Improving Traffic Safety During Arrival and Dismissal for Students at the Quinsigamond School

A Major Qualifying Project
Submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
In partial fulfillment of the degree requirements for the
degree of Bachelor of Science

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ABSTRACT

The purpose of this project was to improve traffic efficiency and safety for students, parents, and staff at the Quinsigamond School in Worcester, Massachusetts. Quantitative and qualitative data was compiled from research about school safety improvements, stakeholder interviews, observational site visits, and traffic data collection. This data formed a comprehensive overview of the morning arrival and afternoon dismissal process, and the circumstances that affect the process. Pedestrian and driver behavior was studied and used to analyze the impact of existing infrastructure on safety and efficiency. This analysis was used to identify major challenges to traffic safety and efficiency and determine the probable causes of these challenges. Recommendations focused on communication and education, operational changes, and engineering-based designs were made to address these challenges and their causes. A multi-phased structure was used for the recommendations to initiate immediate action and foster long-term results.

ACKNOWLEDGEMENTS

The team would like to acknowledge Professor Suzanne LePage and express our gratitude for her guidance, insight, feedback, and support throughout this project. Her expertise in the fields of traffic engineering and urban planning helped our team produce a project that we are enthusiastic about and applied the knowledge we have gained from our academics at Worcester Polytechnic Institute.

We would also like to thank Quinsigamond School Principal Lauren Racca for giving us this opportunity. We are very grateful for her continued assistance throughout this project.

The team would also like to acknowledge and thank WPI alum Jim Kempton, the Director of Street Operations at the City of Worcester Department of Public Works & Parks (DPW&P), for his advice and assistance.

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Special thanks to the Quinsigamond School community including parents, guardians, faculty, and staff for their help with this project and for their continued dedication to improving traffic safety at the Quinsigamond School.

CAPSTONE DESIGN STATEMENT

The goal of this Major Qualifying Project was to identify ways to make arrival and dismissal at the Quinsigamond School safer and more efficient for students, guardians, and traffic passing by the school. Changes to operations and infrastructure were recommended based on conversations with stakeholders, observations, and collected data. The project considered the following constraints: constructability, economic, ethical, environmental, health, and safety, political, social, and sustainability.

Constructability

This project involved designing possible changes to operations and infrastructure to increase safety for students and drivers at the Quinsigamond School. The design recommendations focused on effective changes that can realistically be implemented and maintained by the school staff.

Economic

Financial constraints were considered for the design and implementation of this project. Elementary Schools and their staff would face obstacles to implementing permanent infrastructure changes due to budget, time, and jurisdiction restrictions. Recommended changes accounted for the availability of staff and the ability of the school to pay staff if operational changes altered working hours and responsibilities.

Ethical

This project focused on working directly with the Quinsigamond School, but it could affect the entire surrounding area and community. While working on the project the group considered how the existing conditions impacted the community and how modifications could impact the community positively or negatively. The group gathered data in a manner that complies with the American Society of Civil Engineers (ASCE) Code of Ethics. Throughout this project, care was taken to ensure everyone involved was treated with dignity, fairness, and respect. All research and engineering were completed with the intention of bettering conditions for the community (American Society of Civil Engineers, 2020).

Environmental

This project considered and attempted to address air quality and carbon emissions caused by the school's traffic and cars idling in front of the school during arrival and dismissal. Efficiency of traffic flow was a key focus of the project and recommendations were made to reduce congestion and idling.

Health and Safety

This project's objective was to make arrival and dismissal safer at the Quinsigamond School. Dangerous driver and pedestrian behavior pose a significant safety risk, especially for small children. Conversations with stakeholders and observations of arrival and dismissal operations were used to identify dangerous behaviors and the ways that infrastructure impacted these behaviors. Recommendations were made to improve driver and pedestrian behavior through operational changes, improved communication, and infrastructure modifications.

Social and Political

This project focused on working with the Quinsigamond School to create a safer system for students getting to and from school. Safe and consistent access to education is essential in a community. Input was collected from the Quinsigamond School staff, City of Worcester officials, and parents. Effective communication and collaboration between these groups was necessary to implement changes and have this work have a lasting effect.

Sustainability

The three pillars of sustainability are social, environmental, and economic. This project addressed all three pillars. It addressed air quality, safe access to education, and the economic restraints within Worcester schools.

PROFESSIONAL LICENSURE STATEMENT

In the United States, there are requirements to becoming a professional and practicing engineer. These requirements exist to ensure that the individual practicing engineering has the knowledge to practice engineering safely and take legal responsibility for their work. Engineering licenses are given by the Board of Registration of Professional Engineers and Land Surveyors after completion of all requirements.

To begin the process of becoming a Professional Engineer the individual must obtain a degree from an ABET-accredited school in an engineering-related field and pass the Fundamentals of Engineering (FE) exam. This exam was created by the National Council of Examiners for Engineering and Surveying (NCEES), an organization that has regulated engineering and surveying licensing since the 1920s. This exam proves the test taker has a proficient understanding of the principles of engineering and can start getting working experience. In the 2020 report it was stated that “From its inception, NCEES has kept—and will continue to keep—the protection of the public’s health, safety, and welfare as its core cause,”(NCEES, 2020).

After completing a degree from an ABET-accredited school and passing the FE exam, the individual receives their Engineer-in-Training (EIT) License and Certification and can begin working as an EIT to gain industry experience. A licensed Professional Engineer is required to sign off on any work done during this time. Depending on the state there are different requirements for the next steps, but generally, the individual must write an application detailing the experience they have gained working in their field. If this application is accepted the individual can take the Principles of Engineering (PE) exam (NCEES, 2020).

The Principles of Engineering exam certifies the test taker has a proficient knowledge of engineering along with the ethical responsibility required of an engineer. In civil and environmental engineering many projects involve the public or stakeholder’s well-being. By accepting the job as a licensed engineer, the individual is saying that they have the want, ability, and technical knowledge to complete the project to the client’s specifications and the state’s standard (NCEES, 2020).

EXECUTIVE SUMMARY

The goal of this project was to improve safety for students at the Quinsigamond School and improve the efficiency of traffic during arrival and dismissal. School zones are areas of high traffic congestion during arrival and dismissal and are utilized by vulnerable groups. Children and pedestrians are at a high risk of injury from vehicles. In congested school zones without adequate parking and idling space for vehicles, parents are competing with each other and with traffic passing through the area. This creates a chaotic and dangerous environment for drivers and pedestrians.

Infrastructure can be used to modify driver and pedestrian behavior when designed with consideration for existing behaviors. Installing traffic or pedestrian infrastructure does not guarantee that behaviors will be modified in the intended way, or at all. Infrastructure may be ignored or misused, causing additional concerns for safety and efficiency.

Low-cost changes can be made to improve the impact that infrastructure has and how it is utilized. To better understand the positive, negative, or neutral impact that infrastructure has, observations should be made and input from stakeholders should be gathered. Physical alterations to existing infrastructure can be implemented. Clear education and communication aimed at students and parents about the importance of correctly utilizing traffic and pedestrian infrastructure is a cost-effective solution that has the potential to have a lasting impact.

This project consisted of five objectives created with the goal of improving safety and traffic efficiency in the Quinsigamond School zone. The objectives were:

Objective 1: Collect and evaluate data from the Quinsigamond School zone: The team conducted observations of the arrival and dismissal operations at the Quinsigamond School, interviewed stakeholders, and collected traffic and crash data. This information was collected and analyzed to develop an overview of the entire operation and identify specific problems and their causes.

Objective 2: Identify challenges caused by existing infrastructure: Problem areas were identified as areas in the school zone with high reports of safety and traffic efficiency concerns. These reports were a combination of the group's observations and conversations with stakeholders including parents, faculty, and staff. Issues within the problem areas were analyzed and possible causes of these problems were considered.

Objective 3: Develop Engineering-Based Designs that can be Transitionally Implemented: Potential solutions were identified and assessed by the team. Conversations with school faculty and staff, parents and guardians, and a City of Worcester Department of Public Works engineer, aided in the assessment. The suggested solutions included modifications to existing infrastructure, use of underutilized infrastructure, and education/communication.

Objective 4: Implement Temporary Phase of Design and Evaluate: A feasible, cost-effective, and low-risk solution was identified. This solution involved the use of underutilized infrastructure as well as education and communication with students and their guardians. This solution was implemented, and its impact was evaluated to determine its success and methods of improvement.

Objective 5: Provide recommendations for possible modifications to the pick-up/drop-off plan and street/pedestrian infrastructure: Suggestions were provided for how to continue to improve safety and traffic efficiency in the Quinsigamond School zone. Additionally, a guide was created for addressing safety and traffic efficiency issues for school zones in highly congested areas with limited infrastructure for arrival and dismissal operations.

There were several suggestions made for modifications to the infrastructure and arrival/dismissal operations. The implemented modification was selected because it was determined to be the most feasible during this project. Feasibility included cost, maintenance needs, risk factors, and longevity. Communication about parking options was a cost-effective solution that did not require maintenance, had limited risk factors, and required minimal effort from the Quinsigamond School faculty and staff to maintain after the conclusion of this project.

The goal of informing parents about parking options at the Pentecost Worship Center was to reduce negative behaviors that posed a risk to parents, students, and vehicles. Parking and idling on the shoulder and sidewalks of Blackstone River Road, Stebbins Street, and Falmouth Street were frequently observed problems that caused congestion and safety issues. Informing parents of a safe location to park their vehicles during arrival and dismissal reduced this negative driver behavior. The location of the Pentecost Worship Center parking lot also assisted in addressing the issue of pedestrians crossing the street at the midblock rather than at the crosswalk. The entrance of the parking lot is at a signalized intersection with a crosswalk that connects to the Quinsigamond School property.

Identifying and communicating parking options to parents successfully addressed a portion of a large and complicated problem. Several possible solutions for addressing other aspects of the traffic and safety problems were suggested. The suggestions range in feasibility from simple areas of improvement to major infrastructure changes. The complicated nature of the traffic problems during arrival and dismissal may not be solvable. The goal of the provided suggestions is to find realistic ways to mitigate the safety hazards and congestion around the Quinsigamond School.

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CHAPTER 1: INTRODUCTION

Pedestrian safety and traffic congestion need to be addressed in the area surrounding the Quinsigamond School. The school is located at 14 Blackstone River Road, Worcester, MA 01607, and had a population of approximately 740 students during the 2022-2023 academic year. The goal of this project is to address the safety concerns surrounding school drop-off and pick-up. According to Principal Lauren Racca, a car accident occurred due to several cars being double-parked outside the school last year. The collision occurred when a car was pulling out after dropping off their student and hit an open car door. The road’s current traffic during arrival and dismissal is a serious safety concern.

The congestion affects drivers who are transporting students and drivers who are passing through the neighborhood. Blackstone River Road is often used by commuters and by first responders. The Quinsigamond School is in a metropolitan area of Worcester, close to the College of Holy Cross and several businesses, including a Walmart Supercenter. During arrival and dismissal businesses close to the school are affected by the congestion and by parents utilizing their parking lots and blocking entrances.

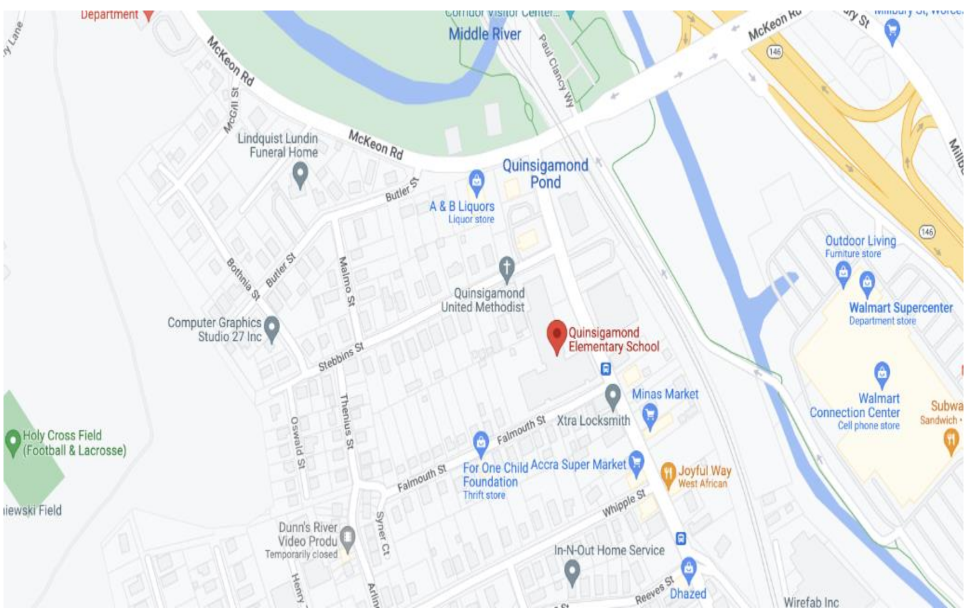


Figure 1: Map displaying the streets and businesses near the Quinsigamond School (Google Maps, n.d.).

Five objectives were created to address and solve the problems brought by various stakeholders.

- Collect and evaluate data from the Quinsigamond School zone.
- Identify challenges caused by existing infrastructure.
- Develop several versions of engineering-based designs that can be transitionally implemented.
- Implement a temporary phase of design and evaluate.
- Provide recommendations.

CHAPTER 2: BACKGROUND

Arrival and dismissal of schools result in increased traffic which can create issues with safety, pollution, and efficiency of travel flow. Arrival and dismissal operations organized by the school as well as car and pedestrian infrastructure have the potential to exacerbate or mitigate these issues. The Quinsigamond School experiences many traffic and safety issues that may be resolved through operational changes and infrastructure improvements. This chapter provides background on the Quinsigamond School and the problems it faces. Information about best practices for street design and infrastructure is also provided in this chapter. These practices focus on pedestrian calming and speed reduction.

2.1 Quinsigamond School

2.1.1 Overview and Procedures

The Quinsigamond School is in the Quinsigamond Village neighborhood of Worcester, MA, and is attended by students in pre-k to sixth grade. The school is located on Blackstone River Road and the property is bordered by Stebbins Street to the North and Falmouth Street to the South (Figure 2).

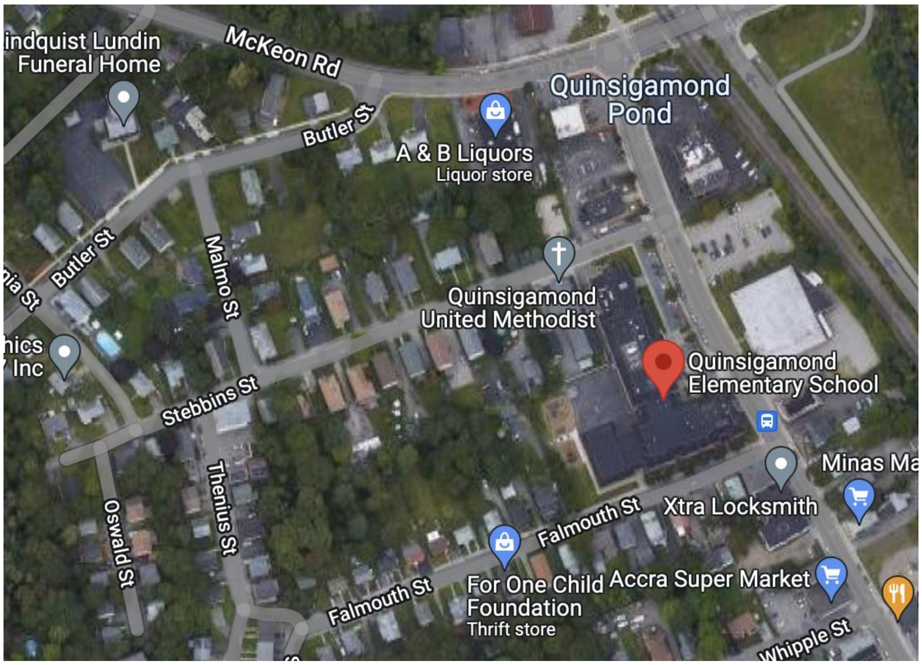


Figure 2: Map of the Quinsigamond School and surrounding properties (Google Maps, n.d.).

According to the Quinsigamond School Family Handbook, transportation via bus is provided for students but they may also walk or be driven to school by a parent or guardian. School begins at 8:25 am and students are marked tardy if they arrive after 8:30 am. Students may enter the building at 8:15 am at the earliest. The Quinsigamond School Family Handbook states that there is no supervision for students who have walked or are dropped off until 8:15 am however, due to safety concerns, staff members have been waiting outside and supervising students who arrive before 8:15 am. School ends at 2:20 pm.

Along Blackstone River Road, in front of the school, there is a slip lane used by parents for morning drop-offs and afternoon pick-ups. Running parallel to this shoulder is a driveway utilized by buses that has an entrance on Stebbins Street and an exit on Blackstone River Road (Figure 3). Six buses drop off and pick up students at the entry driveway in front of the Quinsigamond School. On Tuesdays, Wednesdays, and Thursdays, there is an after-school program at the Quinsigamond School that students from the Quinsigamond School and other Worcester schools attend. On those days four buses pick up students at the regular dismissal time and two buses pick up students who attend the after-school program. Nine special education buses drop off and pick up along Falmouth St., so these students have easy access to the Special Education classrooms located at the southern end of the school. All the buses run in phases, serving multiple schools throughout Worcester. As a result, a delay occurring during an early phase will cause delays for all the following phases.

Figure 3: Map of the Quinsigamond School and important infrastructure (Google Maps, n.d.).

During morning drop-off, parents and guardians may pull onto the slip lane along Blackstone River Rd. and can also pull over along Stebbins St. and Falmouth St. to unload students. All students, apart from Special Education bus students, enter the school through the front entrance.

During afternoon dismissal the buses operate the same as they do during morning drop-off. Dismissal for students who are walking or being picked up by parents and guardians in cars is slightly different. Kindergarten and first-grade students being picked up must be dismissed out of the Southernmost door on Blackstone River Road and are dismissed directly to their parent or guardian by Quinsigamond School staff. Parents who are waiting in the slip lane have their children brought to their car by staff members. Parents may also park their cars and wait for their children at the door. Second-grade through sixth-grade students may be dismissed from the door on Stebbins Street or the door on Falmouth Street. According to Principal Lauren Racca, there are approximately 740 students enrolled at the Quinsigamond School for the 2022-2023 academic year. Approximately 75 students are dismissed from the Stebbins St. door and approximately 100 students are dismissed from the Falmouth St. door in addition to the 36 students that are dismissed to the Special Education buses (Quinsigamond School Family Handbook, 2020).

2.1.2 Problems and Risks

Quinsigamond School students and parents are exposed to and contribute to traffic problems and safety risks. Heavy traffic, limited pedestrian infrastructure, insufficient drop-off and pick-up space, and a tight turning radius for buses have created a dangerous and overwhelming environment for students, parents, staff, and drivers. Existing conditions such as limited road options going North from Quinsigamond Village towards central Worcester contribute to high traffic volumes along Blackstone River Road. The wide shoulder outside of the front of the Quinsigamond School enables parents to double up parking, causing additional congestion. Parents frequently drop students on the opposite side of the street due to a lack of sufficient drop-off and pick-up space and difficulties turning around along Blackstone River Road. Students must then cross dangerous traffic, oftentimes not walking down the road to the existing crosswalks. The turning radius entering and exiting the school’s front driveway is too tight for buses, forcing bus drivers to make slow, difficult turns leading to them running over curbs and sidewalks. The location of two signalized intersections close to the school helps manage the traffic but also creates added confusion when school traffic is backed up, blocking the intersections. Many parents arrive before the school doors are open but wait to leave until after they have seen their child enter the building, even though there are staff members monitoring students in front of the building. This causes the school traffic to be at a standstill, blocking the road to traffic flow and promoting dangerous behavior from parents and drivers passing through. The improper flow of traffic and confusion about the right-of-way between parents, buses, pedestrians, and drivers passing through causes dangerous conditions that existing infrastructure enables rather than prevents.

2.2 School Zones

School zones are defined by the state of Massachusetts as areas within 300 feet of an accredited preschool, elementary school, secondary school, or vocational school or within 100 feet of a public playground. These areas are visually marked by the following signs that have a yellow light that flashes when the 20 mph speed limit is in effect, and the hours in which children are in school (Speed Limit and Advisory Speed Signs).

Figure 4: Massachusetts School Zone Signs (MUTCD, 2009)

Under Massachusetts General Laws Chapter 94C, Section 32J it states that there is a mandatory imprisonment for drug and gun related crimes in school zones between the hours of 5:00 am and midnight (Massachusetts General Laws). This is to discourage drug use in minors in school zones and to protect students from potential gun violence. The goals of school zones are to keep students safe. Safe from crime, drugs, and potential accidents from cars.

2.3 Infrastructure

2.3.1 Elements of Urban Design

Streets

Streets are a crucial part of transportation in the United States. They are utilized by various modes of transportation, including foot, bicycle, car, and transit, and should be designed with priority placed on efficiency and safety. Streets can be changed and should be designed and adapted with the recognition that urban environments and needs are constantly changing. Changes may include moving curbs and alignments, altering lane width, and redirecting traffic. Streets should be designed with consideration for the existing environment and natural environment. Man-made elements should be designed to interact with natural elements such as rain and stormwater (NACTO – Streets, 2015).

Intersections

Intersections are necessary connection points for streets but can increase safety risks for pedestrians, drivers, and transit. Well-designed intersections should reduce crashes, work efficiently, and balance the right of way among all users. Movements within an intersection should feel safe, easy, and intuitive for all users and promote eye contact between them for increased awareness. A compact design addresses these needs and slows traffic near contact points. Excess space left from adjusting the street to be more compact can be utilized for sidewalks and as public spaces and plazas. Traffic signals are utilized to solve issues with delay and congestion without widening roads. When designed well, they should make movements easier and limit confusion about the right of way. Intersections and traffic signals operating within them should be designed as part of a network with coordination between other intersections and traffic signals (NACTO – Intersections, 2015).

Design Controls

Design controls are elements included in a design that can promote certain driver and pedestrian behavior. There are two categories of design types: passive design and proactive design. Passive design accounts for worst-case scenarios and when applied to street design the scenarios focus on reckless and dangerous driving. Wide roads with many lanes, overdesigned buffers, and large setbacks are examples of passive design (Figure 5). Passive design in traffic engineering can inadvertently encourage reckless and dangerous driver behaviors from drivers that would otherwise drive safely. Narrow lanes and minimal setbacks are examples of proactive design that keep drivers alert and cautious (Figure 6). The proactive design acknowledges that human behavior is adaptable. Design elements are used to change driver and pedestrian behavior to be safer and meet the desired outcome (NACTO - Design Controls, 2015).

Figure 5 Figure 6

Figure 5 (Left): Passive street design (NACTO - Design Controls, 2015).

Figure 6 (Right): Proactive street design (NACTO – Design Controls, 2015).

2.3.2 Traffic Calming

Street and intersection design and changes should be completed with the goal of lowering injuries and fatalities, especially in cities. According to data from the National Highway Traffic Safety Administration in urban areas in the United States on average 146 people are killed every day in traffic-related accidents. Speeding and distracted driving are two major contributors to traffic injuries and fatalities for drivers and pedestrians. Higher speeds are directly linked to higher crash risk and severity of injuries. This correlation is documented in Table 1. Proactive design utilizing speed control mechanisms can be implemented to lower driving speeds and keep drivers alert (NACTO - Design Speed, 2015).

Table 1: Driving speed fatality risk chart (NACTO – Design Speed, 2015).

SPEED (MPH)	STOPPING DISTANCE (FT)*	CRASH RISK (%)†	FATALITY RISK (%)†
10–15	25	5	2
20–25	40	15	5
30–35	75	55	45
40+	118	90	85

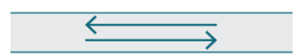
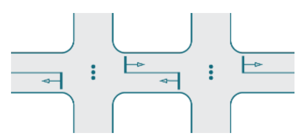
* Stopping Distance includes perception, reaction, and braking times.

† Source: Traditional Neighborhood Development: Street Design Guidelines (1999), ITE Transportation Planning Council Committee 5P-8.

Speed Reduction

Several different infrastructure projects can be completed to reduce speeding (Table 2). These infrastructure types are examples of proactive design that adapt human behavior to be safer by creating visual obstacles that keep drivers more alert and cautious.

Table 2: Speed reduction infrastructure (NACTO – Streets, 2015).

Type	Description	Image
Median	Reduces width, creating a pinch point. Creates a visual obstacle for drivers, keeping them alert. Shortens walking distance for pedestrians.	
Pinch point/Choker	Reduces lane width, like medians. Allows for more sidewalk space for pedestrians.	
Chicane	A visual obstacle that alerts the driver. Created with parking or curb extensions.	
Lane Shift	An obstacle that alerts the driver.	
Speed Hump	Vertically deflect the vehicle, alert the driver, and slow down the vehicle. Useful near sidewalks.	
Two-Way Street	Oncoming traffic encourages drivers to be more careful, especially when streets are narrow.	
Signal Progression	Coordinated signals timed with speed limits can slow down drivers.	
Building Lines	Densely built environments with minimal setbacks encourage alertness.	

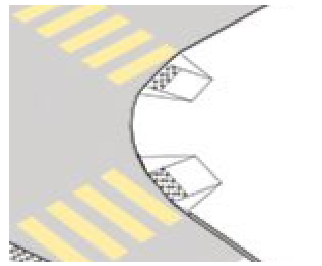
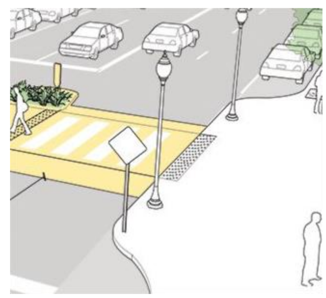
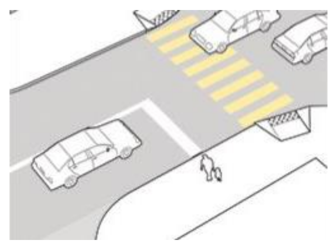
Crosswalks and Crossings

Crosswalks should be designed to protect pedestrians and make them feel comfortable. Crossing distance and location are important aspects of pedestrian comfort that should be considered. All signalized crossings should have highly visible striping that is as wide or wider than the sidewalk it is connected to. This allows pedestrians to pass each other without leaving the crosswalk area. High-visibility striping is more likely to be noticed by drivers, causing them to be more cautious.

Accessible curb ramps must be constructed at all crossings to meet requirements set by the Americans with Disabilities Act (ADA) and to create a safer and more accessible environment for all (NACTO – Intersections, 2015). Curb ramp design includes a ramp portion, transitions, and flared sides. The ramp run must be at least 36” wide. A curb ramp is generally required to have a slope of 8.33 percent (1:12) or less. However, A ramp with a rise of six inches or less may have a slope of 10 percent (1:10), and a ramp with a rise of three inches or less may have a slope of 12.5 percent (1:8). The ADA standards also require “detectable warnings” or ADA pads at curb ramps. These pads are brightly colored and are made of small, equally spaced domes. These pads are designed to be felt with pedestrians’ feet and act as a warning for blind or visually impaired individuals Street lighting is another important feature that should be located at or near intersections to help drivers see pedestrians during times of lower visibility (ADA.gov, n.d.).

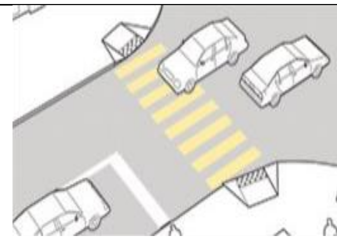
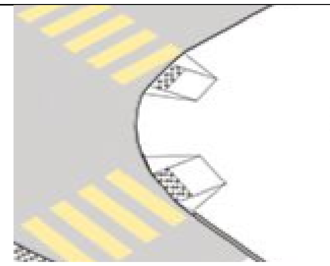
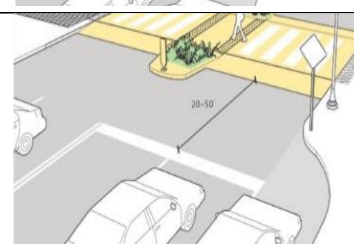
Crosswalks located at an intersection are conventional crosswalks. These crosswalks should be designed as compactly as possible so that pedestrians are located within the driver’s line of vision. Several features can be incorporated into conventional crosswalks to make them safer for pedestrians (Table 3).

Table 3: Safety Features for conventional crosswalks (NACTO – Intersections, 2015).

Feature	Description	Image
High-Visibility Ladder, Zebra, and Continental Crosswalk Markings	Preferable to standard parallel or dashed markings. More visible to drivers.	
Accessible Curb Ramps	Required by the Americans with Disabilities Act (ADA).	
Short Crossing Distances	Use tight turning radii, curb extensions, and medians.	
Advanced Stop Bar	Should be at least eight feet in advance of the crosswalk.	

Crosswalks located at a midblock are midblock crosswalks. Existing and projected pedestrian volumes should be considered when determining the location and design for this type of intersection. Several features can be incorporated into midblock crosswalks to make them safer for pedestrians (Table 4).

Table 4: Safety Features for Midblock Crosswalks (NACTO – Intersections, 2015).

Feature	**Description**	**Image**
Crosswalk Markings	Stripe (Pattern type is less important here than it is at an intersection crossing).	
Accessible Curb Ramps	Required by the Americans with Disabilities Act (ADA).	
Short Crossing Distances	Use curb extensions and medians.	
Advanced Stop Bar	Should be twenty to fifty feet in advance of the crosswalk.	

2.4 IRB and Ethical Research

The Institutional Review Board (IRB) was created in 1974 after the passing of the Human Research Act. This act established clear patient rights and emphasized the subject's well-being when doing studies. To ensure this, academic studies or experiments involving human subjects are regulated by IRB to make sure they are done safely and ethically. Before the beginning of a study, a proposal involving methodology and justifications for the experiment is submitted to the corresponding IRB office (U.S. Food and Drug Administration, 2019).

Worcester Polytechnic Institute has an IRB office that oversees all applications from members of the WPI community. Most colleges in the US have IRB offices due to it being Federally regulated (U.S. Food and Drug Administration, 2019). The research group is required to fill out an online form with the objectives of the project, the methodology, and a full draft of any material or questions you plan to give or ask the subjects. Once submitted, the submittal is reviewed by the IRB office, and they assess the risk to research participants (WPI, 2022). If there are any issues with the proposed research methods, they can be adjusted and resubmitted.

2.5 Data Collection Through Surveys

Surveys are a useful tool for finding out the views of a given population. Because of their relatively low cost and quick turnaround, surveys are one of the most common methods for data collection (Qualtrics, n.d.). There are several ways to administer a survey including digital surveys, phone surveys, talking in person to the subjects, and written surveys. With phone and in-person surveys, the person conducting the survey is in direct communication with the subject, but with written and digital surveys the subject can conduct the survey themselves, on their own time. There are two main types of survey questions, qualitative and quantitative.

Qualitative questions are more open-ended, and opinion based such as, “In your opinion how effective is this security alarm?” when quantitative questions are much more literal such as, “How many times has the security alarm gone off this week?” Utilizing both of these types of questions in surveys can lead to great results but first, the motivation and goals of the survey should be clearly defined (Qualtrics, n.d.). What is the information the study is trying to gain? What questions will achieve this goal? “Survey Fatigue” also must be considered. It is a term describing when people start but do not finish surveys due to boredom, time constraints, or a plethora of other reasons (Fisher, 2020). To avoid this, it is recommended to leave out unnecessary questions and try to keep surveys relatively short. It is also good to have a diverse set of questions, so the survey taker doesn't see the same question format repeatedly and to allow for a wider range of answers.

The language itself within the questions is important. The questions should be written very clearly. It is important to think of who is taking the survey. They may be a new English speaker or have a limited vocabulary. Using simple language makes the survey accessible to a wider range of participants. Questions should be written very directly to both be clear and to avoid leading the participant toward a certain answer. Things like “True or False” or “Agree or Disagree” are great for simple questions. More detailed questions can have scaled responses, multiple choice, or open responses where the participant can type in their thoughts. When constructing these though, bias must be considered. Bias is an undisclosed preference towards an outcome. While everyone has biases, they should be taken out of studies because they can skew data. To do this only information relevant to the question should be provided, and the wording must be neutral and not “leading” the participant. The order of the answers in multiple-choice questions also can lead to biases, so having them shuffled can minimize that effect. Four to five options for multiple-choice questions are the most effective, as too many can lead to confusion and fatigue in the subject (Pew Research Center, 2021).

CHAPTER 3: METHODS

This project aims to make drop-offs and pick-ups at Quinsigamond School safer and more efficient for all involved stakeholders. This will be achieved through engineering design and communication with the city of Worcester and the Quinsigamond School faculty, staff, and parents.

3.1 Objective 1: Collect and evaluate data from the Quinsigamond School zone.

3.1.1 Observations of Existing Conditions

Site Visits

During the data collection period, several observational visits were completed in the mornings and afternoons. The purpose of these visits was to confirm the observations made by stakeholders and to identify and document arrival/dismissal operations, driver behavior, pedestrian behavior, the role of infrastructure, and the impact of external factors such as weather and construction. This information was needed to form a comprehensive understanding of the entire arrival and dismissal process. Doors at the school open at 8:15 am, school begins at 8:25 am and students are marked tardy if they arrive after 8:30 am (Quinsigamond School, 2022, p. 6). The school's dismissal time is 2:30, and the majority of students leave at this time. Eleven visits occurred where observations were recorded between September 2022 and March 2023. Six of these visits were dedicated solely to observations, 4 were dedicated to collecting turning movement data and recording observations, and the first visit was the initial site visit and meeting. This wide period for conducting observations was selected to account for the potential of fluctuating behaviors and traffic patterns caused by seasonal weather and construction on Stebbins Street which occurred throughout the fall. The majority of visits occurred around arrival and dismissal, from 7:30 am to 9:30 am and 1:30 pm to 3:30 pm. However, several visits occurred outside of these time frames to gather information about driver and pedestrian behavior when there is no arrival and dismissal traffic. Observations were documented and provided in Appendix B.

Traffic Counts and Turning Movements

Traffic count and turning movement data at the Blackstone River Road and Stebbins Street signalized intersection were collected using TDC Ultra Counterboards. These counter boards are manufactured by JAMAR Technologies, Inc. and allow users to easily record accurate data showing the quantity, frequency, and turning movements of vehicles at an intersection. Pedestrian movement data at the intersection also can be recorded. Data was collected in the morning from 7:30 am to 9:30 am and in the afternoon from 2:00 pm to 4:00 pm. These two-hour blocks were selected so that data is collected before, during, and after arrival and dismissal. Any fluctuations in traffic movement can then be observed and noted. The collected data was uploaded to PetraPro, a software that allows users to create reports and graphs to view, edit, and analyze data (JAMAR Technologies, Inc., 2020). The turning movement data is provided in Appendix C.

Table 5: Quinsigamond School site visits

Visit Type	**Date**	**Day of Week**	**Time**	**AM/ PM**	**Weather**	**Avg. Temp.**	**Other Info**
Initial Site Visit/overview with L. Racca	9/8/22	Thurs.	12:00 - 1:00	PM	Fair	68°F	
Observations	9/14/22	Wed.	8:00 - 9:00	AM	Fair	58°F	
Observations	10/21/22	Fri.	7:30 - 9:30	AM	Fair	42°F	
Observations	11/16/22	Wed.	1:30 - 3:30	PM	Fog	43°F	
TMC + Observations	1/24/23	Tues.	2:00 - 4:00	PM	Cloudy	34°F	Snow on the ground, mostly cleared.
Observations	1/31/23	Tues.	7:30 - 9:00	AM	Light Snow	24°F	
Observations	1/31/23	Tues.	1:30 - 3:00	PM	Partly Cloudy	34°F	
Observations	2/7/23	Tues.	2:00 - 4:00	PM	Fair	34°F	
TMC + Observations	2/9/23	Thurs.	8:00 - 9:00	AM	Fair	35°F	
TMC + Observations	2/24/23	Fri.	2:15 - 3:15	PM	Cloudy / Windy	26°F	No School
TMC + Observations	3/22/23	Wed.	1:15 - 3:15	AM	Fair	54°F	

3.1.2 Organization and Analysis Methods

Google Maps

Mapping technology was used for the analysis of the group's data, and as a tool to observe the location. The group used Google Maps to get a 2-D bird’s eye view of Quinsigamond school to see the surrounding streets, parking, and bus area. It also provided the location of the surrounding crosswalks, traffic lights, and traffic speeds throughout the day. This information was used to obtain a better sense of the school’s neighborhood.

MassDOT Traffic Data

The Massachusetts Department of Transportation (MassDOT) publishes traffic count data and displays the data on an interactive map. This traffic count data was utilized to obtain a better understanding of the number of cars that pass by the Quinsigamond School at various times throughout the day. This helped the group identify the peak hours and visualize the most common routes that drivers are using in this neighborhood. MassDOT does not have data for the intersection at Blackstone River Road and Stebbins Street, but it does have data for several of the surrounding roads (Massachusetts Department of Transportation, n.d.b).

MassDOT Crash Data

The group also analyzed vehicle crash data, which is publicly available on the mass.gov website through the MassDOT Crash Data Portal. There were several interactive ways for the group to look at car collisions. There are maps that layer crash data over the state or can be zoomed into towns or streets, along with dashboards and filtered searches. The studied crash data was selected based on the crash location around the Quinsigamond School. A spatial search was conducted, and the draw tool was utilized to trace an area that included the length of Blackstone River Road from the McKeon Road intersection to the Whipple Street intersection. The area also included Falmouth Street and Stebbins Street from where the streets intersect with Blackstone River Road, past the Quinsigamond School. The area is located within the green outline in Figure 7. The data retrieved from the MassDOT Crash Data Portal is provided in Appendix D. The data was then used to identify trends such as crash year, crash time, crash severity, crash type, and pedestrian or bus-related crashes (Massachusetts Department of Transportation, n.d.a.).

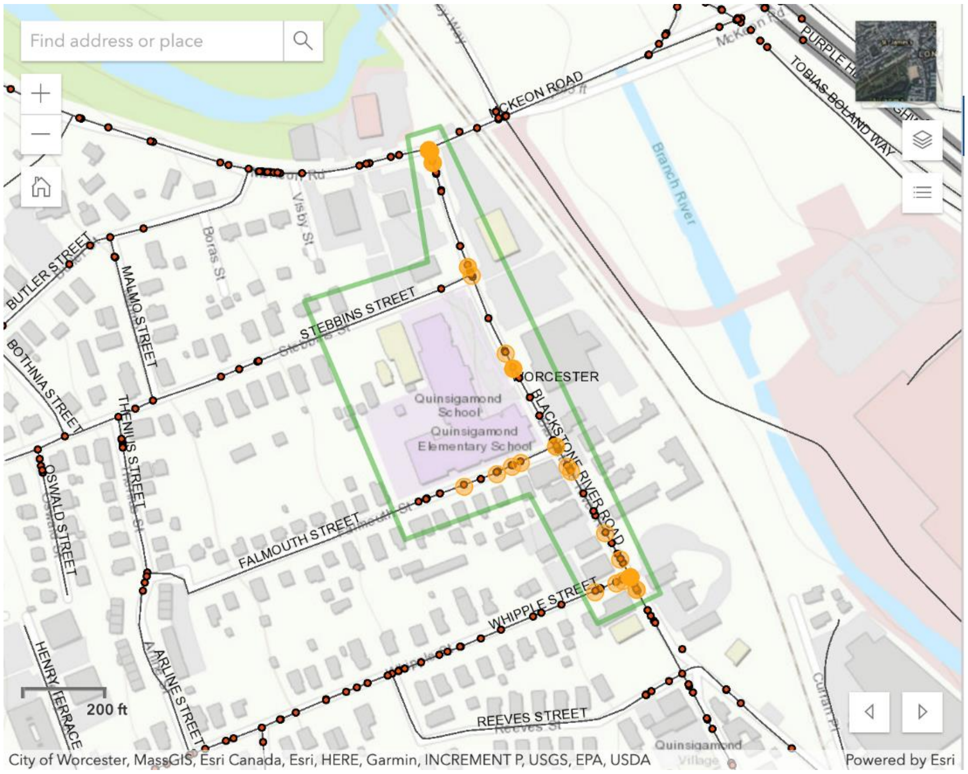


Figure 7: Map of the selected crash data collection area around the Quinsigamond School.

3.1.3: Hearing Directly from Stakeholders

PTO Meetings

The group also attended a Parent Teacher Organization (PTO) meeting on November 30th, 2022, and led an open conversation with parents and staff about the arrival and dismissal system. Before opening the floor for discussion, the group explained some general problems that have been identified during observations to get the conversation started with a presentation. Throughout the semi-structured conversation, the group looked to obtain any information about what parents and staff like and dislike about the system, and if they have any ideas for improvement. The notes taken during the PTO meeting can be found in Appendix E.

Parent Survey

A digital survey was developed using Qualtrics, an online program for creating and distributing surveys. Qualtrics is a useful software because of the range of types of questions one can ask, along with its ability to interpret and analyze data (Qualtrics, n.d). Qualtrics automatically creates graphs and charts to display survey results, and other ways to visualize the data are also available. Qualtrics can turn survey links into QR codes easily, so the surveys were added to a flyer that was given to parents physically during arrival and dismissal. This flyer also contained information about where parents should park, as part of an operational change we chose to test after examining the best options (see Objective 4).

This survey was intended for parents or guardians who drive their children to and from school. The majority of the survey questions were multiple choice so parents could answer quickly and avoid survey fatigue. However, a few open-ended questions were added so parents wouldn't feel pressured to answer a certain way and could elaborate on their answers. All responses were anonymous, and all questions were optional. The goal of the survey was to gather information about parent behaviors during arrival/dismissal and learn their perspectives on the process. The full list of questions can be found in Appendix F.

3.2 Objective 2: Identify challenges caused by existing infrastructure.

To make drop-offs and pick-ups safer and more efficient all traffic problems needed to be addressed such as the infrastructure itself, pedestrian safety while crossing the road to school, and the overall traffic congestion caused during school drop-off and pick-up. The observations done during site visits showed the group the problem areas that need to be addressed. Different solutions were considered based on stakeholder feedback and observed data collection.

Key pieces of infrastructure were identified and their impacts on traffic flow and driver and pedestrian safety were assessed. The infrastructure analysis also revealed if the infrastructure was being utilized properly and the effect of its misuse. Information obtained from stakeholders and site visit observations was used to identify reasons why the infrastructure was misused. In cases where infrastructure was properly utilized, it was then labeled as either having a positive or negative impact on traffic flow and safety. In cases where the infrastructure had both a positive and negative impact, it was labeled as “mixed impact”.

3.3 Objective 3: Develop Engineering-Based Designs that can be Transitionally Implemented.

Once high-impact “problem areas” were identified, modifications to these areas were designed to create a safer environment. The design was affected by existing infrastructure and conditions, similar case studies, and standard traffic-engineering infrastructure approaches. Designs were developed to be implemented in phases, with the earlier phases being short-term changes feasible for the school staff to implement, and the later phases being permanent changes that can be implemented by the city or school. Input from officials working for the City of Worcester should be consulted to guide the design process.

3.4 Objective 4: Implement Temporary Phase of Design and Evaluate.

3.4.1 Implementation

The group, once deciding on the changes the school could make for a more successful pickup and drop-off system, had to coordinate with the Quinsigamond School Staff and parents to communicate these changes. This was done via a flyer the group designed that was given to the school principal to be given to parents. Flyers were also printed by the group and passed out during the morning and dismissal to ensure the people who participate in school drop-off/pick-up get all the information they need. The flyer can be found in Appendix G.

3.4.2 Evaluation

An evaluation of the temporary operation/design change was completed. This evaluation was based on our observations and feedback from staff and parents. A survey was distributed to parents where they rated the safety and efficiency of morning drop-off with the original system and the newly implemented temporary system. The change was implemented with the help and collaboration of the school. The group compared the safety and efficiency of the new operation and design to the old system.

3.5 Objective 5: Provide recommendations for possible modifications to the pick-up/drop-off plan and street/pedestrian infrastructure.

Recommendations for continued improvements to and assessment of traffic safety were compiled. Recommendations that focused on communication and education, operational changes, and engineering-based designs were made to address the identified challenges and their causes. A multi-phased structure was used for the recommendations to initiate immediate action and foster long-term results.

CHAPTER 4: RESULTS AND ANALYSIS

The objectives outlined in the methodology were completed and the results were documented and analyzed to fulfill the overarching objective of improving traffic safety and efficiency.

4.1 Objective 1: Collected and evaluated data from the Quinsigamond School zone.

4.1.1 Observed Existing Conditions

Existing information and data was collected to gain a deeper understanding of the history of traffic issues near the Quinsigamond School and the efforts that have been made to improve conditions. Traffic count data published by the MassDOT included a 2019 traffic flow map with color-coded ranges of average annual daily traffic (AADT) (Figure 8). The traffic flow map included Blackstone River Road, McKeon Road, and Greenwood Street. The stretch of Blackstone River Road in front of the Quinsigamond School was a deep red color which did not match the key, but other roads that were the same color have AADTs ranging from around 6,000 to 11,300. Based on this comparison and the counts recorded on surrounding roads it is fair to assume that this stretch of Blackstone River Road has an AADT in the range of 5,001 to 10,000.

Figure 8: 2019 traffic flow map in the North Quinsigamond Village neighborhood.

Vehicle crash data was obtained from the MassDOT IMPACT Crash Query and Visualization Database. Data was selected for a five year period from January 1, 2018 to December 31, 2022. During this period there were 59 crashes in the selected area, for a 5-year average of 11.8. The majority of these crashes, 66.10%, resulted in property damage only, and there were no fatalities. Rear-end crashes were the most common, making up 35.59%, followed closely by angle crashes which make up 33.90% of crashes. The hours with the highest crash numbers were 8:00 a.m. and 2:00 p.m., 7 crashes occurred during each of these hours (Figure 9). The Quinsigamond School starts at 8:30 a.m., which is within the morning crash peak hour, and ends at 2:20 p.m., which is within the afternoon crash peak hour.

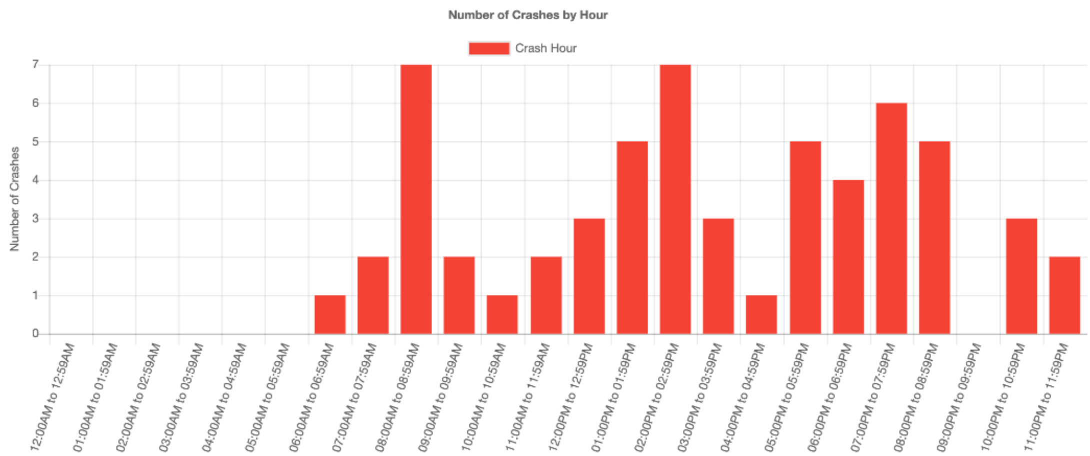


Figure 9: Graph showing the time that each crash occurred over a period of 5-years.

Additional quantitative and qualitative data was collected. Several site visits were conducted to observe arrival and dismissal operations. These visits provided a better understanding of the operations and the safety and efficiency problems that existed. The visits helped to verify claims made by Principal Lauren Racca and allowed for additional observations to be made. A complete overview of the observations can be found in Appendix A.

Traffic counts and turning movements at the Blackstone River Road and Stebbins Street signalized intersection were observed and recorded using JAMAR Technologies, Inc. TDC Ultra Counterboards. This data was then used to create tables and turning movement diagrams to identify times of peak traffic and fluctuations in traffic data before, during, and after arrival and dismissal times. The Peak hour factor was determined using the equation: PHF = Total hourly volume / (4 * Peak 15-minutes within the hour). Two of the three turning movement counts that were conducted had Peak hour factors that were smaller than 0.80. This indicates that the traffic flow was not consistent over the course of the peak hour and the peak 15-minute interval experienced significantly higher volumes of traffic than the other 15-minute intervals.

The peak 15-minute interval represents the period when the highest number of vehicles are able to pass through the intersection however, it does not necessarily represent the period when the highest number of vehicles are trying to pass through the intersection. While the afternoon turning movement count was being conducted on Wednesday, March 22, Blackstone River Road became so congested at dismissal time that vehicles were at a stand still in the intersection. Although many cars were trying to get through the intersection, this 15-minute period had the lowest volume of traffic of the peak hour in the turning movement count.

4.1.2 Organized and Analyzed Data

The group collected data from a variety of sources as outlined in the Methods Chapter. All site visits were documented in Appendix B as well. During the observational site visits, the concerns given to the group by Principal Lauren Racca were confirmed and additional concerns were formed. The concerns included cars double parked in the slip lane in front of the school (Figure 10), cars parked illegally in front of surrounding businesses and in businesses' parking lots, and other traffic flow issues.

Figure 10: Vehicles double parked in the Quinsigamond School slip lane.

The slip lane in front of the school was originally used for school buses when the school was first established but now is used for “quick” parent drop-off and pick-up. During drop-off, the group observed over twenty cars on their September 14th, 2022, site visit in the slip lane area. Due to the build-up of cars, many parents couldn’t exit the slip lane after they dropped off their children. The number of cars in the lane didn’t only affect the cars in the lane itself, it also bled into the main traffic on Blackstone River Road, blocking more lanes and interrupting traffic flow.

During pick-up, the group observed parents waiting in the slip lane up to thirty minutes before school release. The established system for pick-up had a teacher with a walkie-talkie checking each car in the slip lane and communicating with another teacher who quickly brought the child to the car. This system didn’t require the parents in the slip lane to leave the car at all and in theory, could move a line of cars very quickly. However, it became more complicated when parents were double parking or were not pulling up fully to the front of the lane. Cars would also build up at the back of the slip lane and block the Blackstone River Road - Stebbins Street intersection. This likely happened because drivers traveling Southbound on Blackstone River Road were unable to see openings further down the slip lane and fearing they may not find parking further up the slip lane, pull into the first available visible spot which often is the back of the lane. This creates a double-parking effect and also can make it harder for the teachers at dismissal to identify and safely get students to their cars.

Parking across the street from the school was also observed. When cars were parked directly across from the school driveway exit, the already small area for buses to turn was reduced. At times vehicles also blocked the entrance to a business located across the street from the school. It was observed that parents who parked on the far side of the street typically took the shortest route across the street, at the midblock rather than utilizing the crosswalks. There are two crosswalks on either corner of the block the school is on. Figure 11 below shows the unsafe crossing (red arrows) and the location of the crosswalks (green arrows). This identified pedestrian crossing as a problem for the group to address.

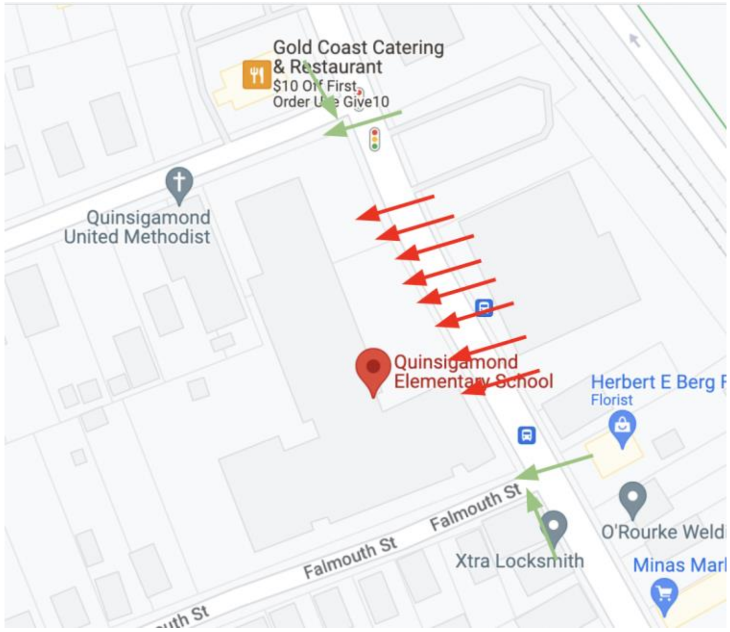


Figure 11: Pedestrian movement across Blackstone River Road

The group also observed crossing guards stopping the flow of traffic to let students cross when the light on Blackstone River Road was green. The crossing guard was observed to stop the cars for groups and single students, and often by the time they were done crossing the pedestrian light would turn on, making the cars in traffic have to wait for two full lights before moving. Breaking up the flow of traffic in this way made it take longer for the cars to move out of the area causing additional congestion.

4.1.3 Stakeholder Feedback

Stakeholder feedback is essential when doing data analysis of this nature. Valuable information was obtained from speaking to faculty, staff, and parents who experienced arrival and dismissal firsthand. Stakeholder feedback is important for getting specific details, and in general, having engagement with the stakeholders fosters a more productive and positive relationship with the team. This communication was also important to show stakeholders that the group and the school were working on finding feasible solutions.

The main stakeholders in this project were the Quinsigamond School faculty and parents. The team communicated with Principal Lauren Racca through email, phone calls, and several in-person meetings at the school to go over observations and ideas for how to solve these problems. A PTO meeting was also attended to speak directly with parents. At the PTO meeting, the group had a semi-structured conversation with parents and faculty. A few general arrival and dismissal observations and problems were presented by the team to start the conversation. Faculty and parents then shared their observations, concerns, and ideas which were documented by the group in Appendix E. Their main concerns were a lack of clear instruction on what to do during pickup and dismissal times, congestion in the slip lane caused by parents exiting their vehicles, and lack of parking options. They wanted a designated area where they can drop their kids off safely and quickly in the morning. . Their main concerns were a lack of clear instruction on what to do during pickup and dismissal times, congestion in the slip lane caused by parents exiting their vehicles, and lack of parking options. They wanted a clearly designated area where they can drop their kids off safely and quickly in the morning. They wanted a clearly designated area where they can drop their kids off safely and quickly in the morning.

The group also had the privilege of communicating with Jim Kempton, professional engineer and director at the City of Worcester Department of Public Works and Parks. He provided the group with information about past development and analysis of traffic around the Quinsigamond School. He also offered advice and information about resources that the city has that could be helpful for the project.

4.2 Objective 2: Identified challenges caused by existing infrastructure.

The analysis of data collected before and during this project led to the identification of several "major problem areas" around the Quinsigamond School. The "major problem areas" were located on three roads, Blackstone River Road, Stebbins Street, and Falmouth Street, and in two parking lots, the Gold Coast Catering and Restaurant lot and the faculty lot located across Blackstone River Road (Figure 12).

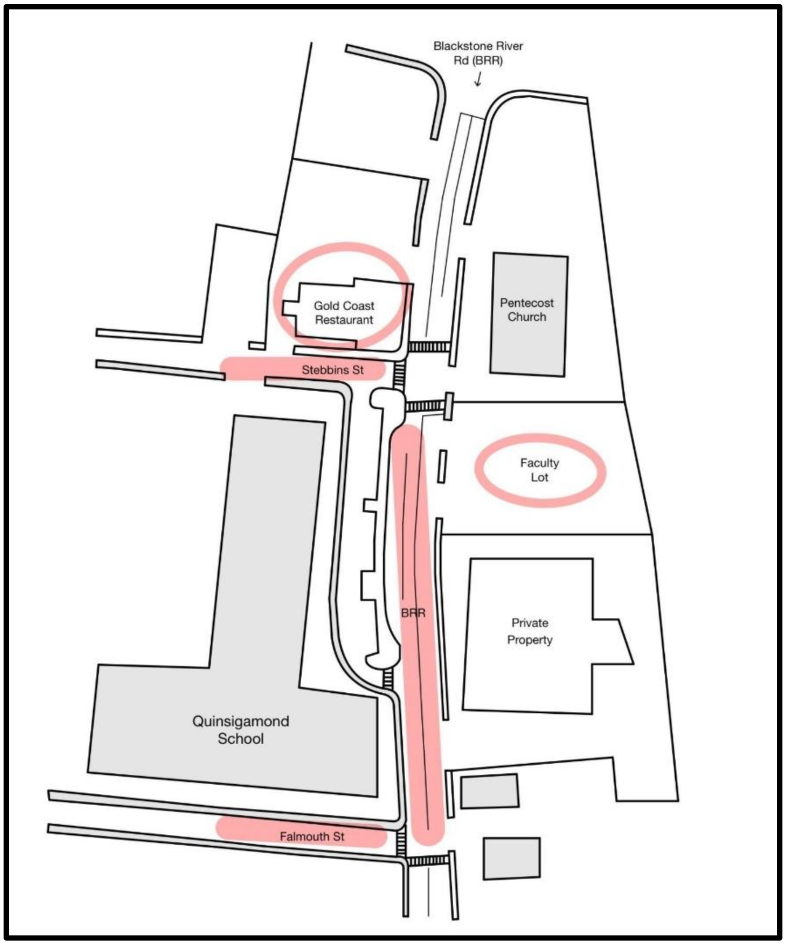


Figure 12: Major problem areas identified near the Quinsigamond School.

The problem areas experienced some issues that were unique to the specific area and also experienced some overlapping issues. Additionally, some problem areas experienced different issues depending on whether it was morning arrival or afternoon dismissal. The observed problems are listed in Table 6 and their corresponding locations are shown in Figure 13 for morning arrival and Figure 14 for afternoon dismissal.

Table 6: Observed problems during morning arrival and afternoon dismissal.

Area	Morning Arrival Problems	Afternoon Dismissal Problems
Blackstone River Road	Crosswalk 1. Students, parents, and staff/faculty crossed the street at the midblock instead of using the crosswalk. Slip Lane 2. -Cars were double parked in the slip lane. -Cars were not moving forward when the car in front of them left. -Cars were backed up into the intersection. -Cars were cutting in front of each other to get in or out of the slip lane. Street 3. Vehicles were parked or idled on the shoulder of the road. Many parents are leaving their cars to walk their student(s) to the door. 4. -Parents stopped at the red light and let their student(s) out of the car in the middle of the street. -Parents stopped at the red light left their vehicle in the street to walk student(s) onto school property. Buses 5. Traffic and congestion made it difficult for buses to exit the school drive-through 6. Buses exiting the school drive-through heading Northbound had a difficult time turning due to the tight turning radius and vehicles parked in the road shoulder. (Cones are sometimes placed on the shoulder by school faculty to prevent parking).	Crosswalk 1. Students, parents, and staff/faculty crossed the street at the midblock instead of using the crosswalk. Slip Lane 2. -Cars were double parked in the slip lane. (Less congested than at morning arrival). -Cars were not moving forward when the car in front of them left. -Cars were backed up into the intersection. -Cars were cutting in front of each other to get in or out of the slip lane. Street 3. Vehicles were parked or idled on the shoulder of the road. Many parents exited their cars to pick up their student(s) from the school. 4. N/A Buses 5. Traffic and congestion made it difficult for buses to exit the school drive-through 6. Buses exiting the school drive-through heading Northbound had a difficult time turning due to the tight turning radius and vehicles parked in the road shoulder. (Cones are sometimes placed on the shoulder by school faculty to prevent parking).
Stebbins Street	Buses 7. Buses had a difficult time getting into the school drive-through because of the tight turning radius. This was a problem for buses going both Southbound and Northbound. 8. Vehicles were blocking the entrance to the drive-through so buses could not enter. (This occurred less frequently in the morning, it was a much bigger problem in the afternoon).	Buses 7. Buses had a difficult time getting into the school drive-through because of the tight turning radius. This was a problem for buses going both Southbound and Northbound 8. Vehicles were blocking the entrance to the drive-through so buses could not enter. (This occurred less frequently in the morning, it was a much bigger problem in the afternoon). Street 9. Vehicles were parked on both sides of the street, making it difficult for two-way traffic to pass through. 10. Vehicles were parked on the

		sidewalk.
Falmouth Street		11. Parents left their vehicles parked or idled on the side of the road when picking up students.
Gold Coast Catering and Restaurant		<u>Parking Lot</u> 12. Parents parked their vehicles in the restaurant lot. They took up parking spots and idled in the drive-through space, blocking restaurant traffic. (A few parents do this in the morning, but the restaurant hours are 11 am to 7 pm so it is only a problem at afternoon dismissal).
Faculty Lot at Blackstone River Road	13.-Parents park in open spots in the faculty lot. -Parents leave vehicles in the drive-through space of the lot and walk student(s) to the school.	13. -Parents park in open spots in the faculty lot. -Parents leave vehicles in the drive-through space of the lot and walk to the school to pick up their student(s).

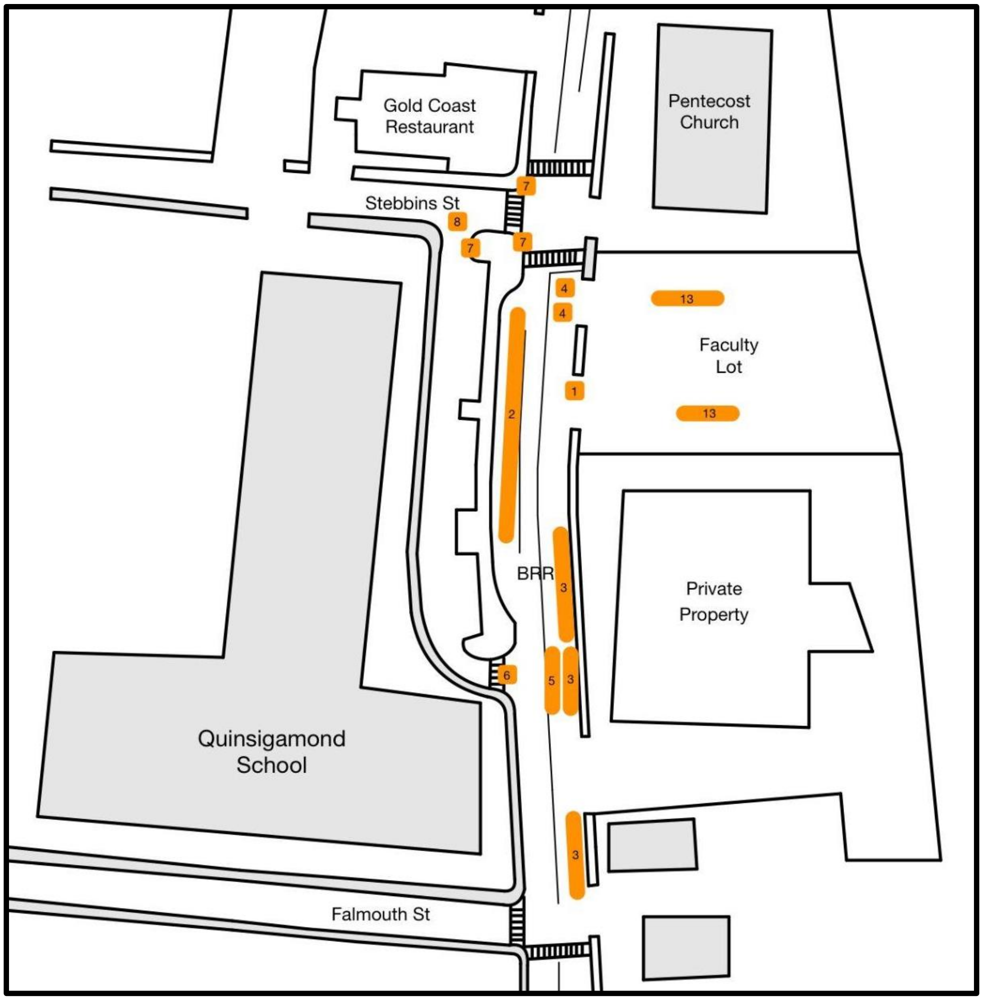


Figure 13: Locations of observed arrival problems.

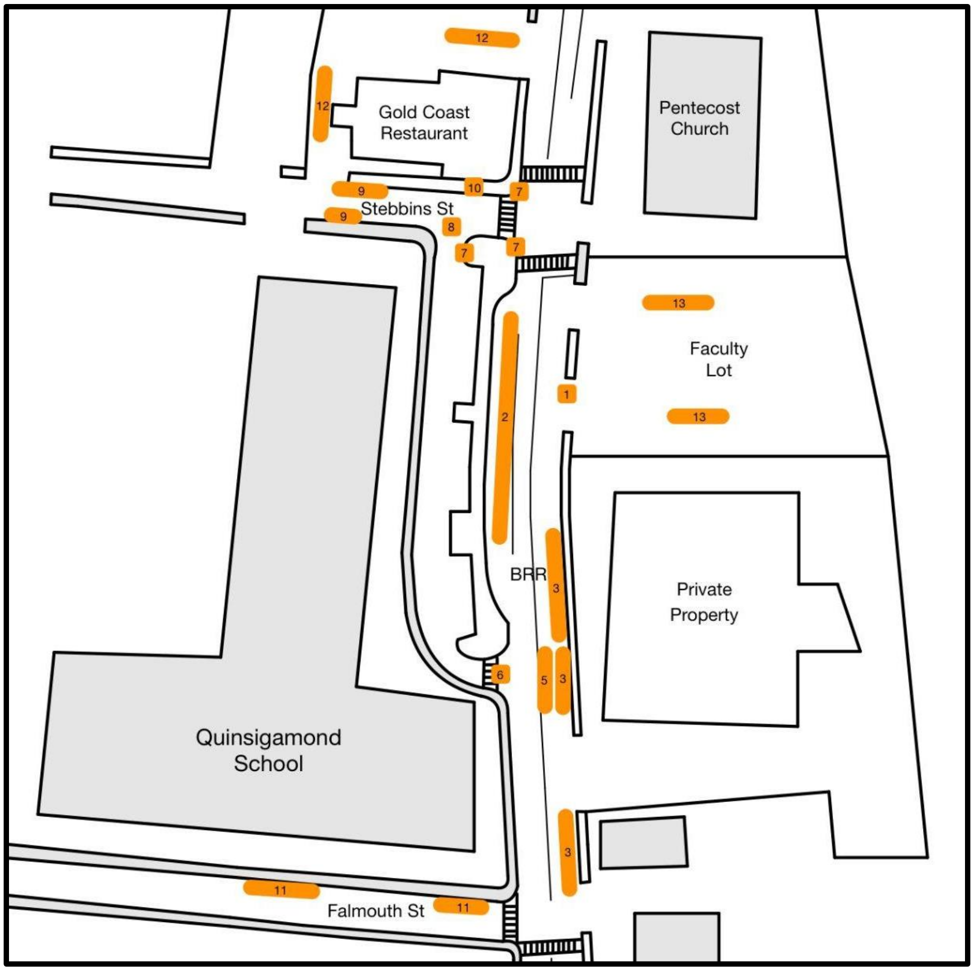


Figure 14: Locations of observed dismissal problems.

After the problems were identified in each area, the causes of the problems were identified. The initial analysis of causes was focused on infrastructure. A review of observations showed that the existing infrastructure could be utilized properly and improve traffic and efficiency, utilized properly, and have a negative impact on traffic and efficiency, or ignored/misused. In cases where existing infrastructure was ignored or misused, it was necessary to identify why it was not compatible with human behavior. Infrastructure was examined and assessed on each street. Six key pieces of infrastructure were selected and identified as either having a positive impact on traffic and safety, a negative impact on traffic and safety, or both a positive and negative impact on traffic and safety.

The locations of the selected infrastructure are shown in Figure 15, positive impacts are in green, negative impacts are in red, and both positive and negative impacts are in yellow.

1. **Driveway Entrance** Impact - Red/Negative: Analysis of the driveway entrance led to the conclusion that in its current state, it had a negative impact on traffic flow and safety, and it needed significant modifications. The narrow opening made it difficult for buses to enter without driving over the sidewalk. Driving over the curve and onto the sidewalk could cause damage to the bus's wheels and could pose a safety risk to pedestrians utilizing the sidewalk. Buses traveling Southbound on Blackstone River Road had to first make a partial right-hand turn and then quickly make a left-hand turn into the driveway. Buses traveling Northbound on Blackstone River Road had to make a U-turn into the driveway. Buses coming from both directions struggled to maneuver the turns.

2. **Driveway Exit** Impact - Red/Negative: Analysis of the driveway exit led to the conclusion that in its current state, it had a negative impact on traffic flow and safety, and it needed significant modifications. The main issue with this area was not the driveway exit itself, but the lack of infrastructure in place to discourage vehicles from blocking the exit during arrival and dismissal. During these times traffic was frequently backed up from the Stebbins Street and McKeon Road intersections. Vehicles were also observed to be parked on the shoulder of Blackstone River Road directly across from the driveway exit.

3. **Stebbins Street-Blackstone River Road Intersection** Impact - Yellow/Mixed Impact: Analysis of the Stebbins Street-Blackstone River Road Intersection led to the conclusion that in its current state, it had a mixed impact on traffic flow and safety. The signalized intersection is equipped with high-visibility ladder crosswalk markings and standard pedestrian signal heads. However, it was observed that many pedestrians, including students, parents, and staff, crossed at the midblock South of the intersection rather than at the intersection crosswalks.

4. **Slip Lane** Impact - Yellow/Mixed Impact: Analysis of the Slip Lane led to the conclusion that in its current state, it had a mixed impact on traffic flow and safety. The slip lane provided a space for parents to drop off or pick up their students. It was safer than waiting on the shoulder of the road or in the middle of the street and caused less congestion than these other options. The width of the slip lane provided room for vehicles to double park. This allowed more vehicles to fit in the space however, it also created a more chaotic and dangerous environment as vehicles fought for space and the ability to pull in and out of the lane.

5. **Driveway** Impact - Green/Positive: Analysis of the driveway led to the conclusion that in its current state, it had a positive impact on traffic flow and safety. The driveway was used by buses for morning arrival and afternoon dismissal and kept buses from blocking traffic during these times. The driveway was protected from vehicles and minimized the distance students had to walk between the bus and the school entrance.

6. **The Pentecost Worship Center Parking Lot** Impact - Green/Positive: Analysis of the Pentecost Worship Center parking lot led to the conclusion that in its current state, it had a positive impact on traffic flow and safety. The parking lot offered a protected space for parents to leave their cars if they wanted to walk their children to the front doors of the school. Parents and students who utilized this lot were observed to utilize the Stebbins Street-Blackstone River Road intersection crosswalks at much higher rates than those who utilized the faculty lot or parked on the shoulder of the road. The Pentecost Worship Center parking lot contained thirty-nine parking spaces including two parking spots marked as accessible spots. This parking lot was observed to be underutilized by parents.

Figure 15: Key infrastructure near the Quinsigamond School and its impacts.

The parking lots where problems were identified were not subject to thorough infrastructure analysis because the main problem identified was simply that they were not appropriate places for parents and guardians to park. Lack of adequate parking was identified as a general issue for the entire area around the Quinsigamond School leading to a search for parking options.

4.3 Objective 3: Developed Engineering-Based Designs that can be Transitionally Implemented.

Following the identification and analysis of problem areas, problematic infrastructure within those areas, and general problems affecting the Quinsigamond School as a whole, possible solutions to improve safety and efficiency were assessed.

Pentecost Church

The Pentecost Church, located at 5 Blackstone River Road, was identified as an appropriate and underutilized parking area. Leaders at the Church had previously given permission for staff and parents to utilize the church parking lot during school hours. Parking in the church lot would improve safety for parents and students, limit crowding and illegal parking in the street, and hopefully reduce accidents and damage to vehicles. Additional analysis as to why there was a lack of parking in some lots and inappropriate parking in others generated ideas for how to redirect drivers away from inappropriate parking and towards the Pentecost Church parking lot.

It was determined that the primary reasons why the church lot was not used were lack of communication and location. There was no officially designated parking area for parents and many of them passed up the church lot in favor of closer parking on the street and in other lots. If parents were made aware that they are allowed and encouraged to park in the Pentecost Church lot, they would be more likely to do so.

The church parking lot contained 39 parking spots including two designated handicap-accessible spots. The paved area wrapped around the church and in many areas was not wide enough for two-way traffic. The lot was fenced in with two access points, both located on Blackstone River Road. The Southern access point was located at the Blackstone River Road-Stebbins Street signalized intersection. The Northern access point was located approximately halfway between the Stebbins Street intersection and the McKeon Road intersection. It was determined that the best way for traffic to flow through the lot was to instruct all cars to enter through the Southern access point. Vehicles traveling Northbound could easily turn right into the lot rather than parking on the street. Vehicles traveling Southbound would also be able to turn into the lot although this would be a bit more difficult because there is no left turn arrow at the intersection. Vehicles would be instructed to navigate the lot in a counterclockwise direction around the church. Vehicles exiting Northbound could use the Northern access point which would be labeled as “exit only” and “right turn only”. Vehicles could use the Southern access point to exit in any direction, including straight onto Stebbins Street (Figure 16).

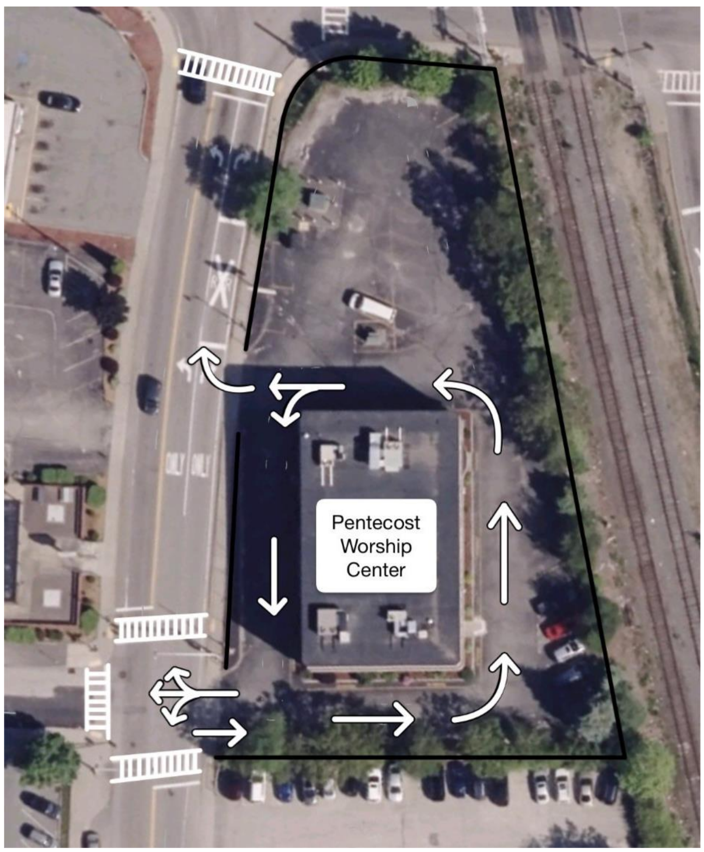


Figure 16: Traffic flow diagram at the Pentecost Worship Center parking lot.

Slip Lane

The slip lane located on Blackstone River Road in front of the Quinsigamond School was identified as a problem area, however, solutions were complicated. Double parking in the slip lane was viewed as both a problem and a solution by school staff and the MQP team. Double parking created more chaos for parents and students pulling in and out of the slip lane and put people and vehicles at risk. The way the slip lane was utilized changed between arrival and dismissal, so the problems needed to be addressed differently for the two times.

During morning arrival parents could drop off their child and leave, creating more movement in the slip lane. However, this movement did not deter parents who wanted to wait in the slip lane with their child in the car or let their child out and wait to watch their child enter the building. The proposed solution to this problem was utilizing a barrier to reduce the size of the slip lane, eliminating double parking. Parents would need to be told that they could not wait in the lane and someone, either a staff member or police officer, would be needed to direct traffic forward. To test if this method worked to address issues with efficiency and safety in the slip lane, cones would be used. These cones would be light enough that they could easily be removed if the method proved ineffective (Figure 17). Semi-permanent barriers were considered as a possible next step if the cones proved effective. However, this idea was rejected due to concerns about plowing and because it was determined that a barrier may cause additional problems during afternoon dismissal.

Figure 17: Diagram of cone placement in the Quinsigamond School slip lane.

At afternoon dismissal students were released from the building within a small window of time and many parents would show up prior to dismissal to wait for their children. Cones could be set up to prevent double parking; however, this would likely cause new problems. Parents who arrived early would not be able to quickly pick up their children and drive off to create room for the next parent. They would have to be parked in the slip lane and once the slip lane filled up it is possible that parents would wait behind the slip lane, blocking the Stebbins Street intersection and blocking traffic flowing through Blackstone River Road Southbound.

4.4 Objective 4: Implemented Temporary Phase of Design and Evaluated.

4.4.1 Implementation

Information about parking at the Pentecost Worship Center was distributed via a flyer which can be found in Appendix G. This flyer contained a statement about parking being available at the Pentecost Worship Center and diagrams showing where the parking lot is and how to navigate through it. The flyer also contained a QR code that leads to the Qualtrics survey where parents could answer questions about their habits during arrival and dismissal and voice their comments and concerns. The flyer was sent home with students to give to their parents and was also handed directly to parents by faculty during arrival and dismissal. This method of distribution was selected because information only distributed electronically had been receiving low engagement from parents. Handing the flyers to parents ensured that they would see the information even if it were just for a few seconds.

4.4.2 Evaluation

The flyers were distributed at the conclusion of this project causing there to be limited opportunities for evaluation of the success of this implementation plan. Conversations with parents and faculty indicate that the Pentecost Worship Center parking lot will be utilized more frequently in the future. The Quinsigamond School faculty has the opportunity to evaluate the success of this implementation over the next few months. Staff should continue to recommend the parking lot as an option for the rest of the school year. As the school year comes to an end Principal Lauren Racca and other staff members should discuss their observations. They should then consider if the parking lot was used by parents, the possible reasons why it was used or was not used, and if it was used what were the impacts on safety and congestion during arrival and dismissal.

If the use of the Pentecost Worship Center parking lot is determined to be a success, it should be integrated into an official arrival and dismissal plan and parents should be informed of this parking option at the start of each school year.

4.5 Objective 5: Provided recommendations for possible modifications to pick-up/drop-off plan and street/pedestrian infrastructure.

4.4.1 Education

Many of the observed issues involved how people interacted with the infrastructure. It was determined that since a lot of the problems were behavior-based, making sure all the stakeholders were educated on the protocol would help efficiency and safety.

A demonstration day before the school year starts is recommended. Parents already receive a parent guide with some instructions on the school pick up and dismissal process, but the group thinks another helpful step would be having the parents also go through the motions of morning drop off with staff directing on with the staff directing them. This is limited by the number of parents who are able to attend due to work, and also would be giving an additional job to the Quinsigamond School staff for the demonstration day, but the group thinks it still could be effective.

The group also recommends that the school starts offering some form of traffic safety education for the students. This can be done in the form of a partnership with an organization like Safe Routes to School or the Worcester Department of Transportation. Having students understand the function and uses of different pieces of infrastructure such as crosswalks will make them understand the processes of how they work and help pedestrians cross safely. Using a photo of the school block during one of these lessons would help students recognize and be aware of the crosswalks around the school, and hopefully point them out to their parents too.

4.4.2 Infrastructure

The group recommends using the Pentecostal Church Parking lot for parent parking, especially in cases where parents want to walk their child to the door because of its proximity to the crosswalk. This would allow parents a safe way to get their child to the door while utilizing the existing infrastructure. Figure 16 shows a more permanent version of this plan, with arrows painted in the lot to show the most efficient flow of traffic. Due to the shape of the parking lot, two-way traffic wouldn’t work because there isn’t enough room for two lanes. The school already has spoken and gotten consent from the church, the next step will be communicating this to the staff and parents so that it is utilized.

The group also found that cones could be used along the slip lane to prevent doubling parking and encourage the slip lane to act more as a queue of moving cars. This would be giving an additional job to a staff member who would need to physically put out and remove the cones every day. The cones couldn't be left out indefinitely because the city does routine street sweeping and plow snow in the winter. When talking with the city the group found that cones often get swept up and crushed in the process, so staff would have to only use the cones during the two dismissal and drop-off windows. Cars also have driven over cones the school has placed across the street in the past. With further communication with the city of Worcester, a police officer can conduct this traffic or even more long term; a permanent barrier could be installed that wouldn't be damaged by street sweeping and plowing.

Cones also are recommended as a visual reminder for cars not to block the shoulders of the driveway the buses use. The turning radius is already tight for the buses and parents being in the area in their vehicles make it more difficult for the bus drivers. A more permanent solution is adding a "Do Not Block Driveway" sign, along with modifying the driveway's entrance. This would include widening it through demolishing and redoing the sidewalk, and the removal or relocation of a small tree and the streetlight. This can be done by the city of Worcester.

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APPENDICES

APPENDIX A: MQP PROPOSAL

Improving Safety During Arrival and Dismissal for Students at the Quinsigamond School

Major Qualifying Project Proposal

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November 8, 2022

CAPSTONE DESIGN STATEMENT

The goal of this Major Qualifying Project is to make pedestrians, specifically students of Quinsigamond School and their guardians, safer during school drop-offs and pick-ups. Changes to operations and infrastructure will be recommended through conversations with stakeholders and designs created using AutoCAD software. The project will consider the following constraints: constructability, economic, ethical, environmental, health and safety, political, social, and sustainability.

Constructability

This project will include designing feasible changes to operations and infrastructure to increase safety for students and drivers at Quinsigamond Elementary School. The design will focus on effective changes that can realistically be implemented and maintained by the school staff.

Economic

Financial constraints will be considered for the design and implementation of this project. Elementary Schools and their staff do not have the budget, time, or jurisdiction to make permanent infrastructure changes. Recommended changes must also account for the availability of staff and the ability of the school to pay staff if operational changes alter hours (ex. Before school programs).

Ethical

This project is working directly with Quinsigamond Elementary School, but it will affect the entire surrounding area and community. While working on the project the group will think of how the design will affect the community, and how they are already being affected by the school's traffic. The group also needs to gather and present the data ethically complying with the ASCE Code of Standards. It ensures that everyone involved is treated with dignity, fairness, and respect. All research and engineering done will be done with the intention of bettering their community.

Environmental

This project will address air quality and carbon emissions caused by the school’s traffic and cars idling in front of the school during drop-off and pick-up periods. One of the final design’s aims is to have less air pollution through physical engineering design and communication with the parents on the school’s protocol.

Health and Safety

This project’s objective is to make school drop and pickup safer at Quinsigamond Elementary school. There is a concern about pedestrians and students crossing not at crosswalks to get to the front door, the buses, and cars idling and blocking traffic. Solutions for these issues will be recommended by the group.

Political

Input will be collected from Quinsigamond Elementary School staff, City of Worcester Officials, and parents. Collaboration between these groups will also be necessary to implement changes.

Social

This project will be working with Quinsigamond Elementary School to create a safer system for children getting to and from school. Safe and consistent access to education is essential in a community. To do this communication will be done with school staff and parents, along with working with the city of Worcester. There is no formal parent organization, so communication with families may have some restraints.

Sustainability

The three pillars of sustainability are social, environmental, and economical. This project will address them all. It will address air quality, safe access to education, and the economic restraints within Worcester schools.

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MISSION STATEMENT:

This Major Qualifying Project aims to make pedestrians, specifically students of Quinsigamond School and their guardians, safer during school drop-offs and pick-ups. The main safety concerns at the school relate to the surrounding traffic on Blackstone River Road. There are issues where parents double park and idle in front of the school waiting for the doors to open, blocking traffic, and making it difficult for cars to pull out. The school buses also have some trouble getting students to the school, specifically turning into the driveway. The turning radius is extremely tight for the buses. There also are people unsafely crossing the road without the use of either of the crosswalks. While these are the main issues, many other problems relating to traffic and stakeholder safety come up throughout this project. These problems will be solved through social and engineering solutions.

CHAPTER 1: INTRODUCTION:

Pedestrian safety and traffic congestion need to be addressed in the area surrounding Quinsigamond School. The school is located at 14 Blackstone River Rd, Worcester, MA 01607, and has a population of 745 students. The group's goal is to address the safety concerns surrounding school drop-off and pick-up. According to Principal Lauren Racca, a car accident occurred due to several cars being double parked outside the school last year. The collision occurred when a car was pulling out after dropping off their student and hit an open car door. The road's current traffic during drop-off and pick-up is a safety concern.

Not only is safety affected, but the surrounding businesses and areas are affected by the traffic. Surrounding businesses have complained of parents and other people dropping off their children using their parking spots according to the principal. The school is in a metropolitan area of Worcester, close to the College of Holy Cross and several businesses, including a Walmart Supercenter. Blackstone River is used often during people's commutes and by first responders.

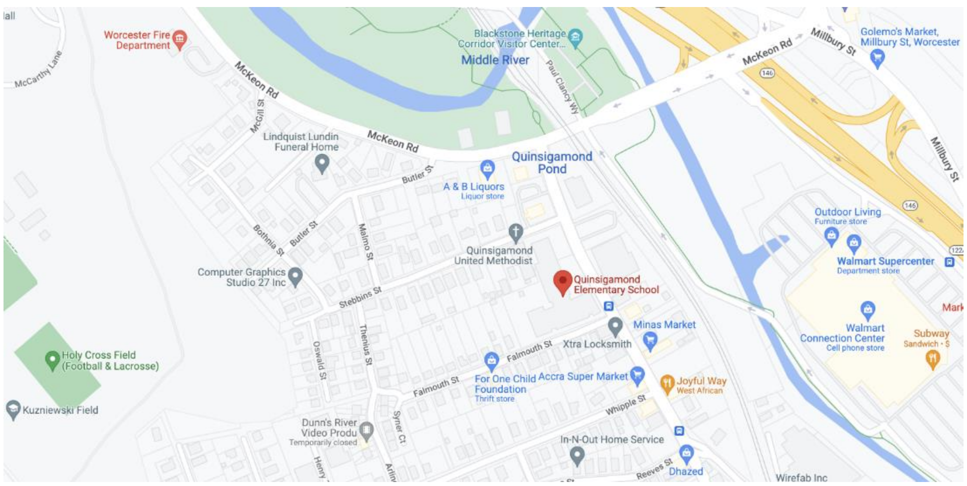


Figure 1: A Google Maps image of the streets and area around Quinsigamond Elementary School (Google Maps)

The group created five objectives to address and solve the problems brought by the stakeholders.

- Collect and evaluate data from the Quinsigamond Elementary School zone.
- Identify challenges caused by existing infrastructure.
- Develop several versions of engineering-based designs that can be transitionally implemented.
- Implement a temporary phase of design and evaluation.
- provide recommendations.

CHAPTER 2: BACKGROUND

Arrival and dismissal of schools result in increased traffic which can create issues with safety, pollution, and efficiency of travel flow. Arrival and dismissal operations organized by the school as well as car and pedestrian infrastructure have the potential to exacerbate or mitigate these issues. Quinsigamond School experiences many traffic and safety issues that may be resolved through operational changes and infrastructure improvements. This chapter provides background on Quinsigamond School and the problems it faces. Information about best practices for street design and infrastructure is also provided in this chapter. These practices focus on pedestrian calming and speed reduction.

2.1 Quinsigamond School

2.1.1 Overview and Procedures

Quinsigamond School is in the Quinsigamond Village neighborhood of Worcester, MA, and is attended by students in pre-k to sixth grade. The school is located on Blackstone River Road and the property is bordered by Stebbins Street to the North and Falmouth Street to the South (Figure 2).

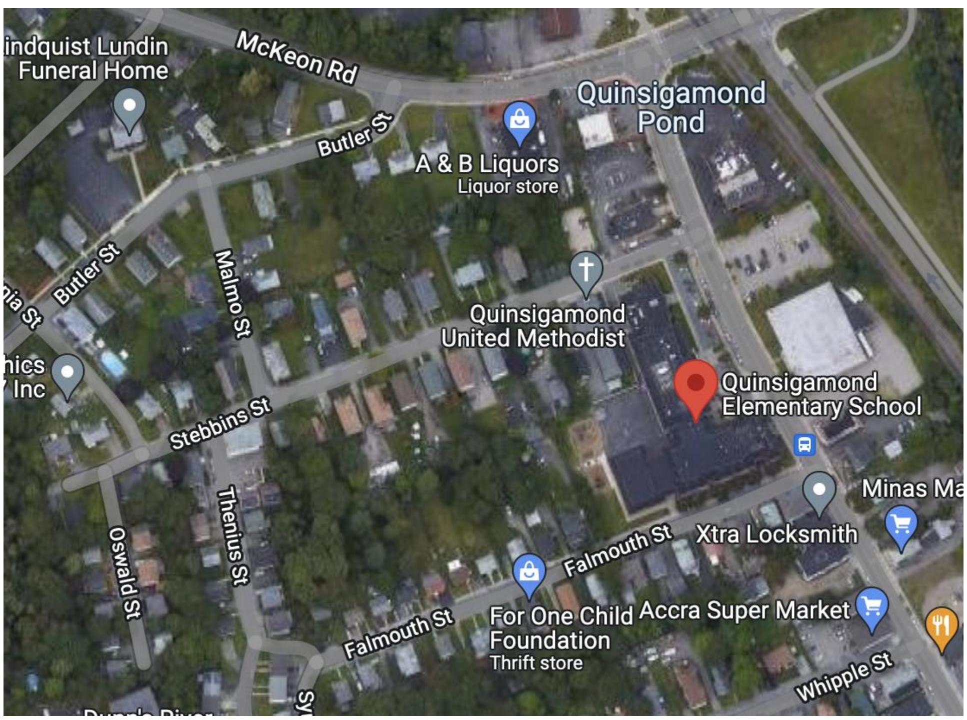


Figure 2: Map of Quinsigamond Elementary School and surrounding properties (Google Maps)

The student base is predominantly labeled as “High Needs" with a majority of students coming from low-income families where English is not their first language (Massachusetts School and District Profiles). According to the Quinsigamond School Family Handbook, transportation via bus is provided for students but they may also walk or be driven to school by a parent or guardian. School begins at 8:25 am and students are marked tardy if they arrive after 8:30 am. Students may enter the building at 8:15 am at the earliest. The Quinsigamond School Family Handbook states that there is no supervision for students who have walked or are dropped off until 8:15 am however, due to safety concerns, staff members have been waiting outside and supervising students who arrive before 8:15 am.

Along Blackstone River Road, in front of the school, there is a shoulder area used by parents for drop-offs. Running parallel to this shoulder is an entry driveway utilized by buses that has an entrance on Stebbins Street and an exit on Blackstone River Road (Figure 3). Seven buses drop off and pick up students at the entry driveway in front of Quinsigamond School. Nine special education buses drop off and pick up along Falmouth St., so these students have easy access to the Special Education classrooms. All the buses run in phases, serving multiple schools throughout Worcester. As a result, a delay occurring during an early phase will cause delays for all the following phases.

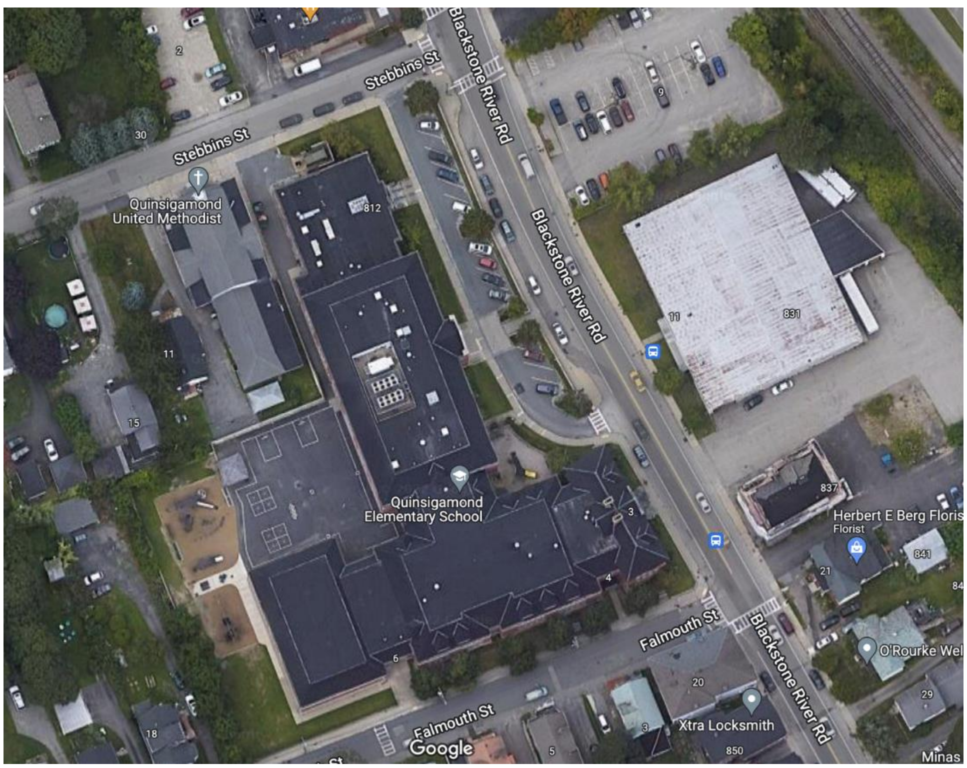


Figure 3: Aerial view of Quinsigamond Elementary School (Google Maps)

During morning drop-off parents and guardians may pull onto the shoulder along Blackstone River Rd. and can also pull over along Stebbins St. and Falmouth St. to unload students. All students, apart from Special Education bus students, enter the school through the front entrance.

During afternoon dismissal the buses operate the same as they do during morning drop-off. Dismissal for students who are walking or being picked up by parents and guardians in cars is slightly different. Kindergarten and first-grade students must be dismissed out of the front door and are individually brought to their parent or guardian by Quinsigamond School staff. Second-grade through sixth-grade students may be dismissed from the front door, the door on Stebbins St., or the door on Falmouth St. According to assistant principal Lauren Racca there are approximately 740 students enrolled at Quinsigamond Elementary School. Approximately 75 students are dismissed from the Stebbins St. door and approximately 100 students are dismissed from the Falmouth St. door in addition to the 36 students that are dismissed to the Special Education buses (Quinsigamond School Family Handbook).

2.1.2 Problems and Risks

Quinsigamond Elementary School students and parents are exposed to and contribute to traffic problems and safety risks. Heavy through traffic, limited pedestrian infrastructure, insufficient drop-off and pick-up space, and tight turning radius for buses have created a dangerous and overwhelming environment for students, parents, staff, and drivers. Existing conditions such as limited road options going North from Quinsigamond Village towards central Worcester contribute to high traffic volumes along Blackstone River Road. The wide shoulder outside of the front of Quinsigamond Elementary School enables parents to double up parking, causing additional congestion. Parents frequently drop students on the opposite side of the street due to a lack of sufficient drop-off and pick-up space and difficulties turning around along Blackstone River Road. Students must then cross dangerous traffic, oftentimes not walking down the road to the existing crosswalks. The turning radius entering and exiting the school's front driveway is too tight for buses, forcing bus drivers to make slow, difficult turns and often leading to them running over curbs and sidewalks. The location of two signalized intersections close to the school creates added confusion as school traffic is backed up through them. Many parents arrive before the school doors are open but wait to leave until after they have seen their child enter the building, even though there are staff members monitoring students in front of the building. This causes the school traffic to become a standstill, blocking the road to through traffic and promoting dangerous behavior from parents and drivers passing through. The improper flow of traffic and right of way between parents, buses, pedestrians, and through drivers causes dangerous conditions that existing infrastructure enables rather than prevents.

2.2 Infrastructure

2.2.1 Elements of Urban Design

Streets

Streets are a crucial part of transportation in the United States. They are utilized by various modes of transportation, including foot, bicycle, car, and transit, and should be designed with priority placed on efficiency and safety. Streets can be changed and should be designed and adapted with the recognition that urban environments and needs are constantly changing. Changes may include moving curbs and alignments, altering lane width, and redirecting traffic. Streets should be designed with consideration for the existing environment and natural environment. Man-made elements should be designed to interact with natural elements such as rain and stormwater (NACTO - Streets).

Intersections

Intersections are necessary connection points for streets but can increase safety risks for pedestrians, drivers, and transit. Well-designed intersections should reduce crashes, work efficiently, and balance the right of way among all users. Movements within an intersection should feel safe, easy, and intuitive for all users and promote eye contact between them for increased awareness. A compact design addresses these needs and slows traffic near contact points. Excess space left from adjusting the street to be more compact can be utilized for sidewalks and as public spaces and plazas. Traffic signals are utilized to solve issues with delay and congestion without widening roads. When designed well they should make movements easier and limit confusion about the right of way. Intersections and traffic signals operating within them should be designed as part of a network with coordination between other intersections and traffic signals (NACTO - Intersections).

Design Controls

Design controls are elements included in a design that can promote certain driver and pedestrian behavior. There are two categories of design types: passive design and proactive design. Passive design accounts for worst-case scenarios and when applied to street design the scenarios focus on reckless and dangerous driving. Wide roads with many lanes, overdesigned buffers, and large setbacks are examples of passive design (Figure 4). Passive design in traffic engineering can inadvertently encourage reckless and dangerous driver behaviors from drivers that would otherwise drive safely. Narrow lanes and minimal setbacks are examples of proactive design that keep drivers alert and cautious (Figure 5). Proactive design acknowledges that human behavior is adaptable. Design elements are used to change driver and pedestrian behavior to be safer and meet the desired outcome (NACTO - Design Controls).

Figure 5

Figure 6

Figure 5 (Left): Passive street design (NACTO - Design Controls

Figure 6 (Right): Proactive street design (NACTO – Design Controls)

2.2.2 Traffic Calming

Street and intersection design and changes should be completed with the goal of lowering injuries and fatalities, especially in cities. According to data from the National Highway Traffic Safety Administration in urban areas in the United States on average 146 people are killed every day in traffic-related accidents. Speeding and distracted driving are two major contributors to traffic injuries and fatalities for drivers and pedestrians. Higher speeds are directly linked to higher crash risk and severity of injuries. This correlation is documented in Table 1. Proactive design utilizing speed control mechanisms can be implemented to lower driving speeds and keep drivers alert (NACTO - Design Speed).

SPEED (MPH)	STOPPING DISTANCE (FT)*	CRASH RISK (%)†	FATALITY RISK (%)†
10–15	25	5	2
20–25	40	15	5
30–35	75	55	45
40+	118	90	85

* Stopping Distance includes perception, reaction, and braking times.

† Source: Traditional Neighborhood Development: Street Design Guidelines (1999), ITE Transportation Planning Council Committee 5P-8.

Table 1: Driving speed fatality risk chart (NACTO – Design Speed)

Speed Reduction

Several different infrastructure projects can be completed to reduce speeding (Table 2). These infrastructure types are examples of proactive design that adapt human behavior to be safer by creating visual obstacles that keep drivers more alert and cautious.

Type	Description	Image	Applicability
Median	-Reduces width, creating a pinch point. -Creates a visual obstacle for drivers, keeping them alert -Shorten walking distance for pedestrians		Could be used to narrow lanes which would prevent drivers from pulling over/turning around where they shouldn’t

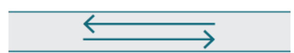
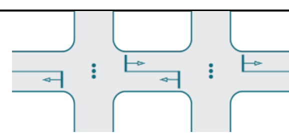
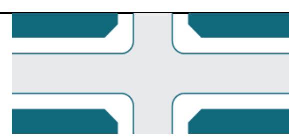
Pinch point/Choker	-Reduce lane width, like medians. -Allows for more sidewalk space for pedestrians		Could be used to narrow lanes which would prevent drivers from pulling over/turning around where they shouldn't. Already exists by drop off shoulder exit
Chicane	-Visual obstacle alerts driver -Created with parking or curb extensions		Slow down/alert drivers
Lane Shift	-Obstacle that alerts driver		Slow down/alert drivers
Speed Hump	-vertically deflect vehicle, alert driver and slows down vehicle -useful near sidewalks		Slow down drivers, alert them to crossing areas. It is not usable on Blackstone River Rd because it is not a school-owned road
Two-Way Street	-Oncoming traffic encourages drivers to be more careful, especially when streets are narrow		Already a two-way street
Signal Progression	-Coordinated signals timed with speed limits can slow down drivers		There are two signalized intersections very close to the school on Blackstone River Rd
Building Lines	-Densely built environments with minimal setbacks encourage alertness		Relatively densely built environment with minimal setbacks

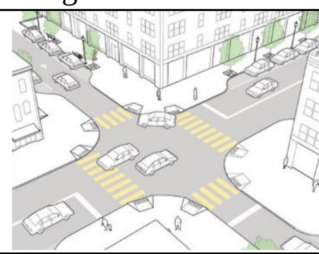
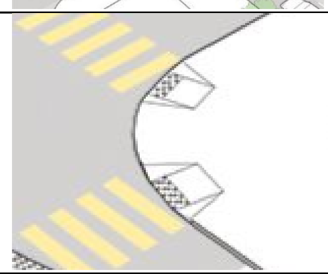
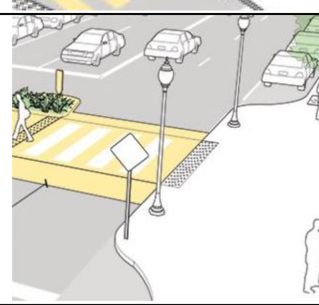
Table 2: Speed reduction infrastructure (NACTO – Streets)

Crosswalks and Crossings

Crosswalks should be designed to protect pedestrians and make them feel comfortable. Crossing distance and location are important aspects of pedestrian comfort that should be considered. All signalized crossings should have highly visible striping that is as wide or wider than the sidewalk it is connected to. This allows pedestrians to pass each other without leaving the crosswalk area. High-visibility striping is more likely to be noticed by drivers, causing them to be more cautious.

Accessible curb ramps must be constructed at all crossings to meet requirements set by the Americans with Disabilities Act (ADA) and to create a safer and more accessible environment for all (NACTO – Intersections). Curb ramp design includes a ramp portion, transitions, and flared sides. The ramp run must be at least 36" wide. A curb ramp is generally required to have a slope of 8.33 percent (1:12) or less. However, A ramp with a rise of six inches or less may have a slope of 10 percent (1:10), and a ramp with a rise of three inches or less may have a slope of 12.5 percent (1:8). Street lighting is another important feature that should be located at or near intersections to help drivers see pedestrians during times of lower visibility (ADA).

Crosswalks located at an intersection are conventional crosswalks. These crosswalks should be designed as compactly as possible so that pedestrians are located within the driver's line of vision. Several features can be incorporated into conventional crosswalks to make them safer for pedestrians (Table 3).

Feature	Description	Image
High-Visibility Ladder, Zebra, and Continental Crosswalk Markings	-Preferable to standard parallel or dashed markings -More visible to drivers	
Accessible Curb Ramps	-Required by the Americans with Disabilities Act (ADA)	
Short Crossing Distances	-Use tight turning radii, curb extensions, and medians	

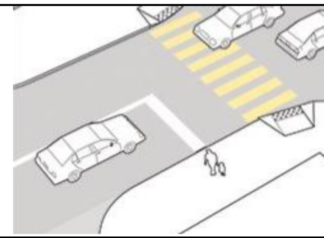
Advanced Stop Bar	-Should be at least eight feet in advance of crosswalk	

Table 3: Safety Features for conventional crosswalks (NACTO – Intersections)

Crosswalks located at a midblock are midblock crosswalks. Existing and projected pedestrian volumes should be considered when determining the location and design for this type of intersection. Several features can be incorporated into midblock crosswalks to make them safer for pedestrians (Table 4).

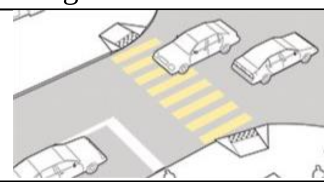
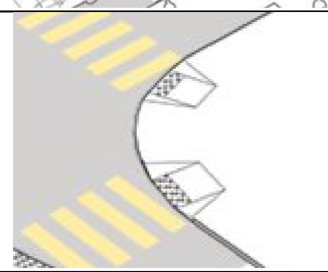
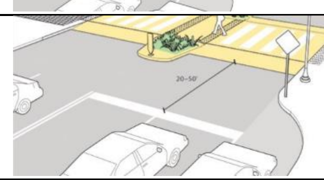
Feature	Description	Image
Crosswalk Markings	-Stripe (pattern type is less important than at intersection crossings)	
Accessible Curb Ramps	-Required by the Americans with Disabilities Act (ADA)	
Short Crossing Distances	-Use Curb Extensions and Medians	
Advanced Stop Bar	-Should be twenty to fifty feet in advance of crosswalk	

Table 4: Safety Features for Midblock Crosswalks (NACTO – Intersections)

CHAPTER 3: METHODS

This project aims to make drop-offs and pick-ups at Quinsigamond Elementary school safer for all involved stakeholders. This will be done through communication with the city of Worcester and the school, along with engineering design.

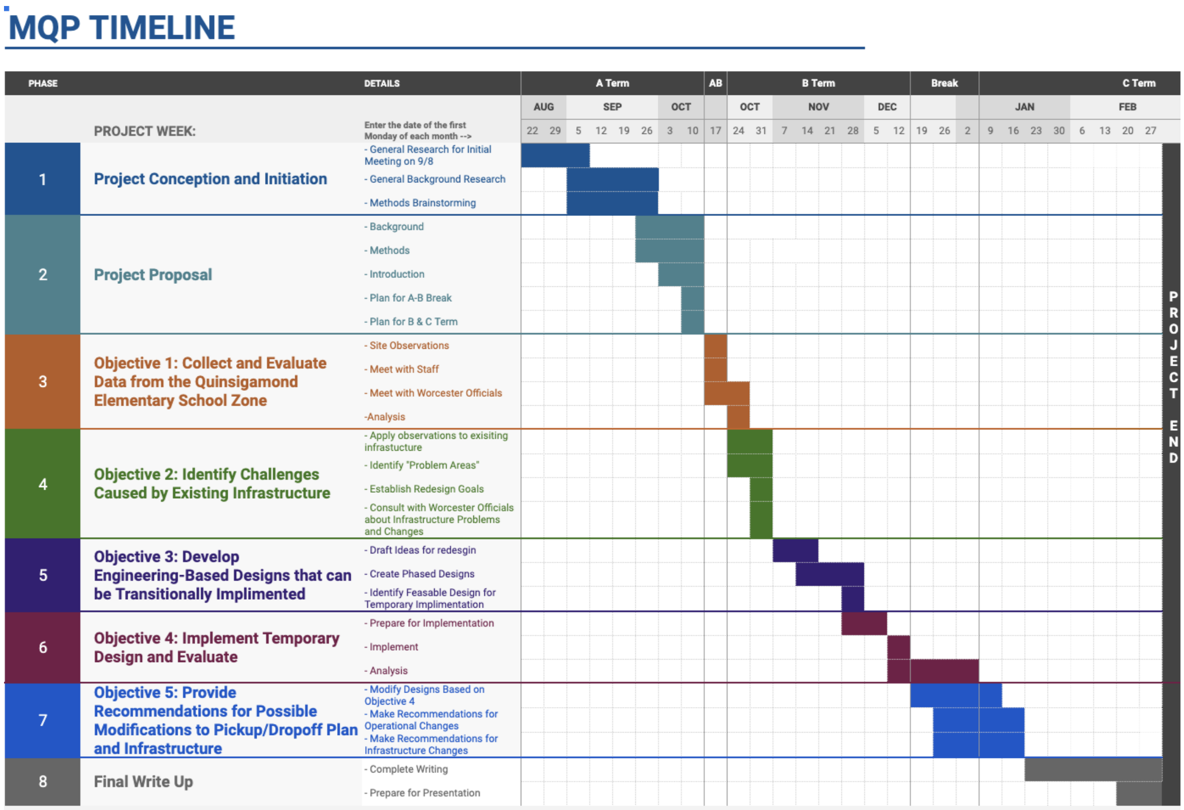


Figure 6: Gantt chart showing the intended timeline for completion of each task.

3.1 Objective 1: Collect and evaluate data from the Quinsigamond School zone.

3.1.1 Observations of Existing Conditions

During the data collection period, several observational visits will be done in the mornings and afternoons. Doors at the school open at 8:15 in the morning, and the group will be able to observe the morning school drop-off starting at 8:00 AM. This visit's purpose is to confirm the observations made by Lauren Racca. The group will have a traffic camera placed inside the school in front of a window facing Blackstone River Road. The camera will be on school property, making it safer from vandals, the elements. The camera will capture in front of the school so the group will be able to get images and videos over a longer period of time.

In reviewing the footage, the group will be able to watch the traffic patterns and make observations about behavior during the entire pick and drop-off periods. Observations will identify trends in how the existing infrastructure is utilized. Still images can be taken from the video to visualize the problems the group sees in the final report.

The group also plans to make physical visits to the school to make qualitative observations. These will include how many students they see waiting outside the school, the amount of traffic the group observes, and any other relevant details to school pick-up and drop-off. During this physical visit, the group also will talk with the principals. They can give the group things to look out for, or other observations they have from lived experience. The traffic camera will be facing the front of the school. The group will split up the two side streets so that what isn't in the camera's view can be observed by the group.

3.1.2 Organization and Analysis Methods

Mapping technology will be used for the analysis of the group's data, and as a tool to observe the location. The group will use Google Maps to get a 2-D bird's eye view of Quinsigamond elementary school to see the surrounding streets, parking, and bus area. It also will provide the location of the surrounding crosswalks and traffic lights, along with giving the group a better sense of the area the school is in.

ArcGIS is a geographic information system that can be useful in mapping and simulating different traffic patterns. The system has several city streets maps already available and can generate different traffic scenarios and evaluate them on safety. While it wouldn't be possible within the time frame to perfectly model the traffic at Quinsigamond Elementary, simpler scenarios can be modeled (About Arcgis: Mapping & Analytics Software and Services).

QGIS is another geographic information system that is useful for visualizing data on a map. The program also has traffic and street data available. QGIS, along with US Census data, is free to download online also which makes it a great resource. Our group will utilize these programs for engineering design and social solutions to ensure pick-up and drop-off are done safely (Arcgis vs QGIS).

The group also will analyze Mass DOT crash data, which is publicly available on the mass.gov website. There are several interactive ways for the group to look at car collisions. There are maps that layer's crash data over the state, or can be zoomed into towns or streets, along with dashboards and filtered search. The group will use this to look at car collisions in the area surrounding the school, along with looking for any other trends that appear in school zones or the Quinsigamond Elementary School area (Commonwealth of Massachusetts).

3.2 Objective 2: Identify challenges caused by existing infrastructure.

Our group wants to overall make drop-offs and pick-ups in the school zone safer. To do that all traffic problems need to be addressed such as the infrastructure itself, pedestrian safety while crossing the road to school, and the overall traffic congestion caused during school drop-off and pick-up. The observations done during site visits will show the group where the problem areas are that need to be addressed. Different solutions will be considered based on stakeholder feedback and observed data collection.

As the design is right now, the buses must turn from Blackstone River Road into the bus lane. The turn radius is very tight, and the buses often must drive over the curb to get to the driveway as referenced in the background. To observe this, the group will look at that area during a site visit. The group also will have access to cameras that may be able to see this. The group will also need to measure the turn radius of the driveway. This can be done through a variety of surveying methods or can be obtained from any existing plans of the front of the school.

3.3 Objective 3: Develop Engineering-Based Designs that can be Transitionally Implemented.

Once high-impact “problem areas” have been identified, modifications to these areas will be designed to create a safer environment. The design will be affected by existing infrastructure and conditions, similar case studies, and standard traffic-engineering infrastructure approaches. Designs will be created in phases, with the earlier phases being short-term changes feasible for the school staff to implement, and the later phases being more permanent changes that can be implemented by the city. Input from officials in the City of Worcester will help guide the design process. The design will be created using AutoCAD software including Civil 3D.

3.4 Objective 4: Implement Temporary Phase of Design and Evaluate.

3.4.1 Implementation

Identify an effective and feasible temporary operation/design change. Once the design is selected the temporary phase will be implemented at the school. Coordination between Quinsigamond Elementary School staff, parents, and bus drivers will be necessary. There will be communication with the Worcester Police Department on how this temporary design can be safely implemented. Depending on their feedback and observations, more coordination may be necessary.

3.4.2 Evaluation

An evaluation of the temporary operation/design change will be completed. This evaluation will be based on our observations and feedback from staff and parents. A focus group of school staff and parents will be conducted. A survey will also be distributed to parents where they will rate the safety and efficiency of morning drop-off with the original system and the newly implemented temporary system. The change will be implemented with the help and collaboration of the school. Any protocol changes will need to be communicated to the parents by the school. The group will compare the safety and efficiency of the new operation and design to the old system. They will identify ways in which the new design has addressed and solved problems identified earlier in the project. We will also examine potential problems that have been created by this design and attempt to mitigate them.

3.5 Objective 5: Provide recommendations for possible modifications to pick-up/drop-off plan and street/pedestrian infrastructure.

After the evaluation of the design change is done, the group will analyze and address any problems or potential problems. A recommendation of the most ideal system for the school will be made. The recommendation will be comprised of the results of the temporary design change. If the changes involve the city the group will provide recommendations to the contact in the city of Worcester along with Quinsigamond School.

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APPENDIX B: ARRIVAL AND DISMISSAL OBSERVATIONS

The MQP team conducted observations via in person site visits at least once a month from September 2022 to March 2023. Observations were made anytime between 7:30 - 9:30 am and 1:15 - 4:00 pm, with the only exception being the 12:00 - 1:00 pm initial site visit with Principal Lauren Racca.

Table 5: Quinsigamond School site visits

Visit Type	**Date**	**Day of Week**	**Time**	**AM/ PM**	**Weather**	**Avg. Temp.**	**Other Info**
Initial Site Visit / overview with L. Racca	9/8/22	Thurs.	12:00 - 1:00	PM	Fair	68°F	
Observations	9/14/22	Wed.	8:00 - 9:00	AM	Fair	58°F	
Observations	10/21/22	Fri.	7:30 - 9:30	AM	Fair	42°F	
Observations	11/16/22	Wed.	1:30 - 3:30	PM	Fog	43°F	
TMC + Observations	1/24/23	Tues.	2:00 - 4:00	PM	Cloudy	34°F	Snow on the ground, mostly cleared.
Observations	1/31/23	Tues.	7:30 - 9:00	AM	Light Snow	24°F	
Observations	1/31/23	Tues.	1:30 - 3:00	PM	Partly Cloudy	34°F	
Observations	2/7/23	Tues.	2:00 - 4:00	PM	Fair	34°F	
TMC + Observations	2/9/23	Thurs.	8:00 - 9:00	AM	Fair	35°F	

TMC + Observations	2/24/23	Fri.	2:15 - 3:15	PM	Cloudy / Windy	26°F	No School
TMC + Observations	3/22/23	Wed.	1:15 - 3:15	AM	Fair	54°F	

Overview of Observations - Stebbins Street

Existing Conditions

Accessibility

At the intersection of Blackstone River Road and Stebbins Street there are curb ramps with flared sides and ADA pads at the crosswalk that crosses Stebbins Street. At the school driveway entrance, there are diagonal curb ramps with flared sides.

Sidewalks

There are sidewalks on both sides of Stebbins Street that are adjacent to the road with no grass strip separation. These sidewalks are in good condition however, there is some overgrowth from shrubbery to the West of the school and cracks from tree roots.

Signage

There are no school zone or children crossing signs on Stebbins Street. There is no posted speed limit so the speed limit would be 30 mph as this is a residential street and would be classified as a “thickly settled” zone. However, school zones have a maximum speed limit of 20 mph.

Along the Northern side of Stebbins Street, there are “No Parking Anytime” signs spanning from the intersection of Blackstone River Road and Stebbins Street to the Quinsigamond United Methodist Church parking lot.

Parking

Street parking is available along the southern side of Stebbins Street and is available on the northern side west of the Quinsigamond United Methodist Church parking lot.

The Quinsigamond United Methodist Church has given the Quinsigamond School faculty and staff permission to utilize their parking lot. This parking lot does not have additional space for parents to park or idle.

Behavior - Morning Arrival

Driver

It was observed that Stebbins Street did not receive much traffic and there were not many parents that dropped off students there in the morning. Parents that did drop off students at Stebbins Street parked on the side of the road next to the school.

Pedestrian

It was observed that there were not many pedestrians on Stebbins Street during morning arrival. There were a few students that were dropped off by their parents. Some students were walked to the front doors of the school by their parents and others walked by themselves. Pedestrians were observed using pedestrian infrastructure including sidewalks and crosswalks. Pedestrians that crossed at the intersection of Blackstone River Road and Stebbins Street did not always wait for the pedestrian walk signal before crossing.

Behavior - Afternoon Dismissal

Driver

It was observed that Stebbins Street received more traffic and was utilized more by parents at afternoon dismissal than at morning arrival. Parents parked on both sides of Stebbins Street and were observed parking on the sidewalk to avoid blocking the traffic flow.

Pedestrian

It was observed that there were more pedestrians on Stebbins Street during afternoon dismissal than at morning arrival. Students exiting from the Stebbins Street doors would often meet their parents on this street. Pedestrians were observed using pedestrian infrastructure including sidewalks and crosswalks. However, pedestrians were also observed crossing farther up Stebbins Street at the midblock. Pedestrians that crossed at the intersection of Blackstone River Road and Stebbins Street did not always wait for the pedestrian walk signal before crossing.

Overview of Observations - Falmouth Street

Existing Conditions

Accessibility

At the intersection of Blackstone River Road and Falmouth Street there are diagonal curb ramps with flared sides and ADA pads at the crosswalk that crosses Falmouth Street. At the

Quinsigamond School Falmouth Street door, there is a curb ramp with flared sides and an ADA pad. There is a sidewalk that does not line up with the curb ramp.

Sidewalks

There are sidewalks on both sides of Falmouth Street that are adjacent to the road with no grass strip separation. The sidewalks directly outside of the school on the Northern side of Falmouth Street are wide and in good condition. The sidewalks on the Southern side of Falmouth Street and the sidewalks West of the school on both sides of the street are overgrown from shrubbery and there are cracks from tree roots.

Signage

There are no school zone or children crossing signs on Falmouth Street. There is no posted speed limit so the speed limit would be 30 mph as this is a residential street and would be classified as a “thickly settled” zone. However, school zones have a maximum speed limit of 20 mph.

Along the Northern side of Falmouth Street, there are “No Parking Anytime” signs spanning from the intersection of Blackstone River Road and Falmouth Street past the Quinsigamond School property. On the Southern side of Falmouth Street, there are no “No Parking 8 AM - 3 PM School Days” signs spanning from the intersection of Blackstone River Road and Falmouth Street to the second building on Falmouth Street. There are “Parking by Resident Permit Only” signs starting at this point and pointing past the Quinsigamond School property.

Parking

There is no designated area for public street parking along Falmouth Street. All areas contain signage indicating that parking is not allowed or requires resident permits.

Behavior - Morning Arrival

Driver

It was observed that Falmouth Street did not receive much traffic and there were not many parents that dropped off students there in the morning. Parents that did drop off students at Falmouth Street parked on the side of the road next to the school.

Pedestrian

It was observed that there were not many pedestrians on Falmouth Street during morning arrival. There were a few students that were dropped off by their parents. Some students were walked to the front doors of the school by their parents and others walked by themselves. Pedestrians were observed using pedestrian infrastructure including sidewalks and crosswalks.

Behavior - Afternoon Dismissal

Driver

It was observed that Falmouth Street received more traffic and was utilized more by parents at afternoon dismissal than at morning arrival. Parents parked on both sides of Falmouth Street to pick up students leaving from the Falmouth Street exit and the Blackstone River Road South exit.

Pedestrian

It was observed that there were more pedestrians on Falmouth Street during afternoon dismissal than at morning arrival. Students exiting from the Falmouth Street doors would often meet their parents on this street. Parents also walked from their cars on Falmouth Street to the Blackstone River Road South doors to pick up students exiting there. Pedestrians were observed using pedestrian infrastructure including sidewalks and crosswalks. However, pedestrians were also observed crossing farther up Falmouth Street at the midblock.

Overview of Observations - Blackstone River Road

Existing Conditions

Accessibility

The signalized T-intersection of Blackstone River Road and Stebbins Street contains curb ramps with flared sides and ADA pads, high-visibility ladder crosswalk markings, and a standard pedestrian signal head. There are pedestrian crossing signs located just North and South of the intersection to alert oncoming traffic. The T-intersection of Blackstone River Road and Falmouth Street contains diagonal curb ramps with flared sides and ADA pads, high-visibility ladder crosswalk markings, and pedestrian crossing signs with push-button-activated flashing lights.

At the school driveway exit, there are curb ramps with flared sides and a high-visibility ladder crosswalk. In front of the main entrance of the Quinsigamond School, there is a wide pedestrian ramp with railings that cuts through the island between Blackstone River Road and the school driveway.

Sidewalks

There are sidewalks on both sides of Stebbins Street that are adjacent to the road with no grass strip separation. These sidewalks are in good condition however, there are areas where vegetation is encroaching on the sidewalk.

Signage

The is a “School Zone” sign located at the Northern end of Blackstone River Road and another located just North of the intersection of Blackstone River Road and Greenwood Street. The signs state that the speed limit is 20 mph from 7:30 AM to 8:30 AM and 2:30 PM to 3:30 PM on school days.

There are pedestrian crossing signs facing the Northbound and Southbound direction at the intersection of Blackstone River Road and Stebbins Street and the intersection of Blackstone River Road and Falmouth Street.

There are “No Parking Anytime” signs across from the driveway exit and North of the slip lane. There are “Do Not Enter” signs located at the Quinsigamond School driveway exit.

Parking

Street parking is available in the slip lane outside of the Quinsigamond School and on a portion of the road shoulder across the street and south of the slip lane. There is a faculty parking lot located across Blackstone River Road.

The Church of Pentecost has given the Quinsigamond School faculty, staff, and parents permission to utilize their parking lot.

Behavior - Morning Arrival

Driver

Significant congestion was observed along Blackstone River Road during morning arrival. The congestion was caused by parent drop-off and traffic passing through the neighborhood. Occasionally emergency vehicles and the blockage of Mckeon Street by trains also added to the congestion.

Parents were observed pulling into the slip lane to drop off their students. Some parents would take a U-turn to pull into the slip lane. They often double-parked their vehicles, trapping drivers who wanted to quickly drop off their students and leave. Some parents were observed parking their vehicles and walking their students to the front doors of the school. Parents were also observed waiting in the slip lane in their parked vehicles for their students to enter the building. When vehicles at the front of the slip lane pulled out vehicles farther back did not always pull up to the front. When the slip lane filled up with vehicles parents were observed parking on the shoulder of the road behind and ahead of the slip lane.

Parents heading Northbound on Blackstone River Road were observed parking and idling on the shoulder of the road to drop off their students. Some parents were observed letting their students out of the car when stopped at a red light.

During heavy congestion, drivers were observed blocking the driveway exit while waiting to move forward. This made it very difficult for buses to exit. It was also observed that drivers would park their vehicles on the shoulder directly across from the driveway exit which also made it difficult for buses to exit.

Parents were also observed parking in the faculty lot or leaving their vehicles in the drive-through space of the parking lot.

Pedestrian

Many pedestrians were observed on Blackstone River Road during morning arrival. Most of these pedestrians were students and their parents.

Parents who parked on the shoulder of the street across from the school or in the faculty lot were often observed crossing the street at the midblock rather than at the crosswalk. Faculty who parked in the faculty lot were also frequently observed crossing at the midblock. Pedestrians who did cross at the crosswalk did not always wait for the pedestrian signal before walking. During most of the observational days, there was no crossing guard at the intersection of Blackstone River Road and Stebbins Street. On the days that a crossing guard was there, it was observed that the crossing guard would stop traffic to allow students and parents to cross rather than wait for the pedestrian signal.

Behavior - Afternoon Dismissal

Driver

Significant congestion was observed along Blackstone River Road during afternoon dismissal. The congestion was caused by parent drop-off and traffic passing through the neighborhood. Occasionally emergency vehicles and the blockage of Mckeon Street by trains also added to the congestion.

Parents were observed pulling into the slip lane to pick up their students. Some parents would take a U-turn to pull into the slip lane. They often double-parked their vehicles, trapping drivers who already had their students brought to their cars. When vehicles at the front of the slip lane pulled out vehicles farther back did not always pull up to the front. When the slip lane filled up with vehicles parents were observed parking on the shoulder of the road behind and ahead of the slip lane.

Parents heading Northbound on Blackstone River Road were observed parking and idling on the shoulder of the road to pick up their students.

During heavy congestion, drivers were observed blocking the driveway exit while waiting to move forward. This made it very difficult for buses to exit. It was also observed that drivers would park their vehicles on the shoulder directly across from the driveway exit which also made it difficult for buses to exit.

Parents were also observed parking in the faculty lot and at the Gold Coast Catering and Restaurant lot, or leaving their vehicles in the drive-through space of those parking lots. During afternoon dismissal there were a couple of parents who parked in the Pentecost Church parking lot.

Pedestrian

Many pedestrians were observed on Blackstone River Road during afternoon dismissal. Most of these pedestrians were students and their parents.

Parents who parked on the shoulder of the street across from the school or in the faculty lot were often observed crossing the street at the midblock rather than at the crosswalk. Faculty who parked in the faculty lot were also frequently observed crossing at the midblock. Pedestrians who did cross at the crosswalk did not always wait for the pedestrian signal before walking. During most of the observational days, there was no crossing guard at the intersection of Blackstone River Road and Stebbins Street. On the days that a crossing guard was there, it was observed that the crossing guard would stop traffic to allow students and parents to cross rather than wait for the pedestrian signal.

Parents and students that parked in the Pentecost Church lot were observed crossing at the crosswalk because the crosswalk is located directly between the church and the school.

APPENDIX C: TURNING MOVEMENT DATA

The MQP team collected turning movement counts at the intersection of Blackstone River Road and Stebbins Street. Turning movement counts were collected in the morning from 8:00 am to 9:00 am and in the afternoon from 2:00 pm to 4:00 pm. The turning movement counts show the direction that vehicles are heading and for each direction show the number of vehicles that turned left, the number of vehicles that continued straight, and the number of vehicles that turned right. The recorded data is displayed in 15-minute intervals. The number of pedestrians and the directions they went were also recorded. For one of the counts, the number of heavy vehicles was also recorded.

Overview of Calculations

The total volume of vehicles that passed through the intersection at each 15-minute interval was calculated. Then, the sum of four consecutive intervals was calculated to determine the volume of vehicles that passed through the intersection in the previous hour. The hour with the largest volume of vehicles was the peak hour. The peak hour factor (PHF) is a measure of how well the volume of traffic is dispersed over the peak hour. The busiest 15-minute interval of the peak hour is compared with the total volume of the peak hour using the following equation:

$$PHF = \text{Total hourly volume} / (4 * \text{Peak 15-minutes within the hour})$$

The largest possible peak hour factor is 1, which indicates that traffic volumes were the same for each 15-minute interval of the hour. Lower peak hour factors indicate that there was inconsistent traffic flow across the four 15-minute intervals of the hour. Freeways typically have peak hour factors of between 0.80 and 0.95. During peak hours, urban and suburban areas typically experience traffic volumes represented by higher peak hour factors (University of Idaho, n.d.).

The percentage of heavy vehicles was determined by dividing the number of heavy vehicles that entered the intersection during the peak hour by the total number of vehicles that entered the intersection during the peak hour.

Collected Data:

Turning Movement Count

Municipality: City of Worcester
Location: Blackstone River Road / Stebbins St
Weather: PM: Cloudy 34°F

Date: 1/24/2023
Day of the Week: Tuesday

Start Time	Blackstone River Rd NB				Stebbins St EB				Blackstone River Rd SB				Church Parking Lot WB				Vehicle	Hour
(PM)	L	S	R	PED	L	S	R	PED	L	S	R	PED	L	S	R	PED	Total	Total
14:00	4	85	0	3	6	0	3	3	0	112	4	4	0	0	0	0	214	
14:15	3	109	0	3	19	0	5	11	0	131	1	1	2	0	1	0	271	
14:30	2	129	0	0	6	0	5	16	0	143	2	0	0	0	0	0	287	
14:45	2	147	0	2	7	0	2	6	0	148	2	2	0	0	0	0	**308**	1080
15:00	3	154	0	0	3	0	2	5	0	118	1	0	0	0	0	0	281	**1147**
15:15	1	92	0	0	5	2	4	1	0	142	2	0	0	0	0	0	248	1124
15:30	4	109	0	0	1	0	4	1	0	131	4	1	0	0	0	0	253	1090
15:45	4	130	1	0	3	0	1	6	0	136	4	0	0	0	1	0	280	1062
Total	23	955	1	8	50	2	26	49	0	1061	20	8	2	0	2	0		
Peak hr Total	10	539	0	5	35	0	14	38	0	540	6	3	2	0	1	0		

NB Total (Peak): 549
NB Pct (Peak): 47.86%

EB Total (Peak): 49
EB Pct (Peak): 4.27%

SB Total (Peak): 546
SB Pct (Peak): 47.60%

WB Total (Peak): 3
WB Pct (Peak): 0.26%

Peak Hour Factor	
Total Peak Hour Volume:	1147
Highest 15-min. Volume:	308
Peak Hour Factor:	**0.93**

Turning Movement Count

Municipality: City of Worcester
Location: Blackstone River Road / Stebbins St
Weather: AM: Fair 35°F

Date: 2/9/2023
Day of the Week: Thursday

Start Time	Blackstone River Rd NB				Stebbins St EB				Blackstone River Rd SB				Church Parking Lot WB				Vehicle	Hour
(AM)	L	S	R	PED	L	S	R	PED	L	S	R	PED	L	S	R	PED	Total	Total
8:00	3	104	2	31	10	0	14	4	0	145	2	1	1	0	1	0	282	
8:15	5	161	1	11	12	1	15	6	0	158	4	2	0	0	1	0	**358**	
8:30	4	99	0	0	7	0	3	0	0	95	4	5	0	0	0	0	212	
8:45	1	110	0	0	1	0	1	0	0	107	0	0	0	0	0	0	220	**1072**
Peak hr Total	13	474	3	42	30	1	33	10	0	505	10	8	1	0	2	0		

NB Total (Peak): 490
NB Pct (Peak): 45.71%

EB Total (Peak): 64
EB Pct (Peak): 5.97%

SB Total (Peak): 515
SB Pct (Peak): 48.04%

WB Total (Peak): 3
WB Pct (Peak): 0.28%

Peak Hour Factor	
Total Peak Hour Volume:	1072
Highest 15-min. Volume:	358
Peak Hour Factor:	**0.75**

Turning Movement Count

Municipality: City of Worcester
Location: Blackstone River Road / Stebbins St
Weather: PM: Fair

Date: 3/22/2023
Day of the Week: Wednesday

Start Time	Blackstone River Rd NB					Stebbins St EB					Blackstone River Rd SB					Church Parking Lot WB					Vehicle	Hour
(PM)	L	S	R	HV	PED	L	S	R	HV	PED	L	S	R	HV	PED	L	S	R	HV	PED	Total	Total
13:15	2	105	0	5	1	4	0	7	0	0	0	100	0	7	0	0	0	0	0	1	218	
13:30	1	84	0	3	2	3	0	2	0	2	0	94	6	6	2	0	0	1	0	0	191	
13:45	3	102	0	6	0	2	0	2	0	7	0	118	2	5	1	0	0	0	0	0	229	
14:00	3	86	0	5	2	3	0	6	0	1	0	150	6	6	1	0	0	0	0	1	254	892
14:15	7	74	0	6	6	6	0	14	0	12	1	82	5	9	7	1	0	1	0	7	191	865
14:30	4	148	0	7	2	12	0	13	3	10	0	164	3	10	1	0	0	0	0	1	**344**	1018
14:45	2	137	0	6	1	8	0	4	0	12	0	123	4	8	1	0	0	0	0	0	278	**1067**
Total	22	736	0	38	14	38	0	48	3	44	1	831	26	51	13	1	0	2	0	10		
Peak hr Total	16	445	0	24	11	29	0	37	3	35	1	519	18	33	10	1	0	1	0	9		

NB Total (Peak): 461
NB Pct (Peak): 43.21%

EB Total (Peak): 66
EB Pct (Peak): 6.19%

SB Total (Peak): 538
SB Pct (Peak): 50.42%

WB Total (Peak): 2
WB Pct (Peak): 0.19%

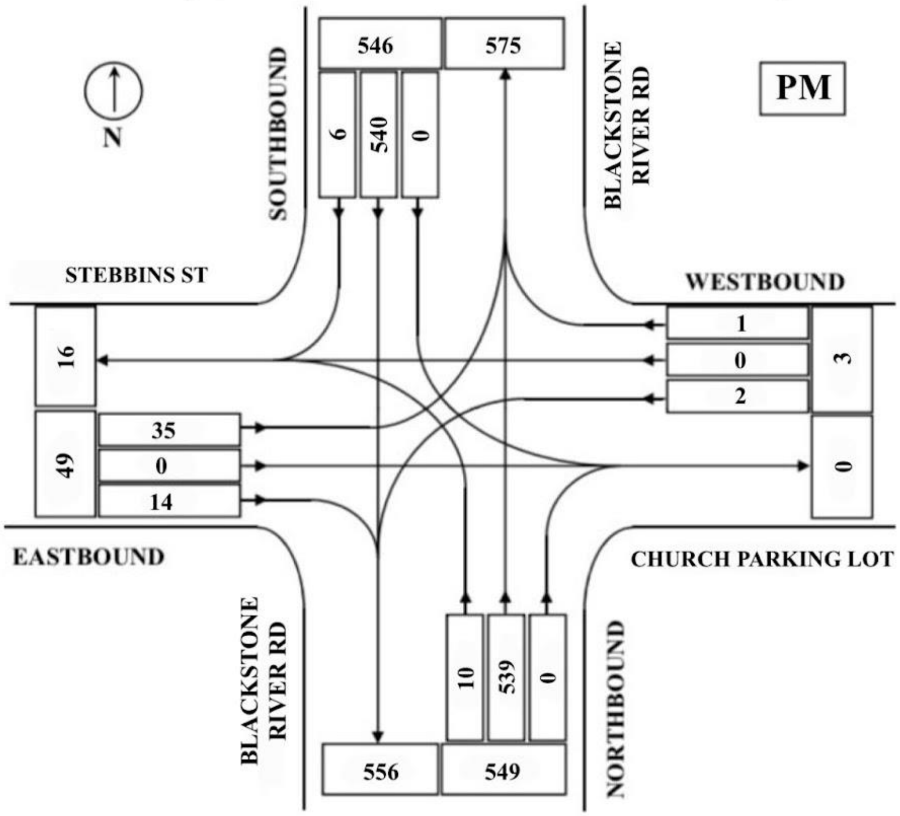
Peak Hour Factor	
Total Peak Hour Volume:	1067
Highest 15-min. Volume:	344
Peak Hour Factor:	**0.78**

Pct Heavy Vehicles (Peak)	
# of Heavy Vehicles:	60
% of Heavy Vehicles:	**5.62%**

CMRPC

INTERSECTION TURNING MOVEMENT COUNT

CITY: Worcester DATE: 1/24/23 DAY OF WEEK: Tues.
INTERSECTION: Blackstone River Rd/Stebbins St



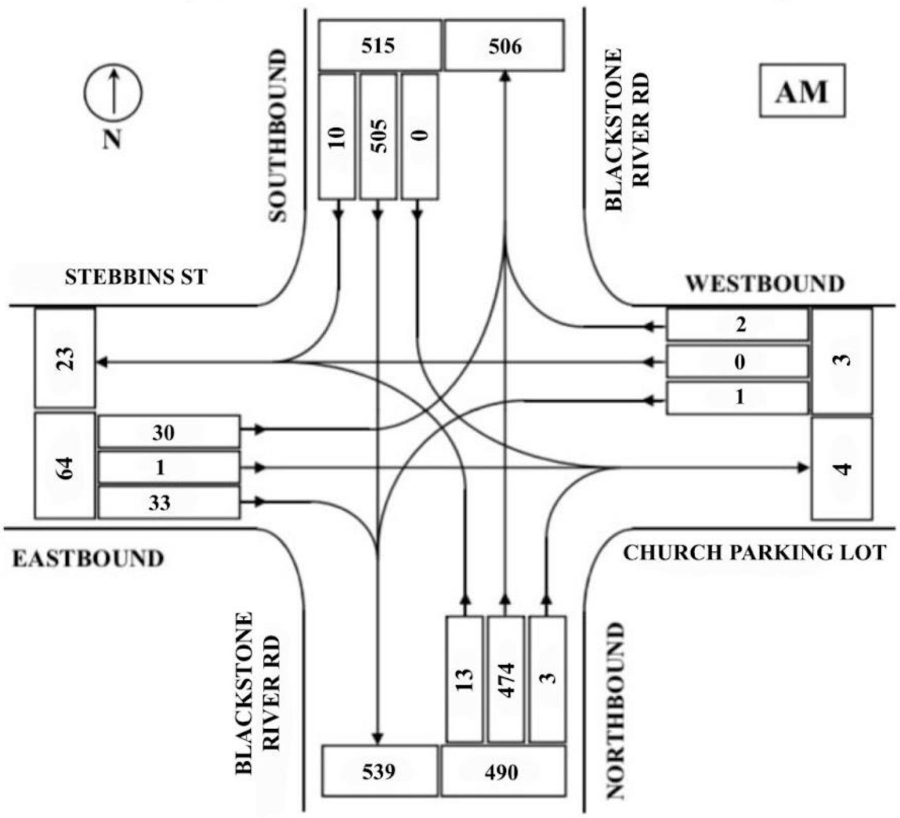
STREET	ENTERING VOLUMES	PERCENT OF FLOW	TIME OF COUNT	
Blackstone River Rd NB	549	47.86%	2:15 - 3:15 PM	
Stebbins St EB	49	4.27%	PHF = 0.93	
Blackstone River Rd SB	546	47.60%	VEHICLES COUNTED	
Church Driveway WB	3	0.26%	ALL VEHICLES:	1147
TOTAL	1147	100.00%	TRUCKS:	-
			PERCENT TRUCKS:	-

CMRPC

INTERSECTION TURNING MOVEMENT COUNT

CITY: Worcester DATE: 2/9/23 DAY OF WEEK: Thurs.

INTERSECTION: Blackstone River Rd/Stebbins St

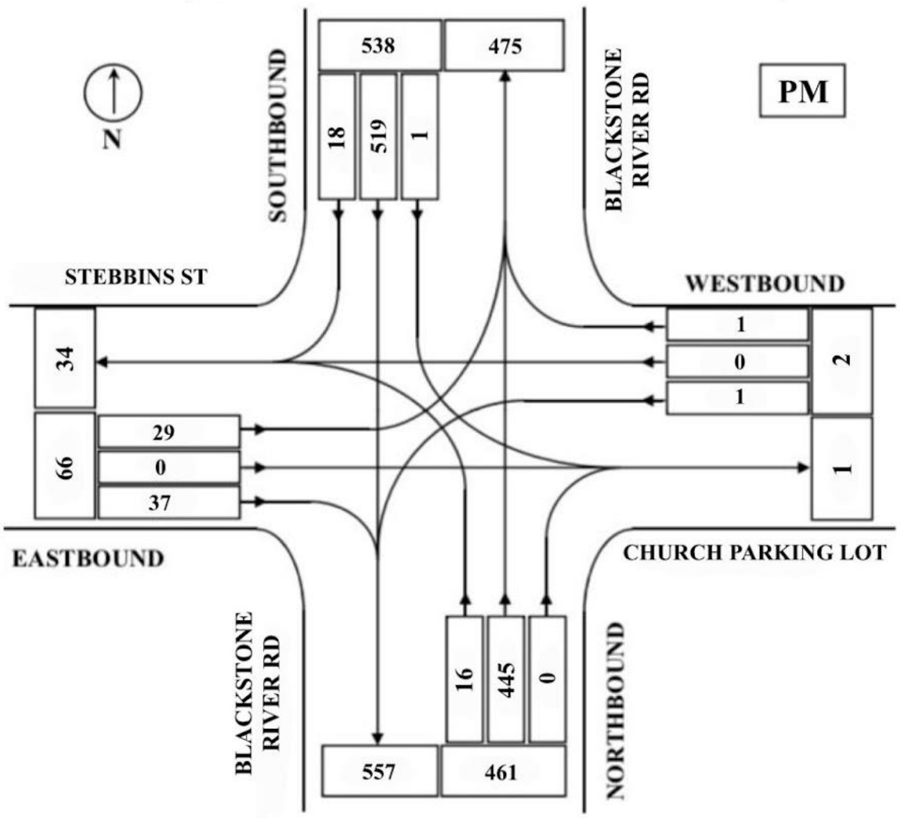


STREET	ENTERING VOLUMES	PERCENT OF FLOW	TIME OF COUNT	
Blackstone River Rd NB	490	45.71%	8:00 - 9:00 AM	
Stebbins St EB	64	5.97%	PHF = 0.75	
Blackstone River Rd SB	515	48.04%	VEHICLES COUNTED	
Church Parking Lot WB	3	0.28%	ALL VEHICLES:	1072
TOTAL	1072	100.00%	TRUCKS:	-
			PERCENT TRUCKS:	-

CMRPC

INTERSECTION TURNING MOVEMENT COUNT

CITY: Worcester DATE: 3/22/23 DAY OF WEEK: Weds.
INTERSECTION: Blackstone River Rd/Stebbins St



STREET	ENTERING VOLUMES	PERCENT OF FLOW	TIME OF COUNT	
Blackstone River Rd NB	461	43.21%	2:00 - 3:00 PM	
Stebbins St EB	66	6.19%	PHF = 0.78	
Blackstone River Rd SB	538	50.42%	VEHICLES COUNTED	
Church Parking Lot WB	2	0.19%	ALL VEHICLES:	1067
TOTAL	1067	100.00%	TRUCKS:	60
			PERCENT TRUCKS:	5.62%

APPENDIX D: VEHICLE CRASH DATA

Vehicle crash data was collected from the MassDOT Crash Data Portal. The specific crash data was selected based on the crash location around the Quinsigamond School. A spatial search was conducted, and the draw tool was utilized to trace an area that included the length of Blackstone River Road from the McKeon Road intersection to the Whipple Street intersection. The area also included Falmouth Street and Stebbins Street from where the streets intersect with Blackstone River Road, past the Quinsigamond School.

A five-year span from January 1, 2018 to December 31, 2022 was selected for the crash data selection.

Figure 7: Map of the selected crash data collection area around the Quinsigamond School.

Table 7: Crash data categorized by severity type, each year for five years.

Year	*Fatal*	*Injury*	*PDO*	*Not Reported / Unknown*	*Total*
2018	0	3	13	1	17
2019	0	3	11	1	15
2020	0	0	4	0	4
2021	0	5	4	3	12
2022	0	1	7	3	11
5-year average	0 (0.00%)	2.4 (20.34%)	7.8 (66.10%)	1.6 (13.56%)	11.8 (100.00%)

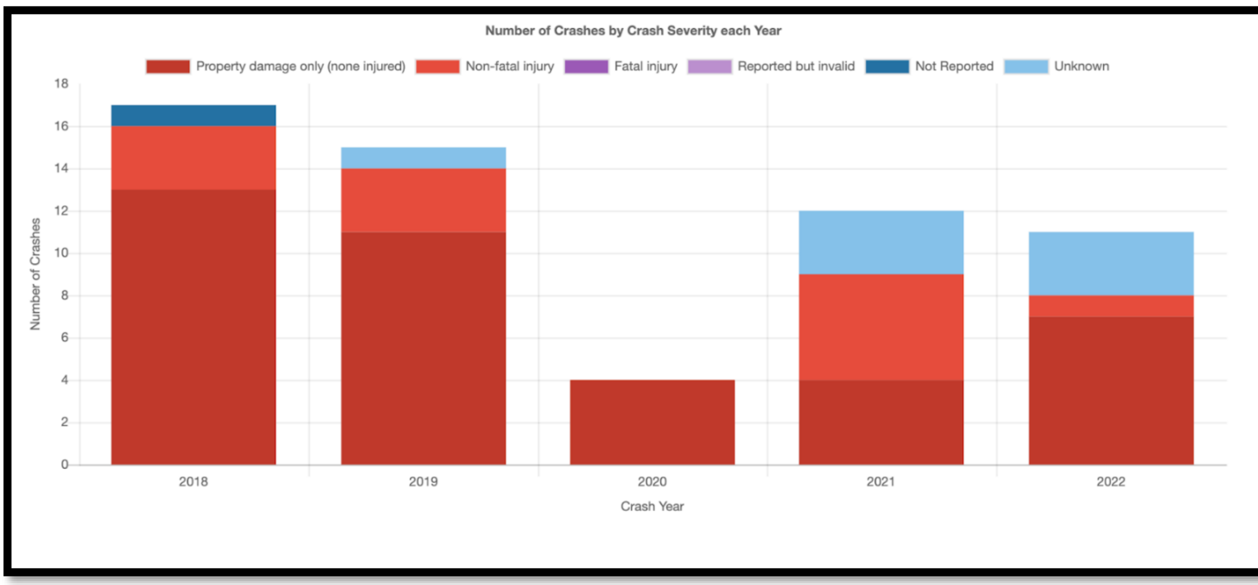


Figure 18: Charts displaying crash severity data from table 7.

Table 8: Crash data categorized by crash type, each year for five years.

Year	Single Vehicle	Rear-End	Angle	Sideswipe, Same Direction	Head-On/Front to Front	Unknown	Total
2018	1	7	5	3	1	0	17
2019	2	5	6	2	0	0	15
2020	0	0	2	2	0	0	4
2021	0	6	3	2	1	0	12
2022	0	3	4	3	0	1	11
5-year average	0.6 (5.08%)	4.2 (35.59%)	4 (33.90%)	2.4 (20.34%)	0.4 (3.39%)	0.2 (1.69%)	11.8 (100.00%)

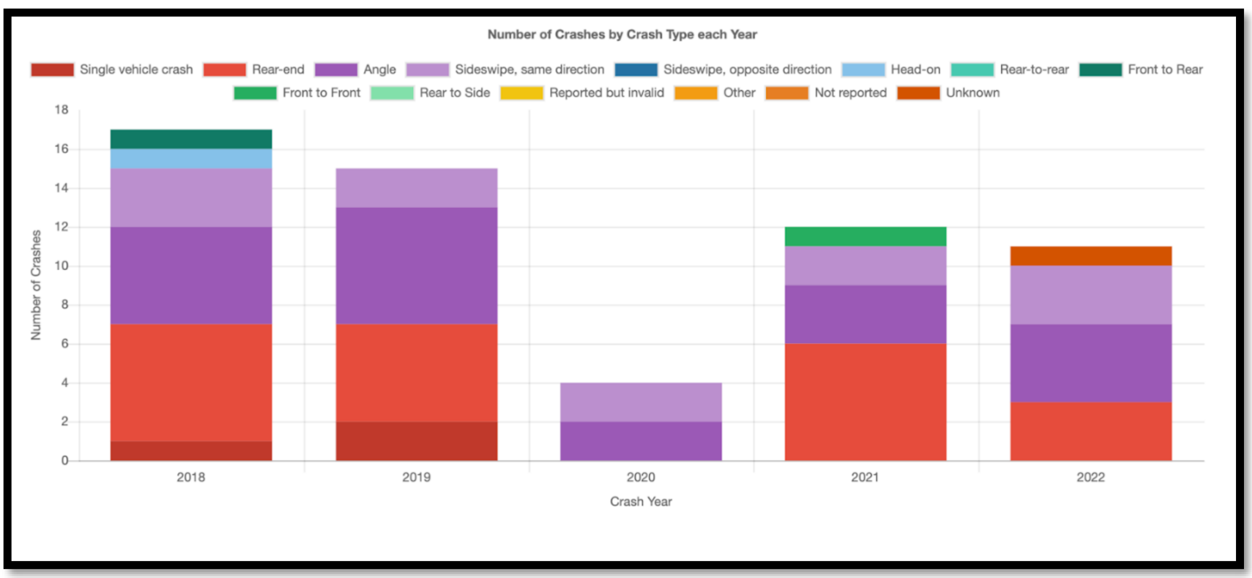


Figure 19: Charts displaying crash severity data from table 8.

Table 9: Crash data by hour of crash.

AM												
Hour	12	1	2	3	4	5	6	7	8	9	10	11
# of Crashes	0	0	0	0	0	0	1	2	7	2	1	2
PM												
Hour	12	1	2	3	4	5	6	7	8	9	10	11
# of Crashes	3	5	7	3	1	5	4	6	5	0	3	2

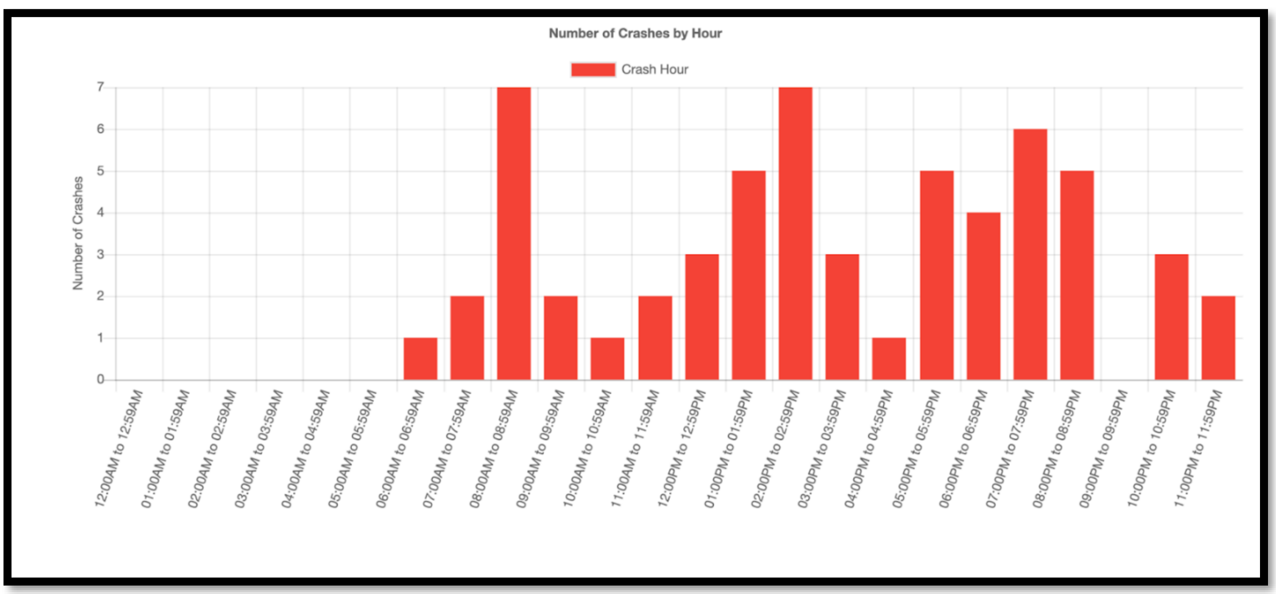


Figure 9: Charts displaying crash severity data from table 9.

APPENDIX E: NOTES FROM PTO MEETING

A PTO meeting was held on 11/30/2022. The MQP group attended the meeting and led a discussion with parents and faculty focused on arrival and dismissal observations, concerns, and ideas. The notes written during the meeting can be seen in Figure X.

Notes

- Initially there were five parents and one teacher in person and one parent and two teachers on a video call.
    - Two more parents came in part of the way through the feedback section
- All parents in attendance (5) drive their children to and from school.
- All parents in attendance (5) drop their kid off and drive off, they do not walk their kids to the front door.
    - They have noticed that a lot of parents leave their cars in the slip lane or on the other side of the road and walk their children to the door which causes traffic problems and blocks parents into the slip lane.

Main Takeaways

- There is a lack of clear instruction about what to do during arrival and dismissal and what is or isn't allowed.
- Parents (At least the ones in attendance) want a space designated for quick dropoff and pickup so that they don't get stuck with parents who walk their kids to the door.

Feedback from parents

- There is a lack of instruction and directing
    - Would like to have instructions sent out at the beginning of the year clearly stating what to do and what not to do.
    - Would like to have someone directing traffic (police officer, staff member, etc).
- Some parents park at the restaurant
    - Most of them don't really "park" but idle in the drive thru and middle of the lot, blocking customers.
- Falmouth St Problem - Winter
    - Icy sidewalks outside residences.
    - Dangerous snowfall off of roof on Blackstone River Rd on Falmouth St corner.
- Inefficient crossings
    - Crossing guard stops traffic too frequently and not in sync with pedestrian crossing signals, causing buildup of cars.

- Parents have observed one of the crossing guards leaving before they are supposed to.
- Parents would prefer a longer green light along Blackstone River Rd during arrival and dismissal hours to allow as much traffic to flow through as possible.

- Drop Off goes smoother than pickup
    - Drop off is more spread out while during pickup all students are released at once and everyone is trying to leave at once.
        - Lauren Racca said that they just started releasing students in waves which should hopefully help. However, parents do not seem to be aware of this so they all still show up at the same time.
- Turn Around
    - Parents and teachers have witnessed other parents U-turning right in front of the school.
    - One parent shared that she drops off and U-turns on Stebbins St because Blackstone River Rd is too chaotic.

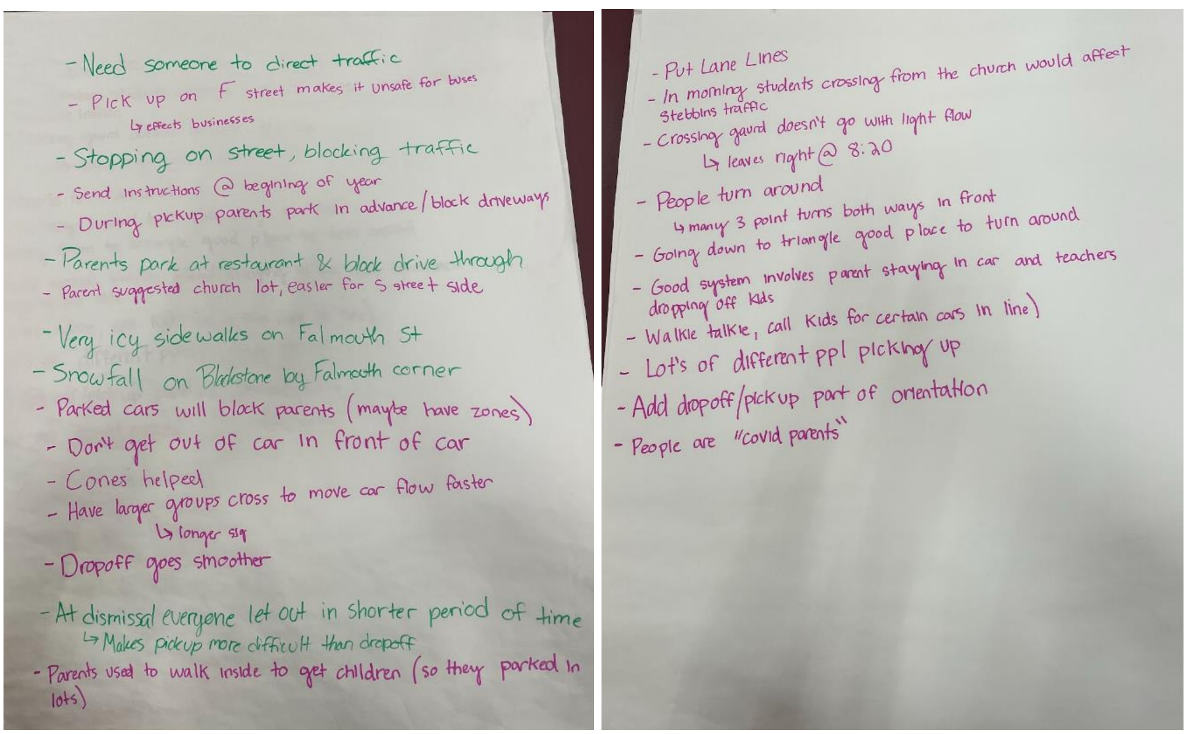


Figure 20: Notes from the Quinsigamond School PTO meeting held on 11/30/2022.

APPENDIX F: SURVEY QUESTIONS

The following is a survey for parents of Quinsigamond School students. The goal of the survey was to gather information about parent behavior during drop off and pick up, and to learn their concerns and perspectives.

Survey:

[Introduction]

Hello Quinsigamond School parents and guardians! We want to learn more about your experiences getting your children to and from school! The survey below has a mix of multiple choice and open-ended questions. This survey is anonymous, and all questions are optional. The information gathered in this survey will be used to help improve the arrival and dismissal process. Please only answer for students who attend Quinsigamond School.

[p.1]

What grade(s) is your child(ren) in? [Can select multiple]

Kindergarten
First Grade
Second Grade
Third Grade
Fourth Grade Fifth Grade

How does your child(ren) get to school most frequently?

Schoolbus
Walking
Driven in personal vehicle
Other (please specify)

[p.2]

Rank Each of these statements regarding MORNING DROPOFF based on how much you agree with them:

I am able to drop off my child in a timely manner.

Strongly Agree
Agree
Neither agree nor disagree
Disagree
Strongly Disagree

I feel safe about dropping off my child.

Strongly Agree
Agree
Neither agree nor disagree
Disagree
Strongly Disagree

The parents and staff have clear communication regarding drop off.

Strongly Agree
Agree
Neither agree nor disagree
Disagree
Strongly Disagree

[p.3]

Is there any reasoning for your answers or observations you want to share?

[Open Ended]

[p.4]

Which of these best shows your route to school during drop-off?

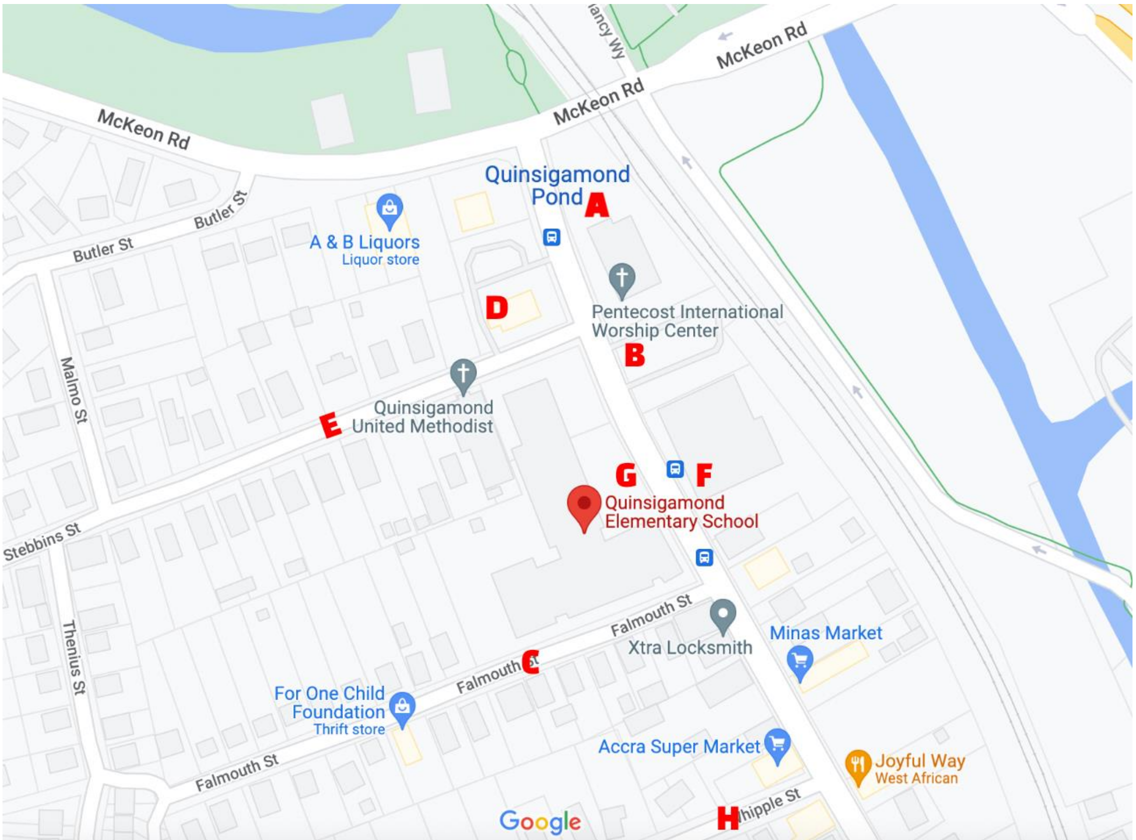
I come from the Stebbins Street Side
I come from the Falmouth Street Side

When driving your child to school do you..?

Park your car and walk your child to the door?
Stop your car in front of the school and have your child get out?

[p.5]

Use the map for the following questions:



Where do you park your car?

A: In the Pentecost International Worship Center
B: In the parking lot across the street
C: On Falmouth Street
D: In The Gold Coast Restaurant Parking Lot
E: On Stebbins Street
F: On Blackstone River Road across the street
G: On Blackstone River Road in front of the School
H: On Whipple Street
Other: (Please Specify)

[p.6]

When walking your child to the door do you…?

Cross in the middle of Blackstone River Road
Cross the street using the crosswalk on the Stebbins street side
Cross the street using the crosswalk on the Falmouth street side
I don’t cross the street.
Other: (Please Specify)

Why do you cross the street where you do?

[Open-ended]

[p.7]

Rank these statements about AFTER-SCHOOL PICKUP based on how much you agree with them:

I am able to drop off my child in a timely manner

Strongly Agree
Agree
Neither agree nor disagree
Disagree
Strongly Disagree

I feel safe about dropping off my child

Strongly Agree
Agree
Neither agree nor disagree
Disagree
Strongly Disagree

The parents and staff have clear communication regarding drop off

Strongly Agree
Agree
Neither agree nor disagree
Disagree
Strongly Disagree

[p.8]

What time do you arrive at the school to pick up your child?

Before 2:00
Between 2:00 and 2:10
Between 2:10 and 2:20
Between 2:20 and 2:30
Between 2:30 and 2:40
After 2:40

When picking up your child do you…

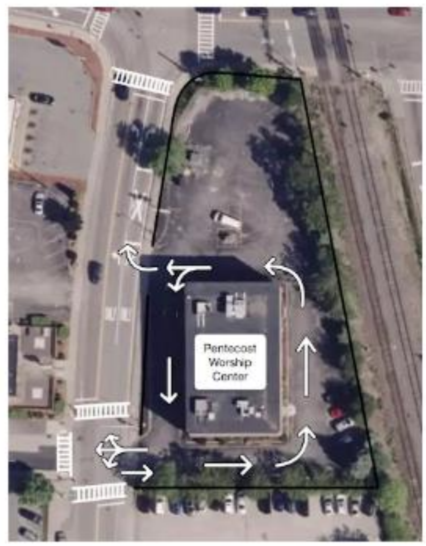
Park somewhere nearby and have your child meet you
Park somewhere nearby and meet your child at the door
Pull over in front of the school and have your child hop in
Other (please specify)

[Outro]

Thank you for taking the time to complete this survey! Your responses are very valuable to us.

APPENDIX G: PARKING FLYER

Looking For Parking?



Parking spots are available at the Pentecost Worship Center during arrival and dismissal

Please scan the QR code and take the survey to help us make arrival and dismissal safer and more efficient