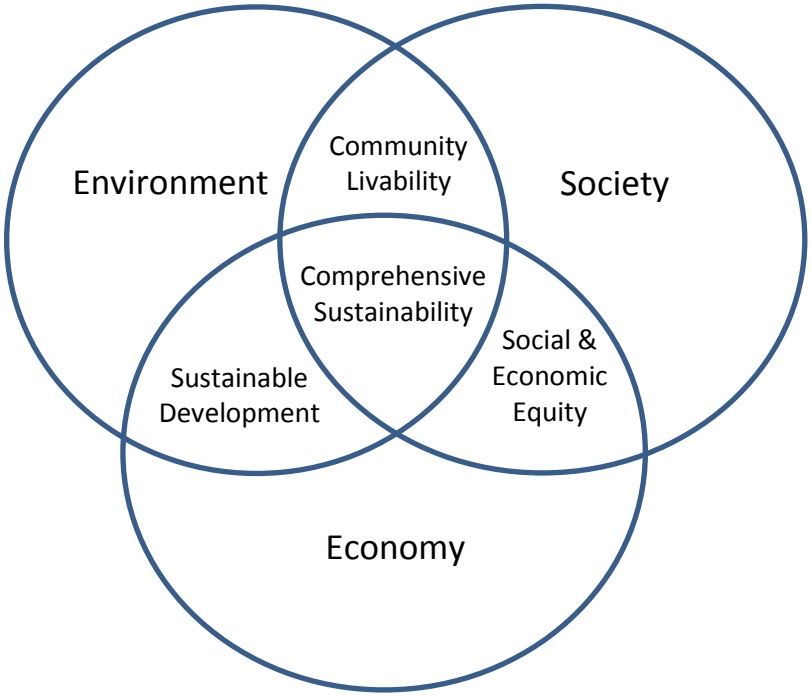


Figure 37: Community Livability (Arnot)

Along with the environmental and economic benefits, the most important benefit to Worcester may be cultural development. The wellbeing of the citizens needs to be taken into consideration and acknowledged as a priority. British Columbia has done just that by investing over a $1,000,000CAD into bicycle path, bike lanes, trails and so much more to motivate their citizens to choose bicycling over automotive options.(Ministry of Transportation and Infrastructure, 2011) Other studies have looked at European countries as models for bicycle friendly communities such as Sweden.(Börjesson & Eliasson, 2010) Sweden being dependent upon bicycles for a great majority of their transportation has seen a correlation between the health of their country and the average amount of exercise one may encounter. Worcester could see a similar increase in cultural education by having more community wide events such as an expanded Bike Week or events are multiple museums. The impact a bikeway on this would be easing the commute between areas and even becoming a central event for people to become involved with.

The benefits of expanding and implementing new bicycle routes within the city of Worcester would not only benefit the communities and city as a whole, but individual people on the basic levels of education and health. These reasons should be enough to encourage the installation of said bikeway.

Summary

This chapter has introduced bicycle ways as a means of travel, along with the way they impact transportation in urban areas. In particular, the chapter addresses some of the concerns for the City of Worcester by providing examples from other cities which have constructed similar paths. The following section of this report will provide the specific approach taken to develop and implement a bicycle path within the City of Worcester.

3 Bikeway Planning and Design

To accomplish the goal of creating a proposal for the implementation of a bikeway in the city of Worcester, first and foremost the needs of the general public will have to be determined. To accomplish this, a survey will be conducted and distributed to as many people in Worcester as possible. Once there is a good idea of what the citizens of Worcester want to see in a bikeway and a need for a bikeway is determined, a route will be found satisfying the majority of potential users. Finally to help keep the financial burden of creating a bikeway low for the city of Worcester, potential funding options will be determined which Worcester would be eligible for.

3.1 Survey Development

To obtain a better understanding of the public need for a bicycle path a survey will be conducted and distributed to the major colleges, shops, and online in the Worcester area. The survey will determine whether or not the individual believes Worcester needs a bikeway. It shall also determine how often the bikeway might be used, where it should go, and concerns the individual might have. Questions will be asked to determine where the bikeway should go by asking each survey taker what points of interest they would like to see on the bikeway, what they might use the way for, and what their concerns might be in respect to traffic and terrain. The idea is to satisfy the largest number of people in order to get the greatest number of people on the bikeway and make the project worthwhile.

The survey will also determine the individuals comfort level with riding on the road. Furthermore, the individual will be asked how they envision the optimal bikeway would look like. With this information, it can be determined if the bikeway will be successful as just a painted line, barrier, or wall separating users from cars. The survey will also ask questions relating to bike rentals to determine if it is worth investing and implementing a bike rental system to attract more users.

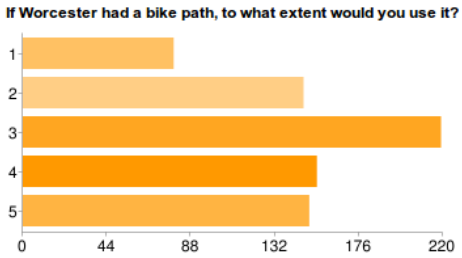
The survey was conducted online through the use of Google Docs. The majority of the 755 respondents held university affiliations, with 9% of respondents not claiming a university affiliation. As the survey was distributed via email to a number of universities, while paper fliers were the primary means of contacting those without university affiliation, ease of access likely played a role in this skewing of respondents. Despite this, the ages and genders of survey respondents were well balanced suggesting the survey would provide accurate insight to at least the “college affiliated” demographic. The complete set of survey results and questions is included in Appendix 7.1.

3.2 Survey Analysis

Yes	**658**	87%
No	**24**	3%
Undecided	**69**	9%

Figure 38: Survey Results - Need

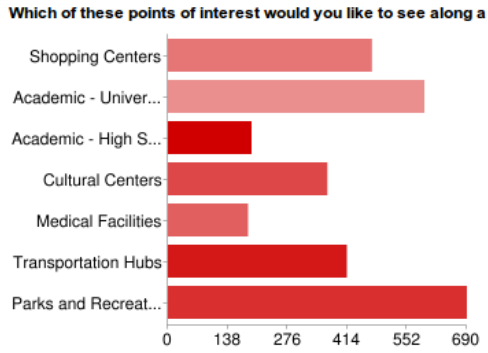
Figure 38 shows the results to the first question of the survey. It was meant to determine if there was a need for a bikeway in Worcester. Looking at the results from this question, it can be determined that the majority of the survey takers thought that there would be a need for a bike path. This is a good indicator that Worcester wants to see bikeways in the future.



1	**79**	10%
2	**147**	19%
3	**219**	29%
4	**154**	20%
5	**150**	20%

Figure 39: Survey Results - Extent of Use

Figure 39 asked to what extent the survey taker would plan on using the bikeway. The results of this question were needed to determine the extent of use for the bikeways. This will help in forming a need based analysis for the bikeway. The results here show that the majority of survey respondents would moderately use a bikeway if one were to be built.



Shopping Centers	**471**	63%
Academic - Universities	**592**	79%
Academic - High Schools, Middle Schools, etc.	**193**	26%
Cultural Centers	**368**	49%
Medical Facilities	**185**	25%
Transportation Hubs	**413**	55%
Parks and Recreational Areas	**690**	92%

People may select more than one checkbox, so percentages may add up to more than 100%.

Figure 40: Survey Results - Points of Interest

Figure 40 asked what the points of interest one would like the potential bikeway to go by. Again this question would help determine the potential route and need a bikeway will have to address. The results here show that there is a need for a bikeway to go to parks and recreational areas, universities, and transportation hubs.

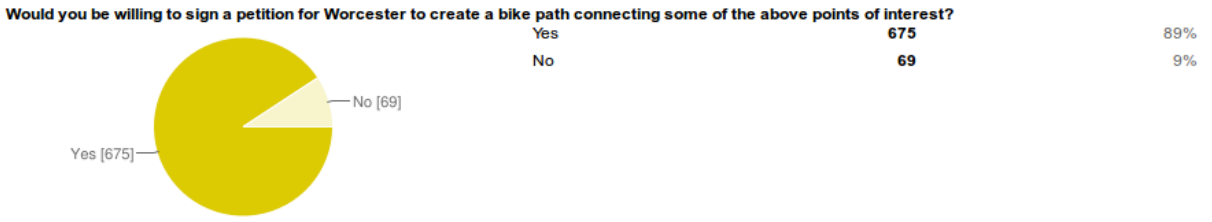


Figure 41: Survey Results - Petition

Figure 41 shows the results of the survey question regarding whether or not the survey taker would be willing to sign a petition for bikeways. This question was asked to determine if the survey taker was willing to show the city that they would support the bikeways in Worcester. With this information, the feasibility study can show the City that there is a need for a bikeway. Because the majority of respondents were willing to sign a petition, this information can be used to show Worcester could use bikeways.

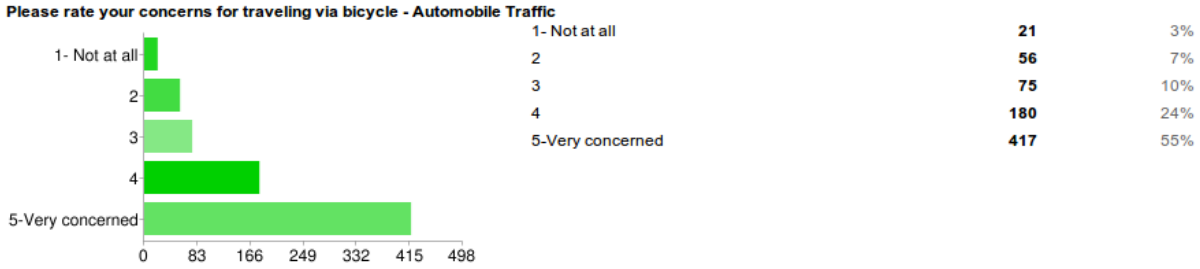


Figure 42: Survey Results - Automobile Traffic

Figure 42 was to determine the concerns a biker might have in respect to automobile traffic. The results for this question are meant to be used to determine the comfort level of each biker. The results as seen in Figure 42 show that the majority of potential bikeway users are very concerned with automobile traffic.

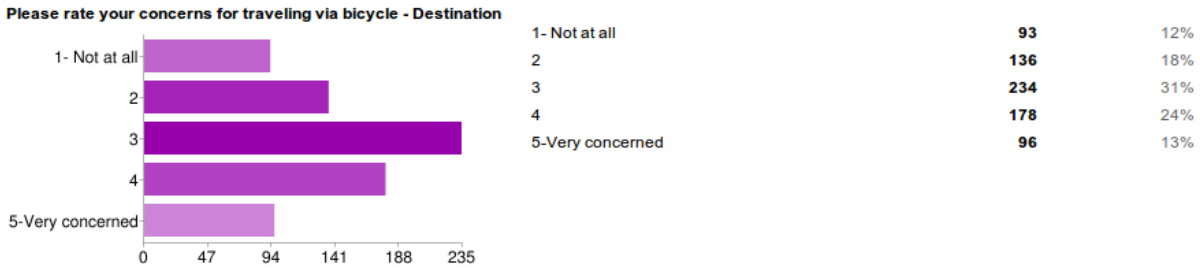


Figure 43: Survey Results - Destination

Figure 43 addresses the concerns of the biker for the destination they would like to see the bikeway go to. This survey question is to be used to determine how important the destinations of the bikeway will be for the survey taker. As seen in the above figure, the majority of survey takers are moderately concerned with where they would like the bikeway to go.

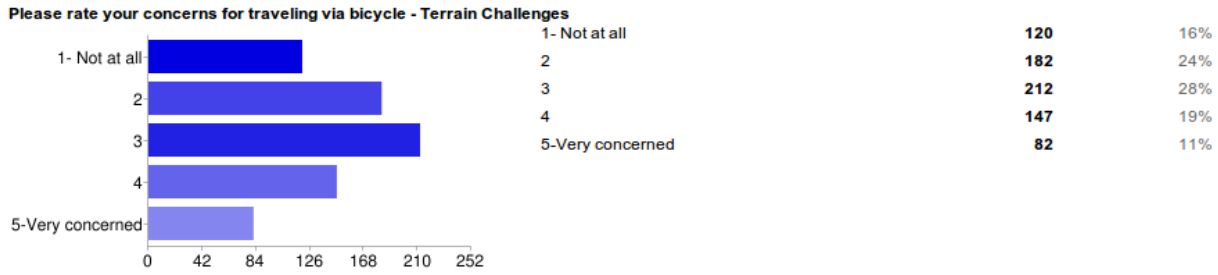


Figure 44: Survey Results - Terrain Challenges

Figure 44 asked the respondents about their concerns for terrain challenges. The question was asked to determine how the majority of users would feel about elevation changes in the bikeway. These results could be used to determine the route of travel for the bikeway. Looking at the results it can be determined that while some people are very concerned with terrain changes, the majority are only moderately or little concerned about the changes in elevation.

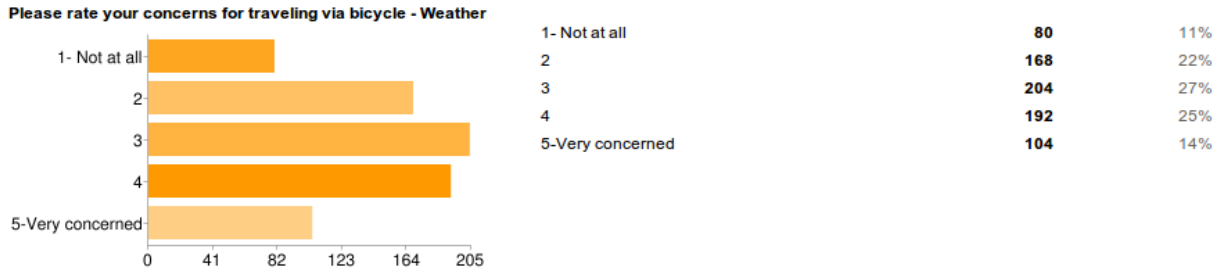


Figure 45: Survey Results - Weather Concerns

Figure 45 takes the travelers concerns regarding weather into consideration. It was used to determine how the weather would affect the bikers' outlook on use of the bikeway. The results of this question were relatively evenly spread out in the little to somewhat concerned range.

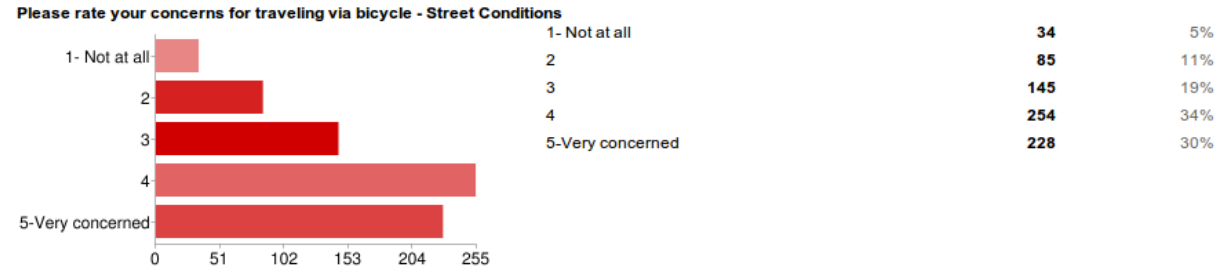


Figure 46: Survey Results - Street Concerns

Figure 46 was meant to determine the concerns of the street conditions for the bikers. This would be used to determine if the bikeway has to be put on newer roads with freshly paved streets or if older streets can be used. The results of this question clearly show that the majority of bikers would like to see roads with better conditions or freshly paved streets.

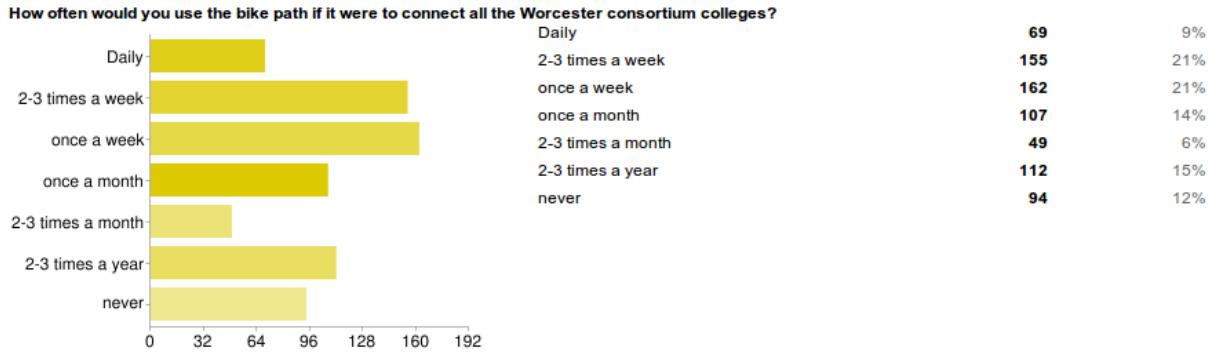


Figure 47: Survey Results - Bike Path Use

Figure 47 shows the results of the survey question regarding the usage of the bikeways. This information is useful in projecting the amount of use the bikeway might see after it is implemented. As seen in the above figure, the usage of the bikeway is relatively evenly spread out with a slight majority of the path usage being between two to three times a week and once a week.

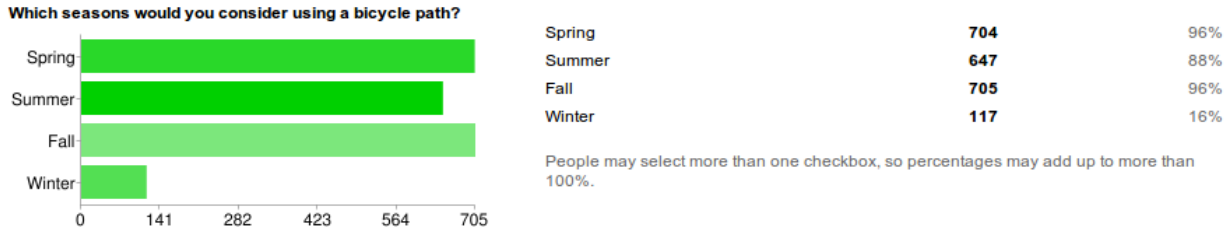


Figure 48: Survey Results - Seasonal Use

Figure 48 shows the question regarding when the survey respondent would most likely be using the bikeways. The results of this survey are to be used to plan on when the bikeways should be maintained. For example if there is a need for bikeway usage in the winter, then the bikeways will have to be plowed. Looking at the results of this question, the majority of the bikeway users will be using the bikeways in the summer, spring, and fall. This shows that there is not much of a need for plowing the ways in the winter.

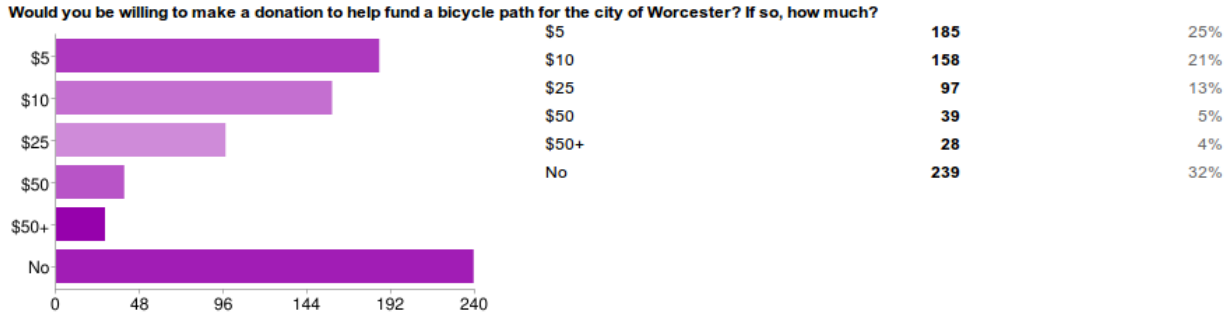


Figure 49: Survey Results - Donation

Figure 49 shows the results to the question asking if the survey taker would be willing to make any donations for the bikeway. The results of this question can be used to determine if the public would be willing to raise money for creating the bikeways as another possible funding source. The results of this survey indicate that the majority of the users wouldn't want to make a donation. There are also a large

number of people who would like to make a donation of five to ten dollars. This shows that about three quarters of the survey takers would be willing to make a little donation for the bikeway.

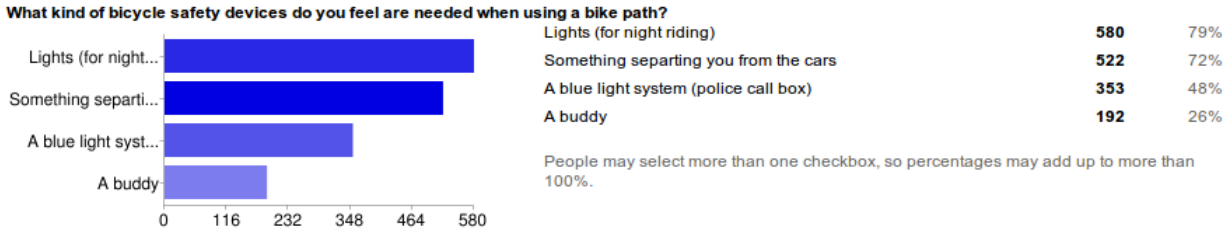


Figure 50: Survey Results -Safety Devices

Figure 50 shows the results for the question regarding the type of safety devices users might want to see on the bikeway. These results were meant to be used for ideas to be implemented in the bikeways concerning bicycle safety. Looking at the results, it is clear that the majority of users would like to see the bikeways implementing lights for night use and something like a barrier separating the bikers from the cars.

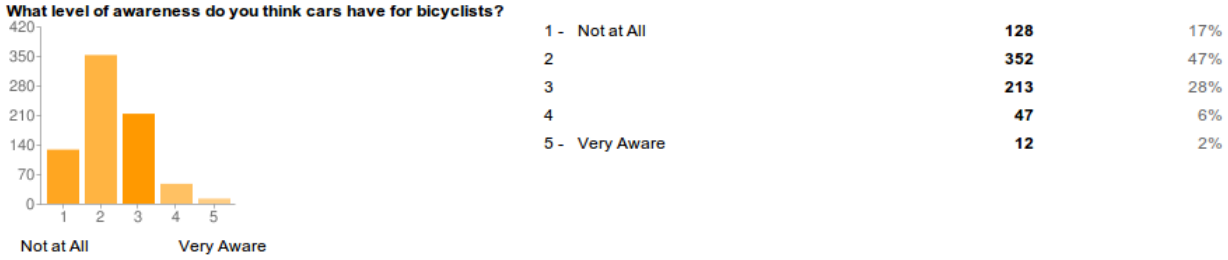


Figure 51: Survey Results - Biker Awareness

Figure 51 asked bikers how aware they thought the cars were of them. The results to this question can be used to determine how safe the survey respondents feel on the road. According to the above figure, it can be seen that most of the survey respondents feel that the cars are relatively unaware of them on the road.

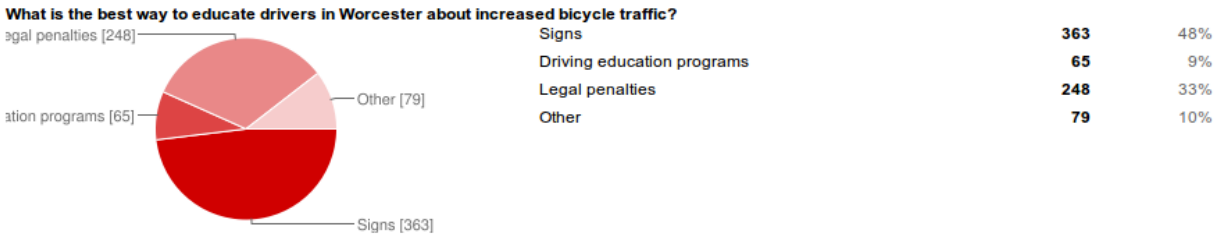


Figure 52: Survey Results - Educating Drivers

Figure 52 asked the survey takers to choose, what they felt to be the best method of educating drivers. The results of this question could be used to determine the best method of education drivers to make them aware of bikers on the road. According to the results, the majority of people would prefer signs to be put up alongside the road along with legal penalties.

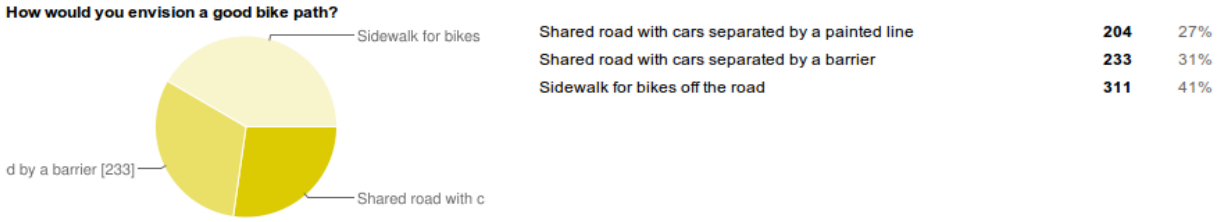


Figure 53: Survey Results - Envisioning a Bike Path

Figure 53 asked survey takers to choose the ideal bikeway as they envisioned it. This question would ideally help in the decision of what type of bikeway should be chosen. The results of this survey question are relatively close together and show that the survey respondents don't have much of a united opinion on what the bikeway should look like.

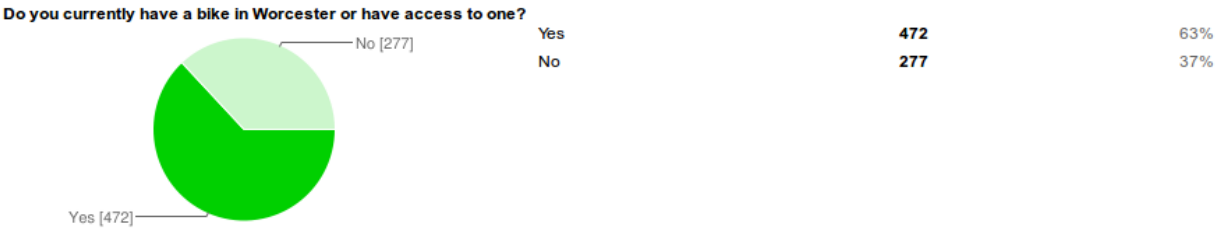


Figure 54: Survey Results - Access to a Bike

Figure 54 addresses the possible need to provide the users of a bike path with bikes. If the bike path is there and no one has a bike to use the bike path with, it will be useless. From the results, it looks like the majority of survey respondents have access to a bike, but there is still a large portion of people who would need a bike.

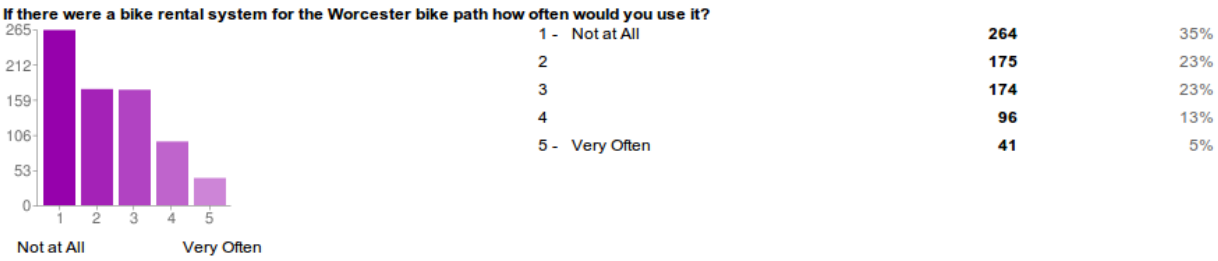


Figure 55: Survey Results - Bike Rental Use

Figure 55 asked if bikers would use a bike rental system if Worcester offered one. This could help determine if there was a need for a bike rental system for users without bikes to have access to. According to this graph, the majority of people would not use the bike rental system at all, while a few stated they would use it a lot. This could be a little skewed as the majority of the survey respondents stated that they already have access to a bike, so they would not use the bike rental system.

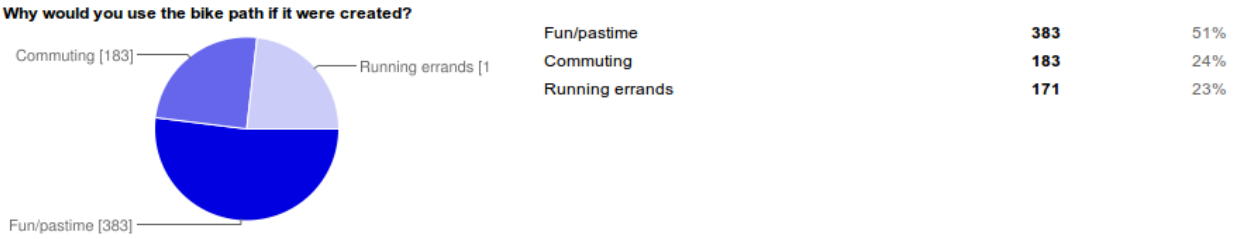


Figure 56: Survey Results - Purpose for Use

Figure 56 determined why the majority of users would use the bikeways. The results could be used to determine the general group using the bikeway and could help choose where the bikeway should go. According to the figure, the majority of bikers would be using the bikeway for fun or as a past time activity. This means that the bikeway would most likely have the most need to go through parks and recreational areas.

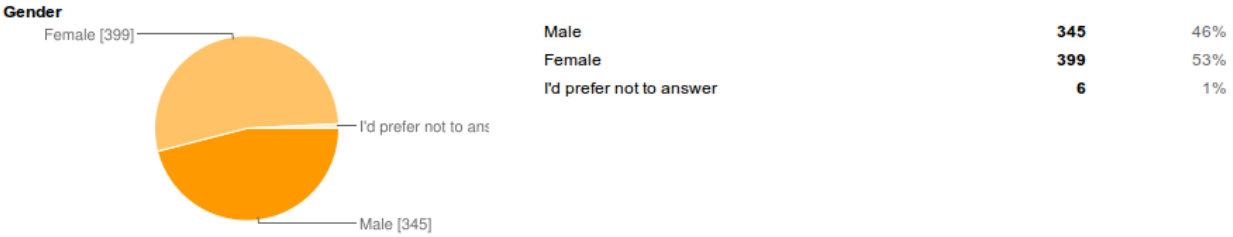


Figure 57: Survey Results - Gender

Figure 57 asked what the survey takers gender was; this information could be used to determine who the majority of potential bikers could be. As seen in the above figure, the majority of survey respondents were female.

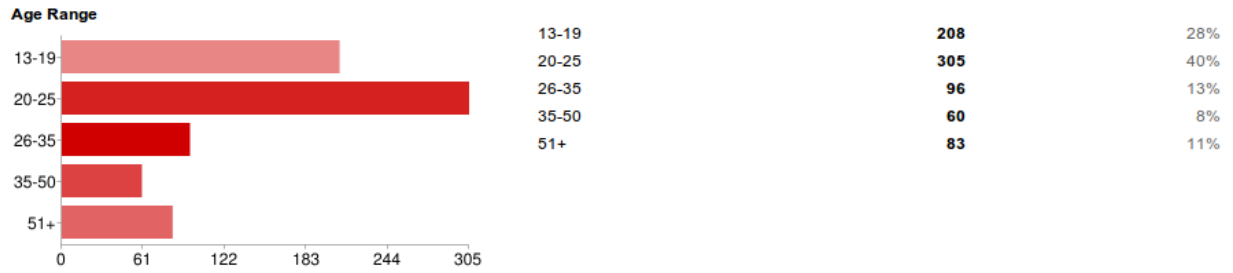


Figure 58: Survey Results - Age

Figure 58 asked the participants of the survey what age group they fall under. The responses to this question can be used to determine the age range of the potential bikers which might skew some of the results. For example an older person might consider that the terrain challenges are more significant of a concern. This information also helps determine the target age group of potential users. As seen in the chart, the target age range for the potential bikers is twenty to twenty-five.

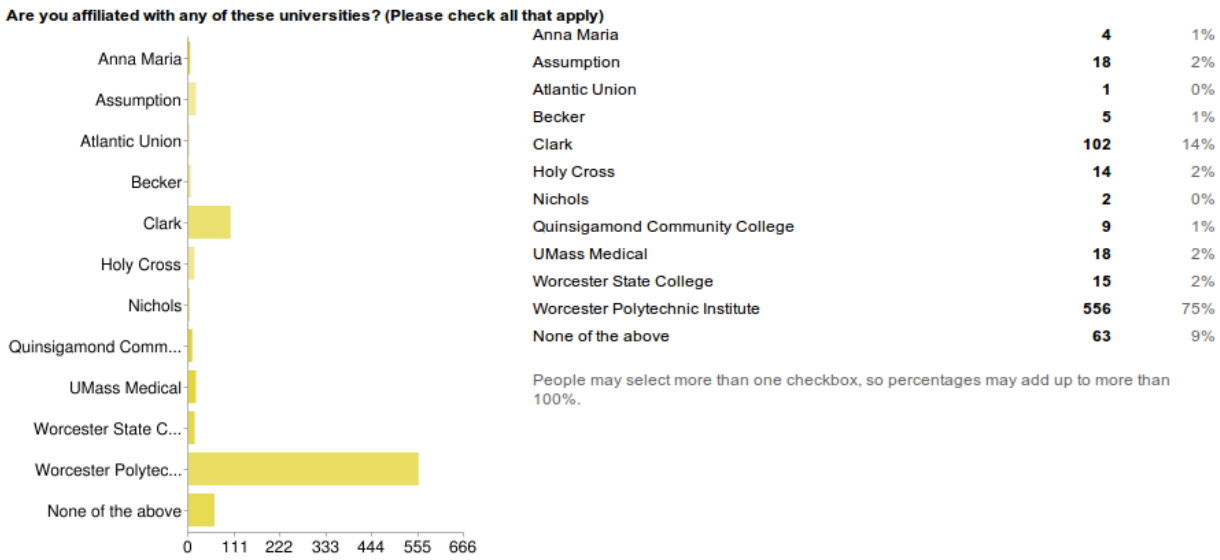


Figure 59: Survey Results - Affiliation

Figure 59 displays the responses to the survey and what the survey respondent is affiliated with. The majority of respondents were from Worcester Polytechnic Institute because the Interactive Qualifying Project was being conducted from there. Clark University also had a larger number of respondents because some friends attend Clark. These results can be used to determine if responses have to be weighted such as which Universities the bikeway should go by and where the bikeway should go.

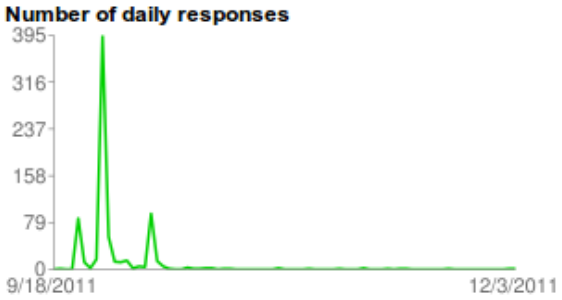


Figure 60: Survey Results - Number of Daily Responses

Figure 60 shows the number of users responding to the survey on a given time frame. As was expected the initial spike of responses is the result of mass e-mails sent out to the Worcester consortium schools and the final spike is due to the flyers posted around Worcester in local shops.

3.3 Route Planning

In order for a bicycle path to gain community and government support, it must be designed to fit the needs of the community. A bicycle path should provide a safe and efficient way for people to travel, and in order to do so a route must be selected which connects common points of interest, taking into account the cyclists safety during their trip, especially the impact of natural obstructions and automobile traffic.

Worcester's population is interesting in that a sizeable percentage of residents are in some way affiliated with the local universities. There are over 30,000 college students in the city of Worcester, making over 16% of the cities' population a college student. (City of Worcester, 2011) In addition to the students, all of these universities require faculty, staff, and administrators who travel to and from the universities on a regular basis. Given this large portion of the city with an interest in the universities, the universities will make a good location for nodes to connect to a bicycle path system. This idea is reinforced by examining the existing plans for a bicycle route in Worcester, shown in Section 2.4.3 Worcester Bikeway Case study, as these plans either connected many of the universities, or intended to in future phases of development. Connecting the universities will server a significant portion of the population, however, in order to ensure public support for the project, it must be attractive to more than the approximately 25% of the population associated with the universities.

It has been shown that bicycle routes can increase the desirability of a residence near the path as well as generate business for local shops which are either on the bicycle path, or provide support for cycling and its equipment. A logical step from this would be to connect the city of Worcester with some of the larger nearby bicycle routes and trails, especially those associated with the East Coast Greenway, a bicycle route under development which would connect Canada to Southern Florida, down the east coast of the United States. (East Coast Greenway, 2011) A bicycle path running north to south through the city of Worcester would not only connect Quinsigamond Community College, Worcester Polytechnic Institute, and the College of the Holy Cross, but it could potentially connect these schools to the East Coast Greenway, filling a gap between the planned route to the north of Worcester, and the Blackstone River Bikeway as shown below in Figure 61. Such a connection has the potential to not only increase traffic on the Worcester route, thus increase the traffic past local business, but to allow for greater publicity for the bicycle path and potentially greater access to funding. Connecting to this route could also provide substantial benefits to the city as a whole, with the potential for bicycle tourism to increase business at local restaurants, stores, and bicycle repair shops.

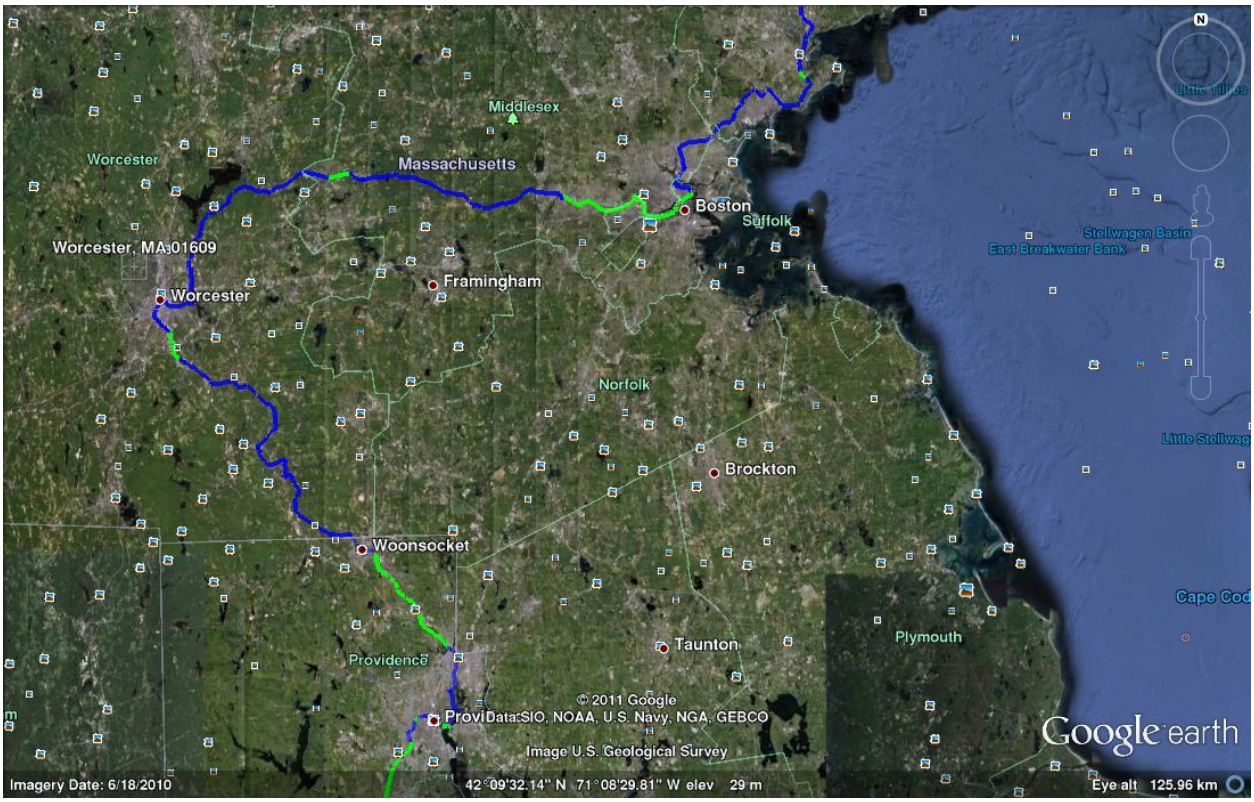


Figure 61: East Coast Greenway near Worcester (East Coast Greenway, 2011) Green paths have already been constructed, blue paths are being considered.

The East Coast Greenway link in conjunction with an expanded bikeway system within the City of Worcester would allow for workers to commute to Worcester via bicycle from towns outside of Worcester, just as it would allow Worcester residents to commute to other cities and towns along the route. Should the Greenway be constructed as it is currently planned, this connection would allow bicycle travel between Worcester and Hudson, an 18 mile trip which would take a little over an hour for the typical cyclist. The bikeway would remove transportation as a barrier to employment for some people, allowing cheap, efficient, and rapid transportation within the city, and between the city and its surrounding area.

In addition to large scale recreational connections, and commuting options for those affiliated with Worcester's many universities, a bikeway system for Worcester should provide some service to the entire population. The ideal bikeway system for Worcester, as described in the following section, would connect many of Worcester's larger residential areas to the bicycle system, allowing residents to travel between them while providing some protection from automobiles. It will provide access from many of these areas to the City Center, allowing residents to safely travel to local businesses, parks, and transportation hubs.

Ultimately, in order for the bicycle path to address the needs of the most people, the survey results should be considered. The results shown below in Figure 62 indicate that parks and recreation areas are the most desirable destination for most potential path users, followed by universities, shopping centers, and transportation hubs. A carefully selected route along the north-south path through Worcester could easily connect many of the Worcester universities, as well as the East Coast Greenway, City Hall, Union Station, and a number of public parks. The existing plans for a bicycle path connect some destinations

east and west of this route, expanding on this could potentially connect more public parks, and the Worcester Regional Airport to the system. Many of these locations already have shopping centers near them, as the shopping centers were developed near existing points of interest. A route which attempted to connect the universities, transportation hubs, and public parks, would likely also connect many of these communities to additional shopping resources due to the existing development practices.

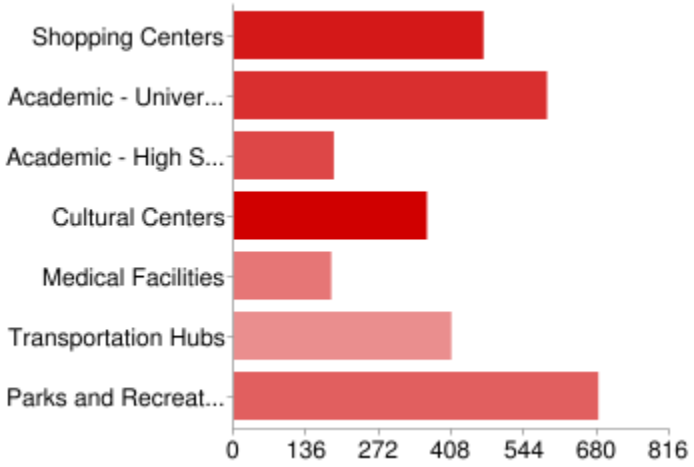


Figure 62: Points of Interest from survey conducted, Appendix 7.2 Survey Results

In order to develop the ideal route for a bicycle path network in the City of Worcester, the route must take into account the desires of the cities' residents, and the safety and practicality of the path. The City of Worcester has previously developed a plan for a bicycle path system which accounted for many of these desires, and with some minor expansion and updating; these plans can be used as a basis of a successful system for the city.

3.3.1 Potential Paths

In order to provide the greatest service to the City of Worcester, the project will propose a number of potential paths for bicycle routes. These paths will vary in terms will provide a number of options with regard to cost and difficulty of implementation while addressing the needs of the city's residents. The benefits of each of these paths will be discussed below.

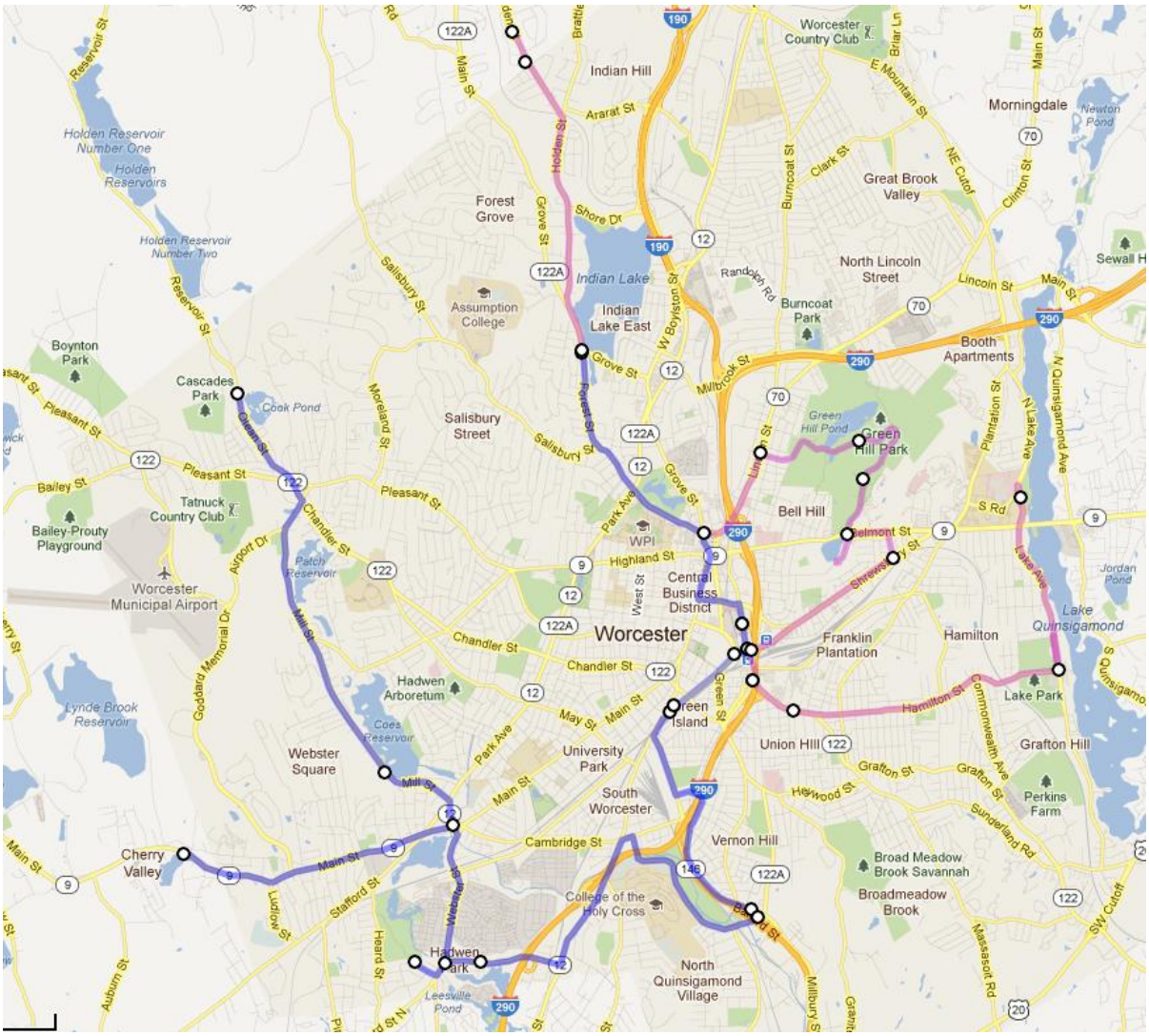


Figure 63: 1998 Worcester Bikeway System, constructed (blue) and planned (purple)

In 1998 the City of Worcester published a brochure showing it's recently developed bicycle routes alongside the plans for additions to the system, these have been redrawn for clarity, and are displayed in Figure 63. Due to changes within the city, the second phase of the route was never completed. The route for the 1998 path focused heavily on connecting existing parks in the City with the City Center. In doing so, the bikeway also connected to Union Station and some of Worcester's Colleges. Phase 2 of this system that was not constructed, would have connected all of these points to Lake Quinsigamond. In order to maximize the effectives of a new citywide bikeway network, as shown in the following section, it should build upon the existing routes, building some of the routes that had been planned in 1998, and adding additional routes to increase the number of desirable destinations.

City-Wide Bikeway Network

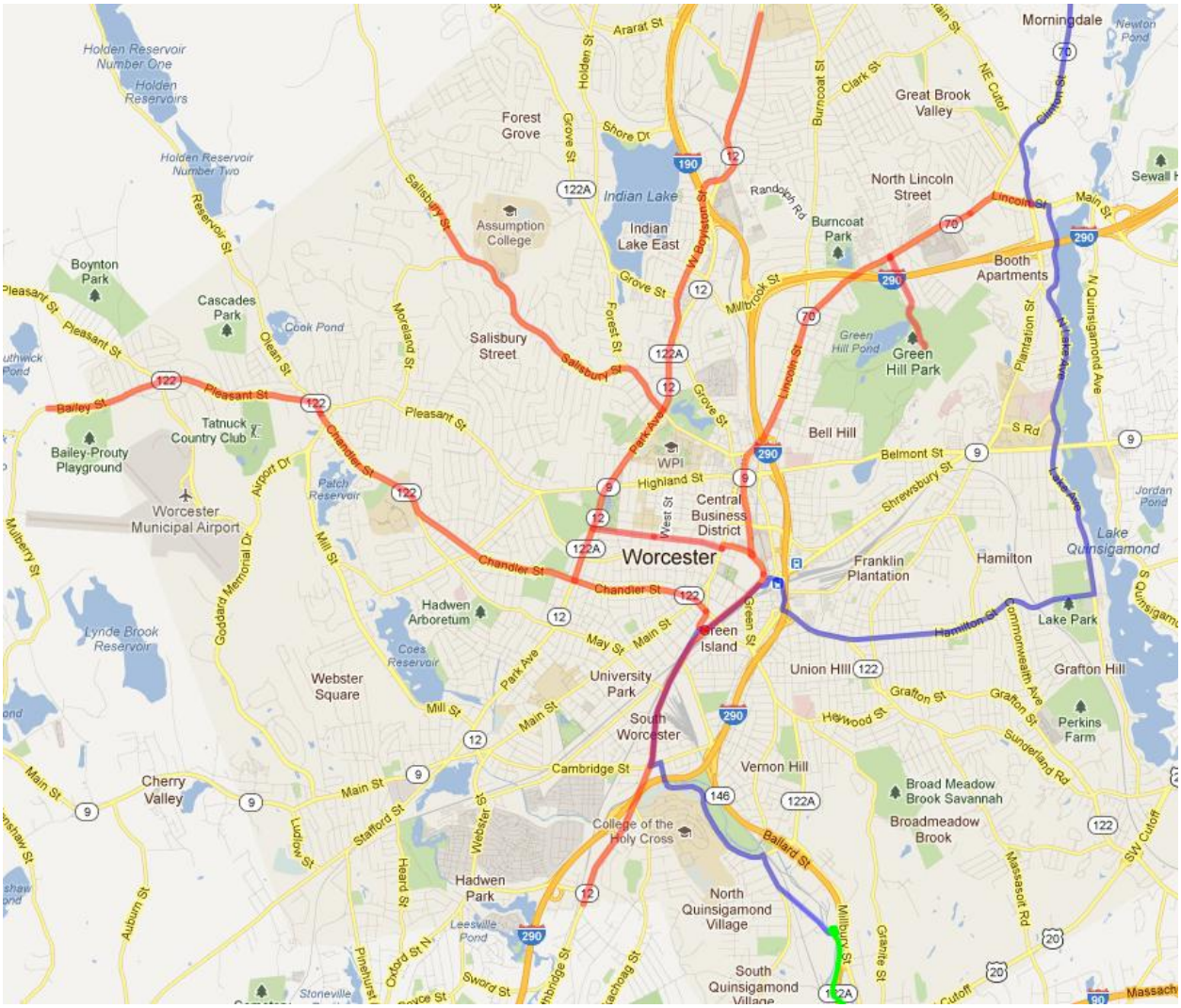


Figure 64: Ideal Path (in red) with East Coast Greenway (in blue)

The route shown above in Figure 64 represents the ideal bikeway network for the City of Worcester. This route connects all of the major universities, and a number of public parks with the city center, Worcester Union Station, and nearby shopping centers. In addition, this network connects with the currently planned route for the East Coast Greenway, running down west side of Lake Quinsigamond. The route would consist of roughly 20 miles of bikeway of various types. This is a considerably small amount of bikeway given Worcester's size, and the number of points of interest that it connects. Some examples of these streets are shown below in Figure 65 through Figure 70.

Figure 65: Southbridge St. near Cambridge St. (Google Inc)

Figure 66: Chandler St. from Park Ave, towards Southbridge St. (Google Inc)

Figure 67: Elm St. from Sever St. towards Park Ave (Google Inc)

Figure 68: Chandler St. at May St. near Worcester State University (Google Inc)

Figure 69: Salisbury St. near Assumption College (Google Inc)

Figure 70: Lincoln St. and Bates Ave. near Green Hill Park and Lincoln Plaza (Google Inc)

Cost Estimate

As follows are several ideas that the WorcBike project group has concluded that there are several phases for the bikeway system to be installed and be thrive successfully. Based on our observations we recommend additions of striping or signing for Phase I. In phase 2 completing another feasibility study and widening specific roads to accommodate bikeways/shared roads or even bike lanes. Phase 3 would be the completion of those as well as additional bikeways to be added onto the existing ones. Phase 4 would be maintenance and expansion.

Phase 1 has been estimated pending that all the roads can be implemented into the final layout. The following chart explains the cost per mile of each section of the bikeway system. Based on the VHB feasibility study in 1996, current opinions of Nicole Freedman and the US inflation rate we were able to estimate the price of this ideal path to be $250,000. The average cost of painting and signage per foot is $2.44. This ultimately very low cost can be incorporated in all the areas proposed for bikeway. For the roads such as Elm street that are significantly narrower in lane size the advised action would be to just hang signage and later widen the roads, however, this would come in phase 2.

Table 5: Route Cost for Signage and Painted Lines

Segment	Width	Edge-Edge	Lane Width	Seg. Length (mi)	Unit Cost ($/ft.)	Cost ($/segment)
Southbridge St	44'	2 lanes	22'	2.2	$2.44	28,343.04
Park Ave to Worcester Airport	45'	4 lanes	9'	4.9	$2.44	63,127.68
South St to Union Station	60'	4 lanes	12'	0.5	$2.44	6,441.60
Quinsigamond to Chandler St (Park Ave)	38'	2 lanes	18'	4.1	$2.44	52,821.12
Salisbury St to Park Ave	40'	2 lanes	15'	2.2	$2.44	28,343.04
Main to Public Park on Elm St	33'	2 lanes	12.5'	0.9	$2.44	11,594.88
Lincoln St	50'	4 lanes	10'	3.2	$2.44	41,226.24
Foster St to Elm St	33'	2 lanes	15'	0.3	$2.44	3,864.96
Lincoln St	50'	4 lanes	10'	1.1	$2.44	14,171.52
Totals				19.4		249,934.08

The expansion of phase 1 would greatly help improve the current state of the bikeways. As it currently stands there are some improvements being made throughout the city, seen in the new sensors for traffic signals and the signs being hung near Union Station(Moylan, Robert Moylan Interview, 2012). This proposal hopefully can make some recommendations that are reasonable to start in the next fiscal year and begin to be implemented following that.

Ultimately this path would connect the multitude of communities of Worcester including elementary schools, colleges, local businesses and so much more. The cost of striping almost 20 miles of bikeway is very small in comparison to the amount of people who could benefit from this. The project it is a very reasonable project to undertake and expand upon in the upcoming years.

Budget Path

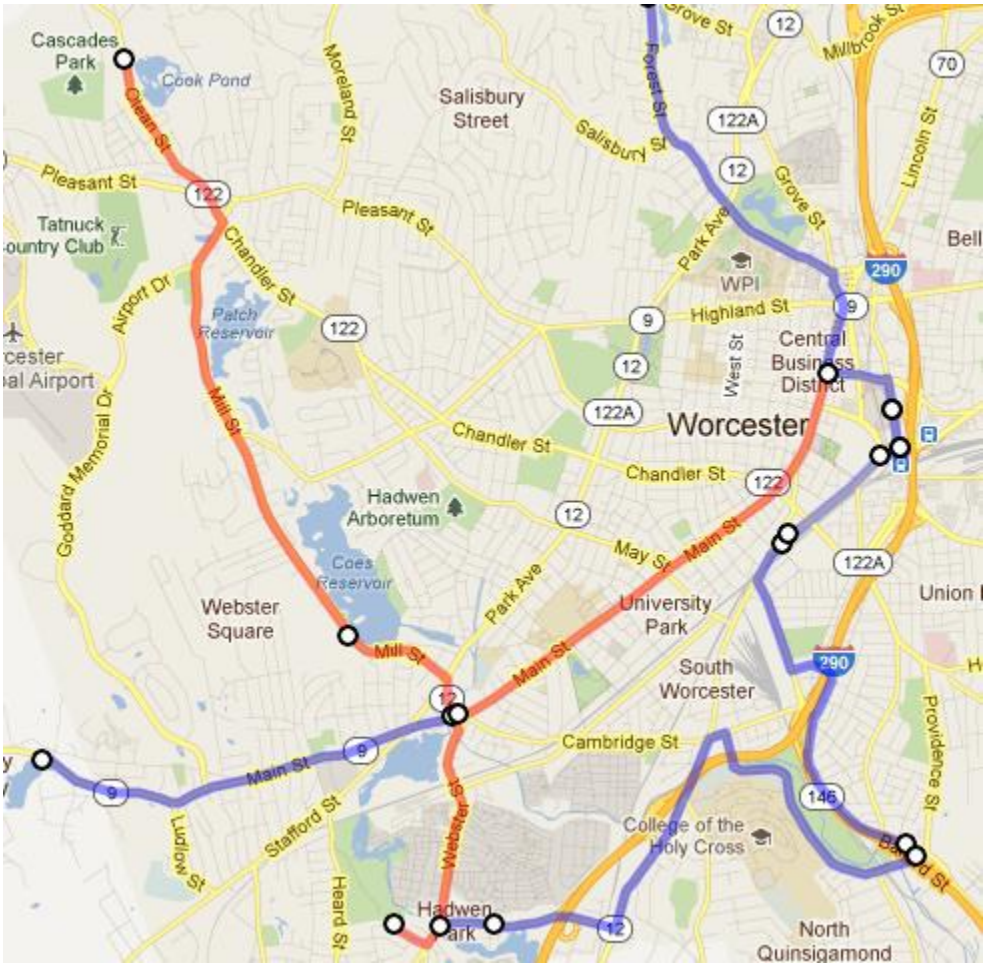


Figure 71: Budget Revitalization of Worcester Bikeways (Improvements and Additions shown in Red)

In order to test the waters and determine if improvements to the bicycle routes in Worcester would be utilized, the city could implement a few short sections of path which would utilize existing paths and make minimal changes to the roads. Such a project might include the revitalization of the Mill St. path, and a connection from Mill St. to Main St. and the City center. This path is shown, above in Figure 71, along with the 1998 path. If such a path were constructed, along with increased enforcement of regulations keeping the paths clear for bicycle travel, the city can begin improving infrastructure with minimal expenditure. As with all bicycle paths, enforcement of the laws regarding their use, keeping them clear of parks cars, trash, etc. would be essential to ensuring that the bikeway is used.

This budget option selects Mill St. for its previous consideration as part of the original Worcester bikeway system. Mill St. is particularly suited for a first phase test, as it has very wide lanes, sections of the road have travel directions split, and many sections have room for expanding the road. Main St was selected as it will have the most significant impact for city residents, providing greater access to many city resources, and bringing the bikeway system into the public view. In addition, the majority of Main St. is wide enough to place a bikeway without road expansion, though potentially with the sacrifice of some parking. The cost for constructing these additions using signage and painted lines is included below in Table 6: Budget Path Construct Cost for Signs and Painted Lines.

Table 6: Budget Path Construct Cost for Signs and Painted Lines

Segment	Width Edge-Edge	Lane Width	Segment Length (mi)	Unit Cost ($/ft.)	Cost ($/segment)
Mill St	88' 4 lanes	22'	4.8	$2.44	61,839.36
Main St.	44' 2 lanes	22'	2.3	$2.44	29,631.36
Totals			7.1		91,470.72

3.4 Funding

To lighten the financial load on the city of Worcester required for the implementation of a bikeway, there are a few available options. In the previous bikeway created for the city of Worcester, financial funding was used by the Intermodal Surface Transportation Efficiency Act. For a new bikeway funding can be found through similar means by using the successor to ISTEA like SAFETEA-LU. SAFETEA-LU was originally supposed to expire earlier, but was extended for short periods of times from between 2009 and 2011 (Questex Media Group, 2011). Now President Obama is calling for another extension to the surface transportation law. This call for an extension is consistent with the trend of the law being extended every time it expires. This extension is beneficial for the City of Worcester, as it may extend funding availability for long enough to permit the city to make decisions regarding the construction of a bikeway, and still consider the funding option provided by SAFETEA-LU(Disney, 2011). From section 1404 (h) of SAFETEA-LU a national SRTS Task Force was created. This task force was developed to create projects for developing a safe route to school. (Task Force | National Center for Safe Routes to School, 2011)Should the Worcester bikeway go past some of the major schools and Universities, creating a way for students to get to school without cars this would qualify the project for additional funding.

In addition to SAFETEA-LI, the Federal Transportations Enhancement (TE) Activities are another potential source of funding for a bikeway. The proposed bikeway for Worcester would qualify for funding options if it were to create bicycle facilities like rental stations or bike storage areas. Funding could also be obtained from TE if the proposed bikeway were to offer bike safety and education activities. This could be implemented in the form of a weekly class offering help on how to ride a bike on the road safely and to be weary of cars. Should Worcester decide to use abandoned rail trails for the bikeway, this would also allow for more funding from TE(Douwes, 2011).

There are many options for funding a bikeway here in the Worcester area. The largest of these programs is SAFETEA-LU, a successor program to ICETEA. SAFETEA-LU includes many initiatives such as a the Safe Routes to School Task Force which will help fund routes to get to school in a safe way with non-motorized vehicles. Transportation Enhancement Activities is another source of Federal funding for bicycle facilities, safety and educational activities, and conversion of abandoned railways. These are the most prominent funding options to help obtain capital for the project, but there are also other ways of obtaining it such as fundraising along with public awareness.

3.4.1 Cost Benefit Analysis

As described in Section 2.2 Bicycle Path Styles, there are many benefits to each type and shared cons based purely on situations. In this next section the types of bikeways specified by AASHTO standards will be clarified with specifications for each type. As stated in section 4.1 of AASHTO(AASHTO, 2010), “Local conditions may vary and engineering judgment should be applied.” Our proposal for Worcester will be based on local aspects and using expert opinions and standards, we should be able to make an educated suggestion of what will be the most successful bikeway for the city. This section should preface this goal and explain in detail what they could entail for potential design and construction.

AASHTO being the American Association of State Highway and Transportation Officials has submitted a draft to the head committee as of February 2010. This document’s suggestions and detailed reasoning for particular bike lanes will be what generalized types we explain. Having determined Worcester as an urban city with lots of potential for on-road routes chapter 4 of the guidebook highly recommends shared lanes for the city(AASHTO, 2010). The chapter is further broken into how they function on one-way or two-way streets as separate lanes or as integrated paths. Also acknowledged in importance is signage and the use of on-road paint and posted signs directing traffic and warning all motorists.

Throughout this project a clear group of advocates have arisen, many of whom are experts in their field of bicycles, and have imparted much of their wisdom. One such person has been Nicole Freedman, Director of Bicycle Programs for the city of Boston. Expanding upon the definitions of bikeways she helped define what each one should look like and approximately cost. As guesstimated a bicycle path that is complete separate from traffic and is only for cyclists should approximately cost $2,000,000 per mile. This, however, is a rather impractical ideal for the streets of Worcester. Not only does it cost an exceeding amount but the physical space is not available to render a bikeway on at the moment. Seen in how many of the proposed paths and studies completed for Worcester have fallen by the wayside and not pushed through the city. The time needed to complete such a project in Massachusetts, even with active advocates, would take close to 10+ years.

The next option that has become quite popular to study is an on-road cycle track. Something originally made popular in Europe is an on-road path that is between the pedestrian side walk and row of parked cars. A cycle track has been implemented in Chicago. Approximately 5 ft. wide as to avoid bicycle-car door collisions has been moderately successful. As shown in Figure 72, the cycle track has lots of signage on-road and posted. This type of project should cost a city about $120,000 per mile. One of the major costs of such a project is the thermoplastic used to designate the lines on the road. If a city has means to lay down the thermoplastic without having to hire a contractor the project cost greatly shrinks. The timing of the project is also quite shorter than a bikeway, it would take approximately 2 years to complete.

Figure 72 – Cycle Track (Burton) typical cycle track implementations consist of painted lines, designated areas for pedestrians, cyclists and parked motorists.

A less protected route for cyclists are standard bike lanes which are separate from the actual flow of traffic but are designated lanes typically using painted lines as a way to separate traffic from the lane. This route usually is in between traffic flow and on street parking. A bike lane is relatively cheap only $25,000-$50,000 per mile and again is approximately 5 feet wide to maximize cyclist abilities to avoid obstacles on the road. Known for the ease in implementation a similar path to this could be reasonably installed in less than 1 year. This may one of the best options for Worcester to get a start on installing a network of bikeways for the benefit of the commuters in this city.

One of the final options a city has to help motorists and cyclist commute harmoniously are shared roads that have posted signs and on road painted chevrons. All classified by the MUTCD, Manual on Traffic Control Devices and the NACTO guide, National Association of City Transportation Officials. The amount of signage needed is specified and which signs should be used per situation, such as share the road on road signs.

The best overall on-road option for Worcester city commuters for immediate results are standard bike lanes, shared routes and possibly cycle tracks to be implemented later. Eventually this would lead to a series of routes and paths that will connect the city's intermodal system, colleges, parks and interest points.

4 Worcester's Next Step

There are many techniques, which have been effectively used to implement bikeways in other cities that the City of Worcester can employ to ensure that its bikeway will be effective. This section will outline these techniques as they've been described previously in this document.

4.1.1 The installment of a (Bike) Czar

As shown in both Boston and New York, there is a significant benefit to having a central figure responsible for the development of a bikeway system. This person, or department, can act as the face of the bikeway movement, while contracting the engineering and construction to appropriate firms such as Vanasse Hangen Brustlin (VHB) who have been involved in a significant amount of bikeway construction, both within the City of Worcester, and elsewhere. These contractors can make use of previous experiences to ensure that the system created for Worcester meets the unique demands of the city, while providing a safe and enjoyable way to travel by bicycle.

In addition to developing plans for bikeway expansion within the city, the figurehead for the bikeway system should also ensure that a complete analysis and inventory of the existing bicycle infrastructure is conducted. The city has already laid out a substantial number of marked bike routes, however many of these routes are not maintained, and the restrictions which make them safe for cyclists are not enforced. By conducting an inspection of these paths, and beginning to enforce the existing restrictions which they introduced, the city will demonstrate its intentions to the public regarding the expansion of the bicycle routes, and increase the visibility of the project. All of these actions should be publicly recognized and advertised, as getting the population interested in the project will ensure that it is used when it is implemented.

4.1.2 Matching Guidelines

Following in line with the newer state and federal government requirements are Worcester's plans for the future streets. For the most part the city plans to match these guidelines for the inclusion of bikeways for all roadways (Moylan, DPW, 2012). This includes plans to apply for funding for all main roads of Worcester so that bikeways can be slowly implemented throughout the city. Also in the plans for Worcester is to apply to have particular sections of streets like Salisbury Street to be excluded from having a bikeway installed. This comes from the amount of effort needed to install a bike lane, including the expansion of the paved road, sidewalks and parking areas. In these circumstances the possibility for the bare minimum such as signage for sharing the road can be added. By making these steps forward the city would be making leaps and bounds into the implementation of a major network of bikeways by the standards set by the government.

4.1.3 Test Deployment

After the political infrastructure is stabilized, the next step in establishing a bikeway network would be to make a small expansion to the system. There are a number of small additions that can be made to the existing infrastructure which would greatly increase the number of cyclists within the city. The Budget Path from Section 3.3.1 Potential Paths gives an example of a small change which might serve as a test route for the system. This path focuses on rebuilding existing infrastructure, as well as providing a

connection to the center of Worcester, City Hall, and the Worcester Commons. This design would bring the bikeway network into public view, serving as an excellent public relations opportunity for the city. This path is mapped in Figure 71: Budget Revitalization of Worcester Bikeways (Improvements and Additions shown in Red), and included again for reference in Figure 73 below, along with Figure 74 and Figure 75, views from along the path.

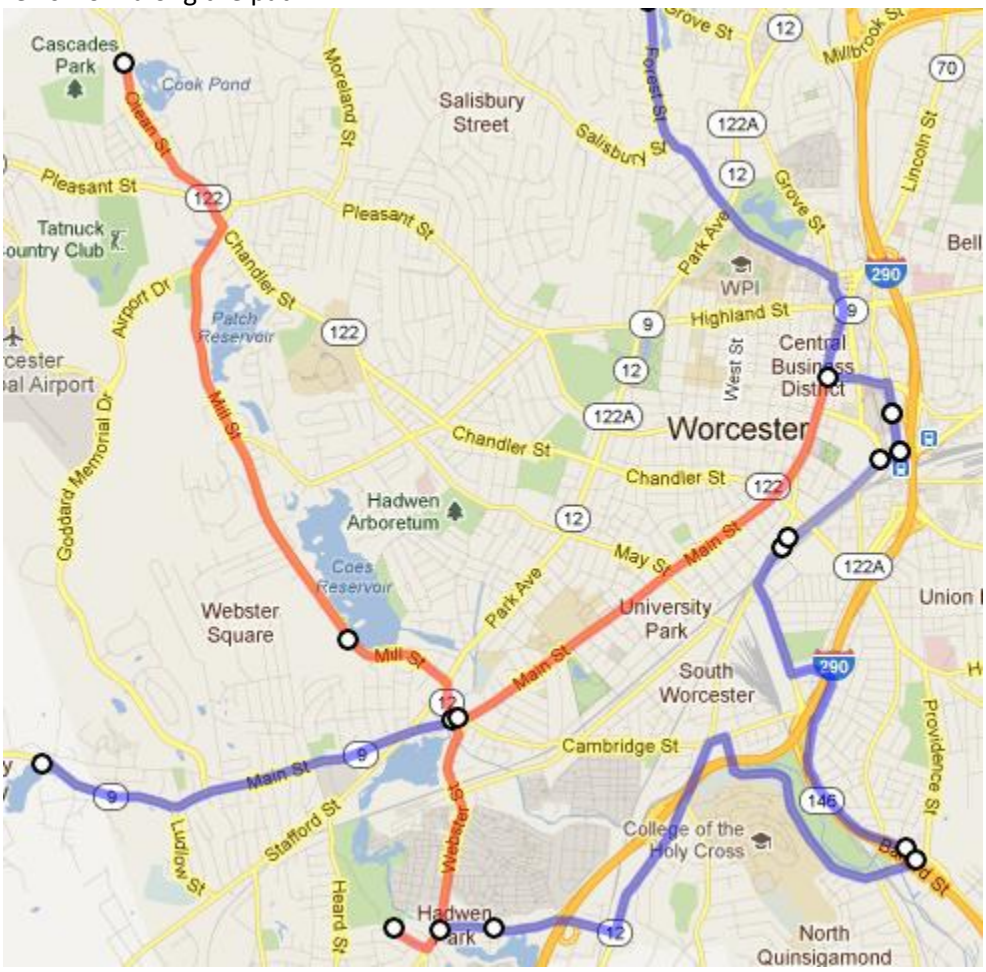


Figure 73: Copy of Budget Revitalization of Worcester Bikeways (Improvements and Additions shown in Red)

Figure 74: Mill Rd. from Main St.(Google Inc)

Figure 75: Main St. and Maywood St. near Clark University (Google Inc)

Another possible route would be down the length of West St, as shown in Figure 77, or any other high traffic street within the city, in order to see the impact on the bicycle-automobile relationship, as well as the overall impact on residents. The cost for developing a short bikeway with painted lines and signage is shown for West St. is shown below in

Table 7: Cost for Painted Lines and Signage on West St. West St. would serve as a good location for a very small test deployment, as the street is wide enough for two lanes of travel and a bike lane, with only a minimal impact to available parking spaces, as shown below in Figure 76. This path would connect Pleasant St. to Highland St., as well as WPI and Becker, allowing easy travel for residents to the Universities, and with a short trip down Pleasant St, City Hall and the Worcester Common.

Figure 76: West St. and Dayton St.

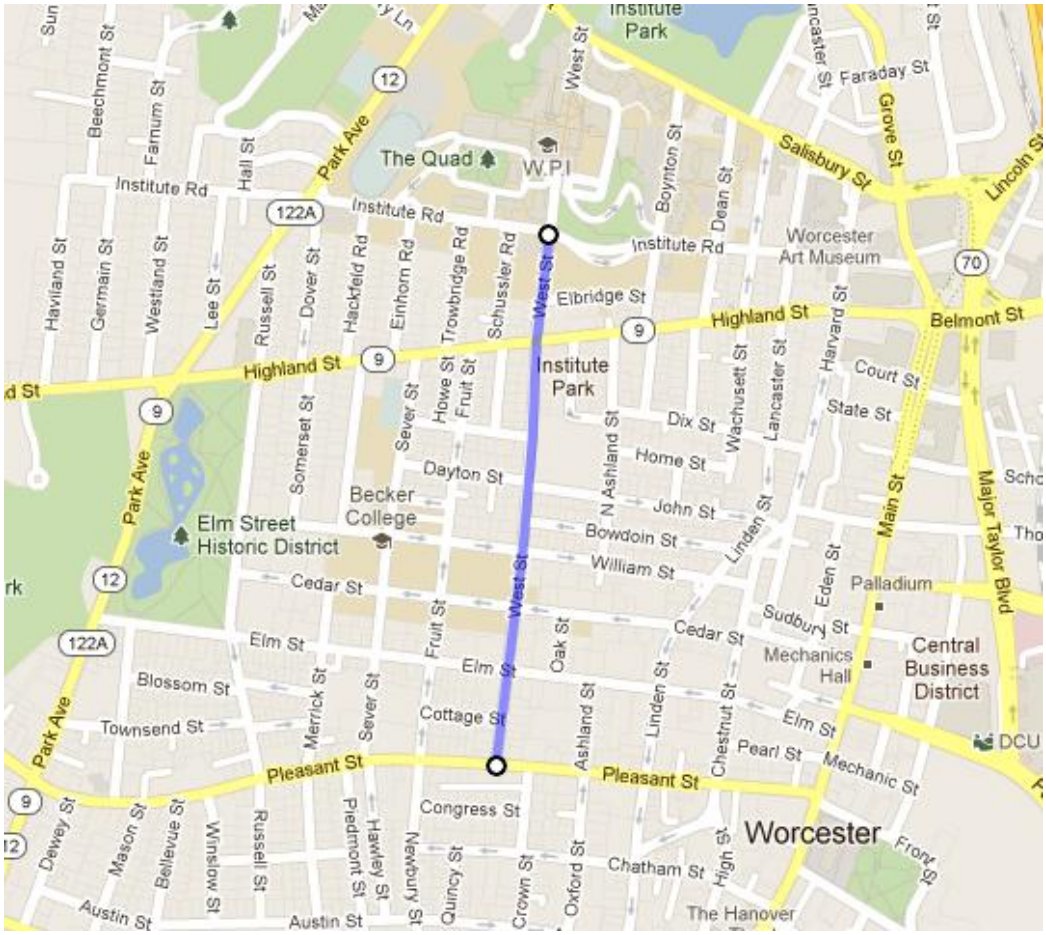


Figure 77: West St. Test Deployment

Table 7: Cost for Painted Lines and Signage on West St.

Segment	Width Edge-Edge	Lane Width	Segment Length (mi)	Unit Cost ($/ft.)	Cost ($/segment)
West St.	30' 2 lanes	15'	0.6	$2.44	$ 7,729.92
Totals			0.6		$ 7,729.92

Such a test deployment should make use of equipment to measure the changes in bicycle and pedestrian traffic, and potentially surveys of nearby residents to determine if it impacts their daily lives.

4.1.4 Large Scale Deployment

A test deployment will provide the city with some insight as to some of the particular challenges that it will face expanding to a city wide bikeway network. Once the test deployment is successful, the city should move on to a larger plan, slowly adding sections of bikeway to the existing network whenever possible, with the ultimate goal of creating a citywide transportation network, such as the Ideal Path from this document, as shown in Figure 64.

During the creation of a large scale system, it is important for the city to strictly enforce the new laws which accompany the bicycle lanes. The transition will bring laws into effect which may be unfamiliar to many residents, and the enforcement of these laws will be crucial to the success of the bikeway system, as they exist to protect the cyclists (Freedman, 2011).

4.1.5 Bike Day

A bike day will greatly benefit Worcester by creating a biker awareness day. On a day like this Worcester could close one of the mains streets and create a pedestrian or bikeway throughout the city, preferably in a circle. This would give residents a taste of what a bikeway could bring to Worcester. Various bike clubs could hold concession stands promoting biking and trying to get people to join. The other shops on the closed off streets could have booths outside and some live entertainment could also be brought in to attract more people to come. The bike day would be a great time to get residents to sign a petition to show the City that there is a need for a bikeway. The city officials could be invited too to show them all the people who would support a bikeway. They could also hold a speech talking about what they plan to do in the future for the implementation of bikeways.

4.1.6 Website

Worcester would benefit greatly from creating a website dedicated to showing the public what plans are in store for the implementation of bikeways throughout the City. Through the implementation of a Facebook, twitter, or regular website where the common citizen can go to see the current projects, the city would allow for more public feedback. The website could post propositions to new projects and ask for feedback to current ones allowing the City to please the maximum number of residents. From the many meetings and interviews with city officials, the one thing which seemed to be common to all, was the fact that there is a severe lack of public awareness. Not everyone has the time to go to every city meeting to keep up to date with what Worcester is currently working on. If Worcester would create a website with the current projects, the public would be much more aware of the projects and be more prone to giving feedback.

5 Conclusions

The City of Worcester is currently undertaking many revitalization projects in the hopes of attracting new residents and businesses. This study aimed to show not only Worcester's need for a bikeway system, but how such a system might be implemented to best suit the needs of the city. By outlining the first steps for the development of such a system, and showing the demand for these systems around the country and the world, this document provides a boost for the City of Worcester to begin the transformation into a bicycle friendly city.

The research presented in this document has shown that a bikeway system for the City of Worcester can be developed with minimal cost, while providing extraordinary transportation benefits to large portions of the city's population. By building off existing bicycle infrastructure through improving and expanding existing bicycle routes within the city, interest in a more comprehensive system can be gauged, allowing the city to test the waters with minimal initial expenditure.

A comprehensive bikeway system has been shown to provide numerous benefits to individual residents and cities as a whole. Bikeways allow for healthier, more affordable transportation for individuals, allowing increased access to city resources and attractions. This increased quality of life attracts more residents, tourists, and businesses to the city, allowing for greater tax revenue, and even further improvement of public infrastructure. In addition, the large scale shift away from private automobile transportation reduces air and noise pollution, and makes the city a safer and more enjoyable location for pedestrians.

The findings presented in this document, from the cost estimate, multiple route plans and feasibility study have presented conclusively that this interdisciplinary qualifying project could become a reality in a very short time. The approach proposed in this document is developed around the City of Worcester, and has the ability to present noticeable changes within the city with rapid implementation. The plan allows for small initial changes, gradually increasing the complexity and coverage of a bikeway network, but even the small initial improvements will bring Worcester into the fold of major cities worldwide looking towards the bicycle as the future of transportation.

This particular project will work within the city of Worcester because it has the ability to be implemented slowly and with the city as it further improves upon itself. As the communities improve so will the sense of public awareness, which only a bikeway can help build. These communities that work so well independently would have the ability to be connected and yet retain their uniqueness. The original path that linked major points of Worcester back in the late 1990's was just a start to connect areas of the city. This path majorly needs the proverbially "dusting off", but once it has been recreated and added to the possibilities for the "Worm Town" are endless.

6 Future Work

6.1 Interaction with Department of Public Works

New York and Boston show that having officials in leadership positions in the transportation department who has a desire to increase bicycle ridership in the city help make these bikeways a reality. We recommend that regular contact with a person in the government, in the planning department, or otherwise are initiated. A discussion of what would be practical to accomplish will be the best way to achieve the overall goal of increasing ridership in Worcester.
After the interview with Robert Moylan, an MQP Civil Engineering team working with the planning office or the DPW office to assist with bikeway projects would be recommended. Robert Moylan and his office work directly with planning firms, such as VHB, and constructions companies to get a fuller understanding of the process of working with government entities.

6.2 Colleges of the Worcester Consortium

Contact with the administration from several universities was made including Clark University, Assumption College, and Worcester State University. The colleges make up about 16% of the Worcester population and represent a sizable cyclist population according to the survey conducted. In response to these initial connections, the universities that responded seemed eager to assist with the development of the bikeway. It is recommended that future projects working on the bikeway contact these universities for their assistance.

6.3 Petition City Council

Robert Moylan suggested that one of the best ways to directly contact the Worcester Government about the bikeway is to petition the city council to analyze the plan that has been put forth and determined its feasibility. In order to ensure the availability of state and federal funding it is important to have the city behind the development plans for a bikeway.

Another alliance that could be forged is with some of the businesses and corporations in the city. The Hanover Insurance Group and UNUM have invested in the city square project and are planning to have their business there. They might be convinced to install bike racks and support bike facilities throughout the city to provide an alternative means of transportation for their employees.
A petition process is a lengthy process and would likely take a month to half a year to complete. The information concerning a petition can be found on the Worcester Government's website: http://www.worcesterma.gov/city-clerk/filing-a-petition.

6.4 System Documentation

There are already some facilities in place for cyclists, mainly in the form of signs. There are various locales around the city that have “Bike Lane” or “Bikeway” signs and many traffic lights that will respond to a cyclist presence. This project recommends a comprehensive study of the preexisting facilities in place. This should include the markings of the locations of signs, bike friendly traffic lights, bike racks, and bike shops, so as to ascertain the full extent of existing infrastructure.

There are currently projects underway, in parallel to this report, which have been funded, planned and executed. One such project is the streetscape improvements of the canal district. This includes Bike lanes on Green Street, Millbury Street, and Water Street. Another project is the update of the Kenneth F. Burns Bridge, which will include bike lanes across the bridge. Cities like Boston and Providence have articulated their existing and planned goals in websites dedicated to this. Worcester could benefit by having a publicized plan that they would be responsible to keep to.

6.5 Future Research

There are several websites that are dedicated to collecting project information in Massachusetts. The Massachusetts Highway Department lists every project that the mass highway department is involved in. http://www.mhd.state.ma.us/ProjectInfo. Another good resource within the local government can be found on their website, http://www4.ci.worcester.ma.us/weblink7/search.aspx. This project recommends looking at these resources to establish what the city has planned for the future.

6.6 CitySquare Project

The City of Worcester is undertaking a huge project to revitalize the downtown area calling it the CitySquare project. The addition of bicycle facilities including bike racks and safe bicycle paths throughout the development would be an important step for increasing ridership in the city. This project recommends the inclusion of bicycle facilities be researched and evaluated for this new property.

6.7 Public Awareness

There are a several newspapers and magazines that circulate around Worcester, the most prevalent being the Worcester Telegram and Worcester Mag. In addition to convincing the Worcester government to construct bikeways, the general public must also be convinced to switch to bicycles in order for any development to be worthwhile. Brittany Durgin is a writer for Worcester Mag and has already written several stories about biking in the city and would be well worth contacting.

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7 Appendices

7.1 Images

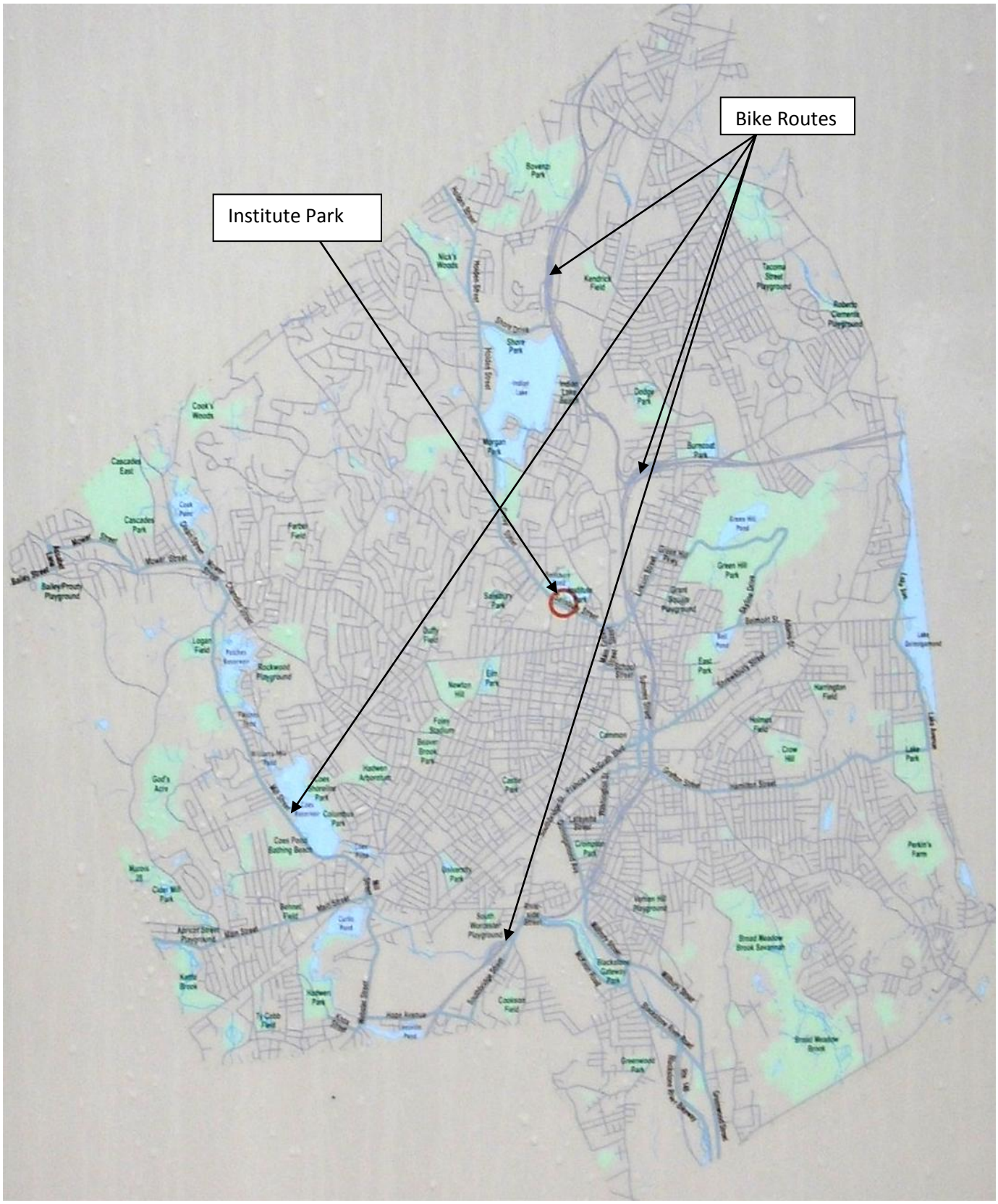


Figure 78: Kiosk At Institute Park

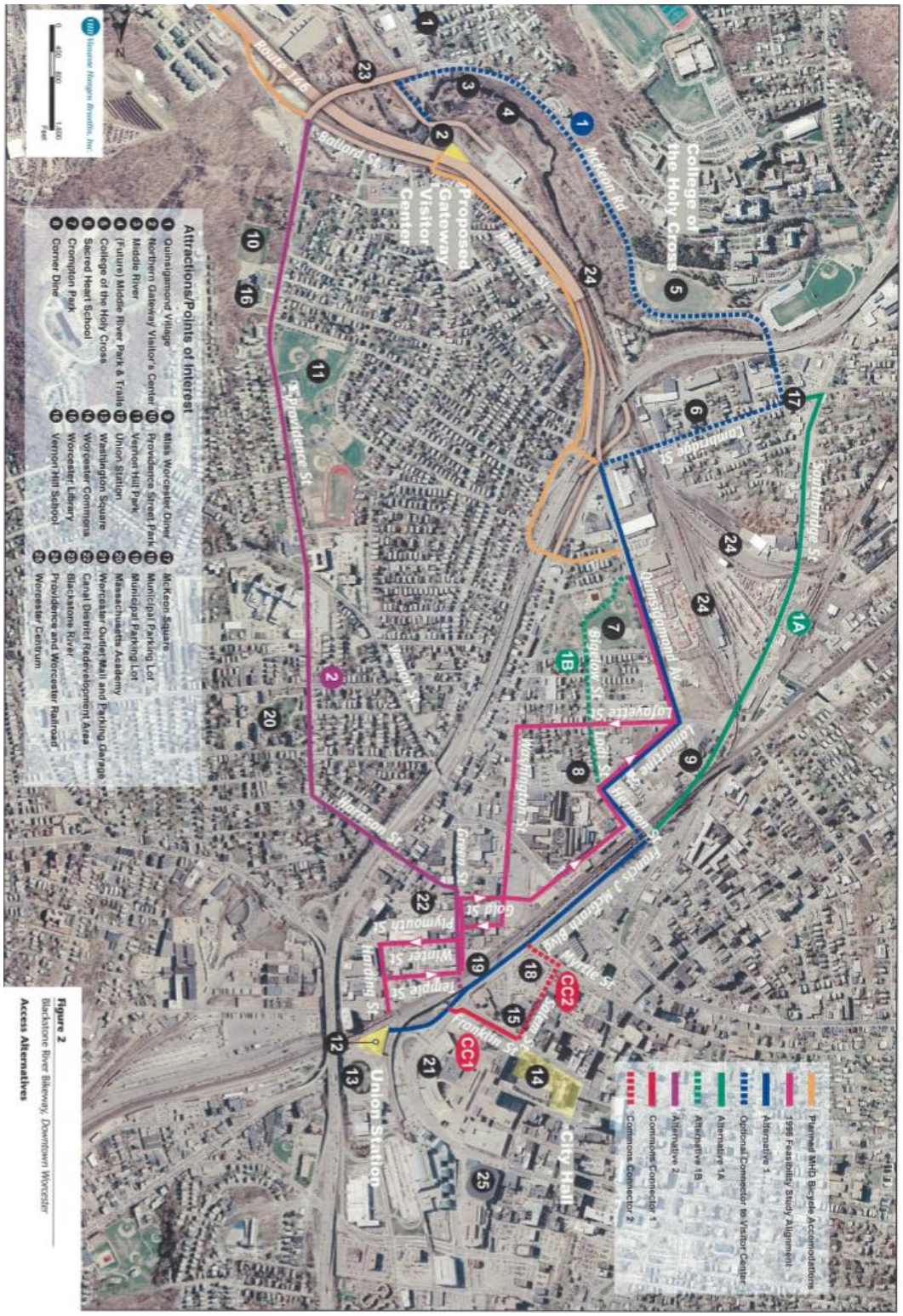


Figure 79: VHB 2003 Feasibility Study-Possible Routes

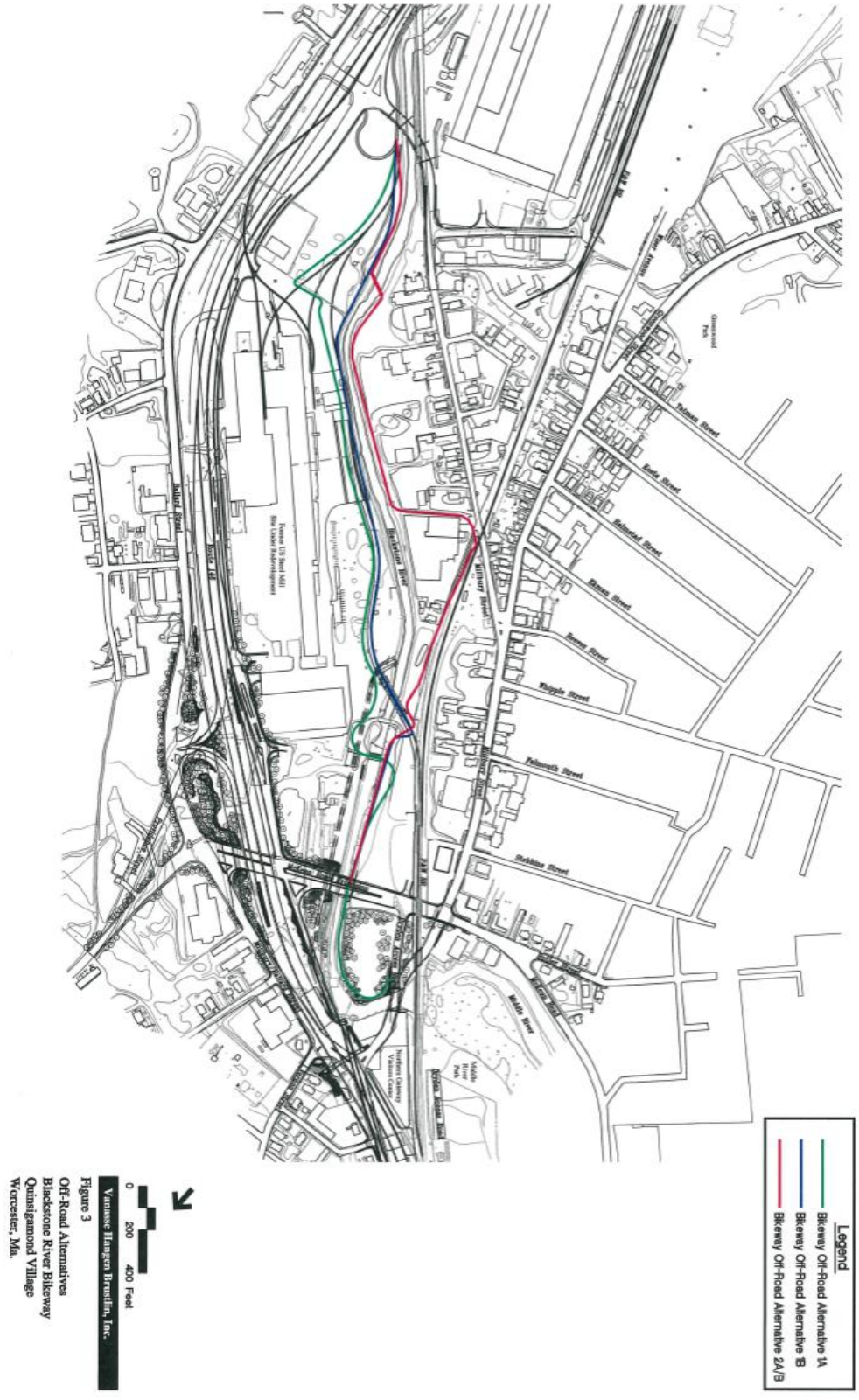
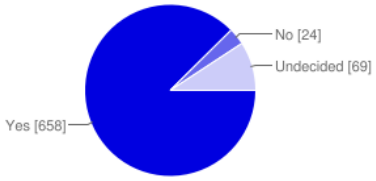


Figure 80: 2004 Feasibility Study of Blackstone River Bikeway Addition

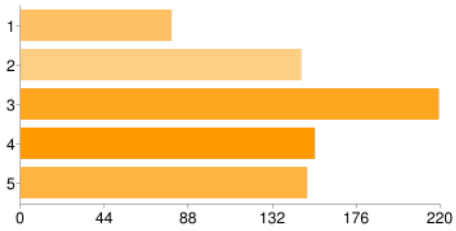
7.2 Survey Results

Do you think Worcester needs a bike path?



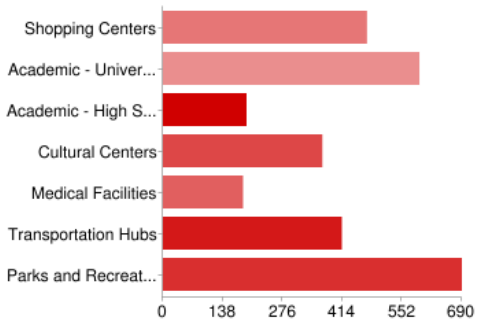
Yes	**658**	87%
No	**24**	3%
Undecided	**69**	9%

If Worcester had a bike path, to what extent would you use it? (1 = not at all 5 = all the time)



1	**79**	10%
2	**147**	19%
3	**219**	29%
4	**154**	20%
5	**150**	20%

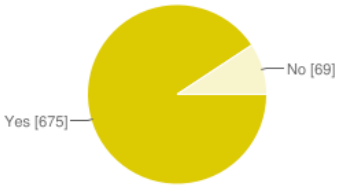
Which of these points of interest would you like to see along a bicycle route?



Shopping Centers	**471**	63%
Academic - Universities	**592**	79%
Academic - High Schools, Middle Schools, etc.	**193**	26%
Cultural Centers	**368**	49%
Medical Facilities	**185**	25%
Transportation Hubs	**413**	55%
Parks and Recreational Areas	**690**	92%

People may select more than one checkbox, so percentages may add up to more than 100%.

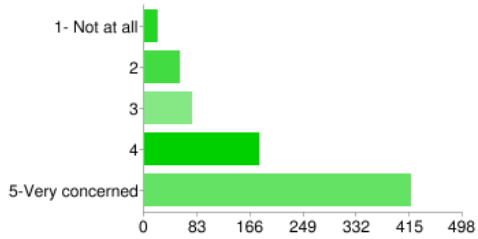
Would you be willing to sign a petition for Worcester to create a bike path connecting some of the above points of interest?



Yes	**675**	89%
No	**69**	9%

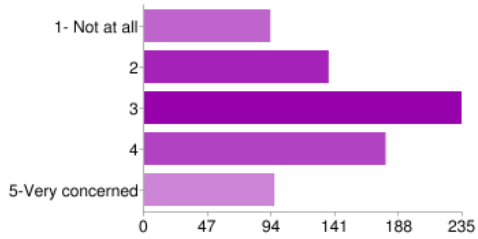
Figure 81: Survey Results - Petition

Please rate your concerns for traveling via bicycle - Automobile Traffic



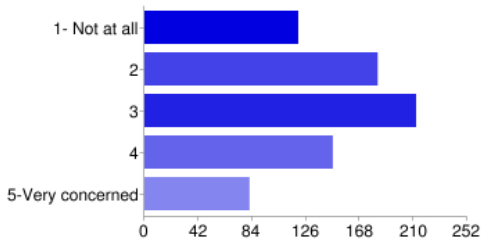
1- Not at all	**21**	3%
2	**56**	7%
3	**75**	10%
4	**180**	24%
5-Very concerned	**417**	55%

Please rate your concerns for traveling via bicycle - Destination



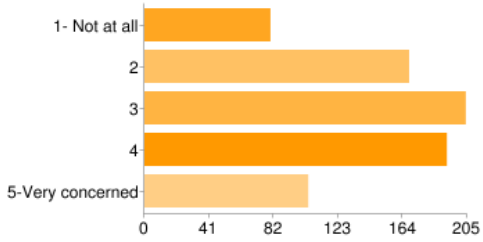
1- Not at all	**93**	12%
2	**136**	18%
3	**234**	31%
4	**178**	24%
5-Very concerned	**96**	13%

Please rate your concerns for traveling via bicycle - Terrain Challenges



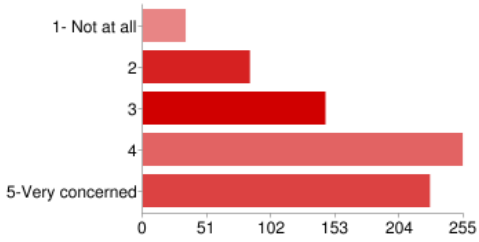
1- Not at all	**120**	16%
2	**182**	24%
3	**212**	28%
4	**147**	19%
5-Very concerned	**82**	11%

Please rate your concerns for traveling via bicycle - Weather



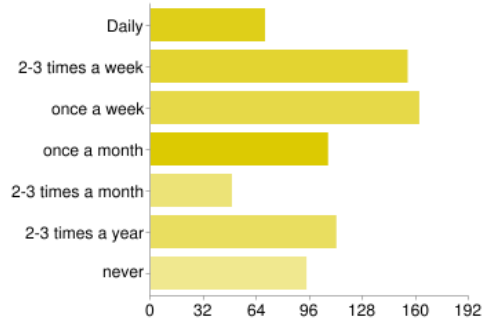
1- Not at all	**80**	11%
2	**168**	22%
3	**204**	27%
4	**192**	25%
5-Very concerned	**104**	14%

Please rate your concerns for traveling via bicycle - Street Conditions



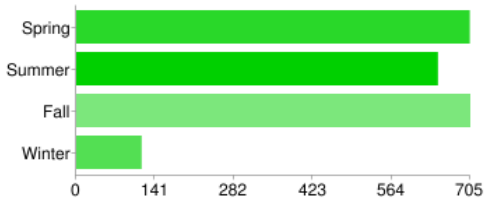
1- Not at all	**34**	5%
2	**85**	11%
3	**145**	19%
4	**254**	34%
5-Very concerned	**228**	30%

How often would you use the bike path if it were to connect all the Worcester consortium colleges?



Daily	**69**	9%
2-3 times a week	**155**	21%
once a week	**162**	21%
once a month	**107**	14%
2-3 times a month	**49**	6%
2-3 times a year	**112**	15%
never	**94**	12%

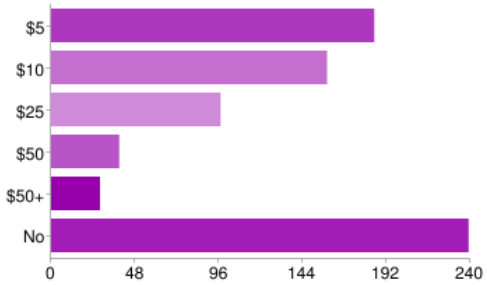
Which seasons would you consider using a bicycle path?



Spring	**704**	96%
Summer	**647**	88%
Fall	**705**	96%
Winter	**117**	16%

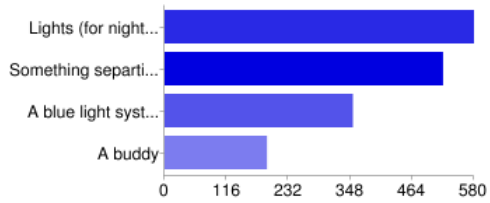
People may select more than one checkbox, so percentages may add up to more than 100%.

Would you be willing to make a donation to help fund a bicycle path for the city of Worcester? If so, how much?



$5	**185**	25%
$10	**158**	21%
$25	**97**	13%
$50	**39**	5%
$50+	**28**	4%
No	**239**	32%

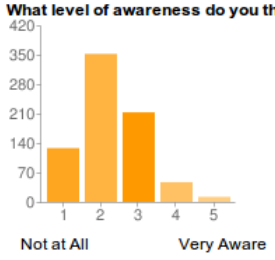
What kind of bicycle safety devices do you feel are needed when using a bike path?



Lights (for night riding)	**580**	79%
Something separting you from the cars	**522**	72%
A blue light system (police call box)	**353**	48%
A buddy	**192**	26%

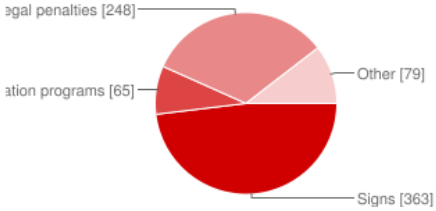
People may select more than one checkbox, so percentages may add up to more than 100%.

What level of awareness do you think cars have for bicyclists?



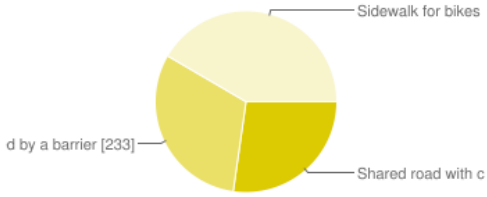
1 - Not at All	**128**	17%
2	**352**	47%
3	**213**	28%
4	**47**	6%
5 - Very Aware	**12**	2%

What is the best way to educate drivers in Worcester about increased bicycle traffic?



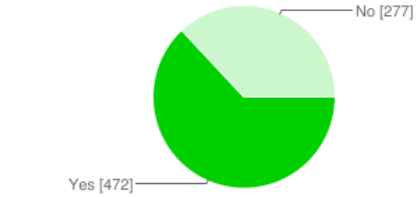
Signs	**363**	48%
Driving education programs	**65**	9%
Legal penalties	**248**	33%
Other	**79**	10%

How would you envision a good bike path?



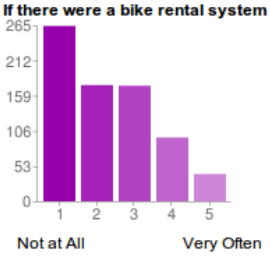
Shared road with cars separated by a painted line	**204**	27%
Shared road with cars separated by a barrier	**233**	31%
Sidewalk for bikes off the road	**311**	41%

Do you currently have a bike in Worcester or have access to one?



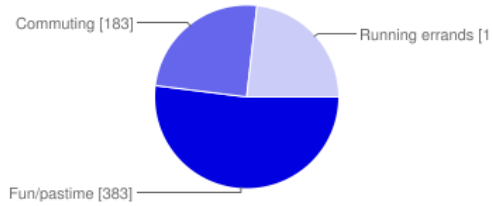
Yes	**472**	63%
No	**277**	37%

If there were a bike rental system for the Worcester bike path how often would you use it?



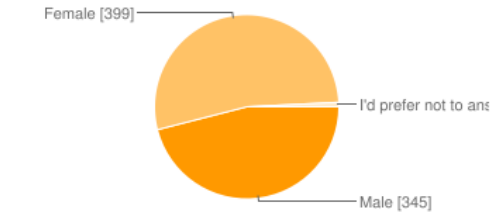
1 - Not at All	**264**	35%
2	**175**	23%
3	**174**	23%
4	**96**	13%
5 - Very Often	**41**	5%

Why would you use the bike path if it were created?



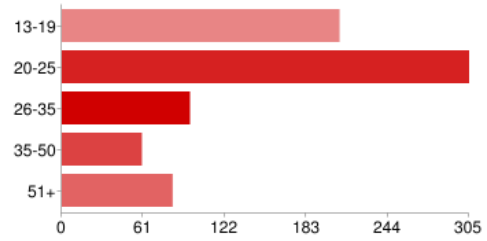
Fun/pastime	**383**	51%
Commuting	**183**	24%
Running errands	**171**	23%

Gender



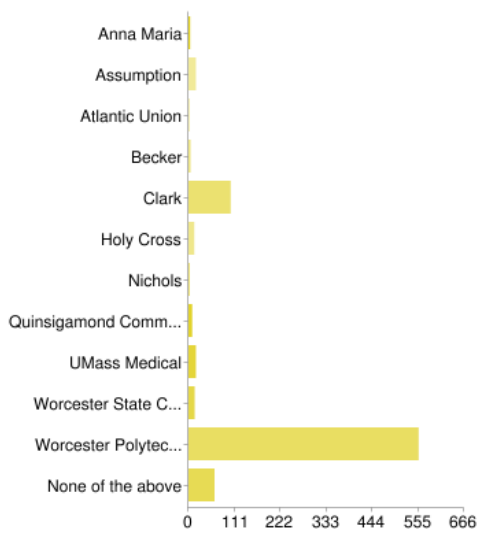
Male	**345**	46%
Female	**399**	53%
I'd prefer not to answer	**6**	1%

Age Range



13-19	**208**	28%
20-25	**305**	40%
26-35	**96**	13%
35-50	**60**	8%
51+	**83**	11%

Are you affiliated with any of these universities? (Please check all that apply)



Anna Maria	**4**	1%
Assumption	**18**	2%
Atlantic Union	**1**	0%
Becker	**5**	1%
Clark	**102**	14%
Holy Cross	**14**	2%
Nichols	**2**	0%
Quinsigamond Community College	**9**	1%
UMass Medical	**18**	2%
Worcester State College	**15**	2%
Worcester Polytechnic Institute	**556**	75%
None of the above	**63**	9%

People may select more than one checkbox, so percentages may add up to more than 100%.