BGM² CONSULTING

April 21, 2023

Queen's University Facilities
355 King Street West, Kingston, ON
K7L 2X3

Re: Traffic Engineering Across Queen's University Campus

Dear Mr. Splinter,

Attached you will find the final report entitled *Traffic Engineering Across Queen's University Campus* prepared by BGM² for our CIVL 460 Capstone Project.

The following report details all background research conducted by the team, the traffic study data and results, the team's design process, and final recommendations for transportation improvements for the main campus at Queen's University.

We hope that you find the contents of this report adequate. If you have any further questions, comments, or concerns regarding the information included in this report, we would be more than happy to discuss further.

Regards,

Natalie Bot Megan Grosso Adrianne Matacot Julianna Moore

BGM² Consulting

Final Report

CIVL 460

Traffic Engineering Across Queen's Campus

Natalie Bot, Megan Grosso, Adrianne Matacot, Julianna Moore

BGM² CONSULTING

CIVL 460 – Civil Engineering Design and Practice IV

Statement of Originality

Our signatures below attest that this submission is our original work following professional engineering practice, we bear the burden of proof for original work. We have read the policy on Academic Integrity posted on Civil Engineering departmental web site and confirm that this is in accordance with the policy.

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Disclaimer

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Executive Summary

Queen's Facilities selected BGM² to carry out a traffic study of the main campus at Queen's University to review the existing Active Transportation (AT) demands of the area and intercampus commuting trends of students and faculty. BGM² has provided feasible design solutions that align with Queen's Facilities' goals for a vehicle-free campus in the future, foster a more inclusive environment, and provide more comfortable and aesthetic infrastructure to pedestrians and non-motorized vehicles.

The team conducted a traffic study in three phases: 1) identified the main corridors within the site limits using AutoCAD site plans and electronic survey data; 2) counted motor vehicles, pedestrian, and cyclist traffic at four high-volume intersections across campus; and 3) collected traffic volume data on Bader Ln. intersections, as the roadway is owned by Queen's University and future design implementation there is more likely. It was apparent that methods of AT were consistently the highest forms of transportation at all intersections analyzed, with pedestrian volumes exceeding 4,500 during peak periods at the intersection of University Ave. & Union St. The team subsequently analyzed the traffic data by calculating the critical approach volumes at each intersection of interest, which depicts the maximum flow of traffic in each laneway. Using the critical approach volumes, trip generation was conducted to ensure other roadways within the transportation network can withstand a potential roadway closure.

The team followed the Ontario Environmental Assessment Process to propose a final conceptual design. BGM² developed a complete list of planning alternatives to consider for implementing the final design, based on all background research and traffic study data collected by the team. The planning alternatives were evaluated based on criterion that accurately depict the feasibility and rationale of the team, and the team decided to select two planning alternatives to incorporate into the design options: Complete Street infrastructure, and roadways open only to AT users and service vehicles. Pedestrian, cyclist, and motor vehicle capacities were analyzed to see which planning alternative was better suited for each respective roadway.

The final recommendations proposed by the team consist of adding Complete Street infrastructure including isolated bike lines and narrowed motor vehicle lanes to Albert St., Barrie St., and Stuart St. The final recommendations also include only allowing road access to AT users and service vehicles on both Bader Ln. and University Ave. between Union St. and Stuart St. These changes increase the comfort and aesthetic of the streets, increase the availability for greenspace and streetscaping, and provide connected bikeway infrastructure throughout campus. Additionally, the team identified three ways to include innovative design solutions in the final recommendations, including the addition of permeable pavement in two locations on campus, the implementation of Low-Speed Electric Vehicles (LSEVs) and the opportunity to introduce a Limited Mobility Vehicle to help address the barrier of navigating campus on a wheelchair. The final recommendations are presented to the client in this report for review and potential implementation in the future.

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1.0 Introduction

Queen's Facilities has selected BGM^2 to carry out a traffic study of the campus at Queen's University to outline the Active Transportation (AT) demands of the area and intercampus commuting patterns of students and faculty. Following the study, the team proposed design changes that aid the transition to a car-free campus in the future. The contents of this report detail the final recommendations provided by the team.

1.1 Problem Statement

A traffic study was requested by Queen's Facilities to review the existing transportation patterns for Queen's University's campus to determine weaknesses in the existing infrastructure. Based on this study, improvement plans addressing campus needs were developed, with the final recommendations aiding with the transition to a vehicle-free campus in the future. This transition would enhance the campus experience, promote a safer and more comfortable landscape for AT commuters, and reduce the noise pollution and carbon emissions within the campus.

1.2 Project Scope

The first phase of the traffic study examines the current traffic patterns by identifying the corridors, inter-campus commuting trends and main modes of transportation. The second phase of the traffic study assesses the specific transportation needs of Queens' students and staff through the collection of current traffic volume data. In this phase, the demand for AT, improved road infrastructure, and the feasibility of a vehicle-free campus was identified. The third phase of the traffic study was added as per client request and involves traffic volume data collection at an additional intersection. In this phase, the team assessed the transportation needs of Bader Ln., a street within the limits of the site that is owned by Queen's University. Figure 1 provides a flowchart summary of the three phases that divide the traffic study into distinct categories.

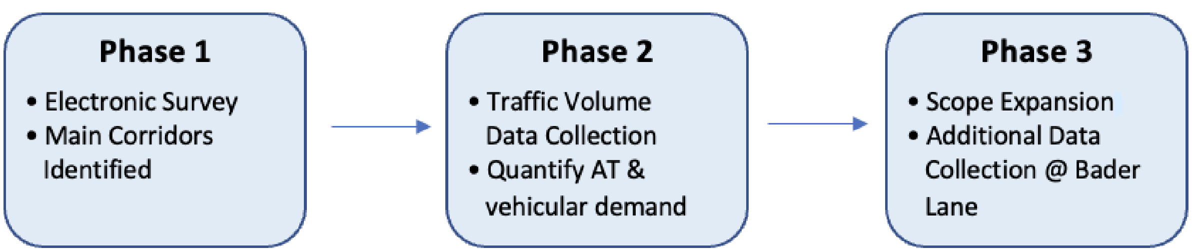

Figure 1: Summary of Traffic Study Phases

The team recommended changes that can be implemented on campus and identified the benefits associated with each option. The final recommendations must be cost-effective, improve traffic flow, accommodate for the growing AT needs of the public, and evaluate the future impact it will have on the campus community. The subsequent construction of the final recommendations was not within the scope of this project.

1.3 The Site

A map of the site is shown Figure 2 in below, located in the Southwestern quadrant of downtown Kingston, Ontario. The site encompasses all of Queen's University's main campus. Queen's Facilities stated the site is bordered by Collingwood St., Barrie St., Earl St., and King St. The outlined area in Figure 2 includes all buildings on the main campus at Queen's University within the site limits, as well as all roads, bike lanes, and pedestrian pathways.

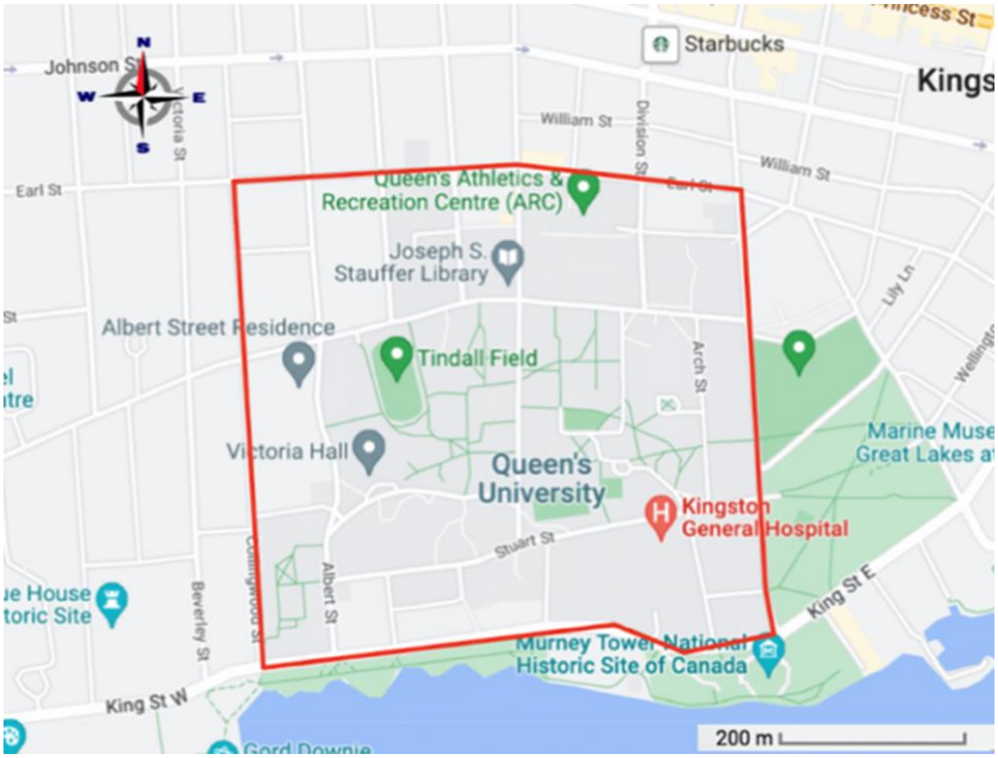

Figure 2: Campus Project Borders (Google Maps, 2022)

1.4 Constraints

BGM² has identified the following constraints, summarized in Table 1 below.

Table 1: Project Constraints

Constraint	Description
Cost	The final recommendations chosen must be cost effective. The client did not define a budget. Therefore, BGM² has carried out a cost estimate of the initial principal cost to implement the recommendations as well as possible long-term maintenance costs.
Timeline	The project had a timeline of approximately eight months as final recommendations had to be provided to the client by April 21, 2023. Effective time management was essential for the completion of an accurate traffic study and detailed analysis.

Constraint	Description
Limited Data	The team has limited historic traffic volume data for Queen's University's campus. Traffic data was collected manually to develop a database regarding current campus trends. Due to the limited data collected over a short period of time, the team recognized there was uncertainty regarding annual traffic trends during analysis.
Existing Infrastructure	The recommendations developed are limited to the existing infrastructure on campus. As a result, there was no option to reconfigure the entirety of campus but rather only make modifications. When analyzing the implementation of the recommendations, the chosen solution should minimize disruption to the daily routine of students and staff.
Accessibility	The recommendations developed should be accessible for all users regardless of level of mobility. The solution should not obstruct users' ability to move throughout campus or create unsafe travel conditions.
Experience	Transportation engineering has not been a core course offered throughout the team's past three years of undergraduate study. BGM² used knowledge gained from current studies, the Department of Civil Engineering and external research to develop the traffic study.
Software	The team does not have access to traffic modeling software due to budget and licensing restrictions. This posed challenges when determining the impact of potential road closures on adjacent streets and has constrained the analysis to manual trip generation.
Environment	The existing campus greenspace should be maintained. Any changes to campus corridors should avoid having to clear or remove areas with grass, trees, or shrubs. Although the construction and operation of the final design was not within the project scope, pollution resulting from its construction was considered. Additionally, the recommendations addressed improvements to combat climate change.
Ownership	Bader Ln., Fifth Field Company Ln., and Arch St. are the only roadways within the site limits that are owned by Queen's University. All other roadways within the campus are owned by the City of Kingston. This impacted and continues to impact the

Constraint	Description
	feasibility of implementation as recommendations made will need to be presented and approved by the City of Kingston.

1.5 Stakeholders

BGM² recognized the importance of identifying the stakeholders in the project to ensure that their concerns are considered and addressed. Stakeholders were categorized as Primary, Secondary or Tertiary level. Primary stakeholders are defined as those who will be directly affected by the outcome of the final recommendations made based on the traffic study. Secondary stakeholders are those who may be indirectly affected because of the recommendations. Finally, tertiary stakeholders are those who will be impacted the least by the outcome of this project.

1.5.1 Primary Stakeholders

The client, Queen's Facilities, was a primary stakeholder as the recommendations being developed are to be assessed and potentially implemented by them. Throughout the duration of the project, open communication with the client was important to ensure the work was within scope and satisfied their requirements. Students, faculty, and staff at Queen's University are another primary stakeholder to consider during the project, as they are present on campus daily and make up the predominant portion of the campus population. Any changes implemented to campus infrastructure and transportation services will impact their commute and daily activities. Furthermore, Queen's Facilities personnel and other service staff who depend on a vehicle to complete daily campus operations are a primary stakeholder.

One of the main purposes of the project proposed by Queen's Facilities was to aid in the transition to a vehicle-free campus in the future, reduce carbon emissions across campus, and promote a healthier living environment. As such, the environment was a primary stakeholder of this project. Green spaces in the surrounding areas must be protected, and the final recommendations considered potential impacts to ecological receptors.

1.5.2 Secondary Stakeholders

As bus routes pass through campus, Kingston Transit were secondary stakeholders in the project. The recommendations developed through the study considered the existing bus routes and how it may affect the city's planning. In addition, the City of Kingston owns the majority of the roads within the study; therefore, the recommendations must be further assessed by city planners.

1.5.3 Tertiary Stakeholders

The Kingston community was a tertiary stakeholder that may be impacted by the recommendations produced from the study. Although they do not directly make up a large population on campus, the final design may influence traffic outside campus borders. Finally, with Kingston General Hospital's (KGH) proximity to campus, emergency vehicles' accessibility may be affected and thus were considered a tertiary stakeholder.

2.0 Background Research

To further understand the scope of this project, preliminary research was conducted on the institution's history, AT, Complete Streets, the Campus Master Plan, and a case study on Toronto's Front St. This research helped aid and inform decisions when design solutions were developed.

2.1 Queen's University History

Queen's University was established on October 16**,** 1841, with inaugural classes held in a small house on Colborne St., North of Princess St. (Queen's University 2022a). Queen's University trustees had purchased 50 acres of undeveloped land between what are now Sir John A. Macdonald Blvd. and Colborne St. (Queen's University 2022a). As student and faculty numbers rose in subsequent years, campus expansion was necessary. Queen's University trustees purchased Summerhill in 1853, which triggered the development of the campus within the limits that are prevalent today (Queen's University 2020). Currently, the campus now consists of over 75 buildings, including 17 residence buildings. A three-dimensional map of the campus facilities, green spaces, and pathways is shown in Figure 3 (please note that the figure attached is not to scale).

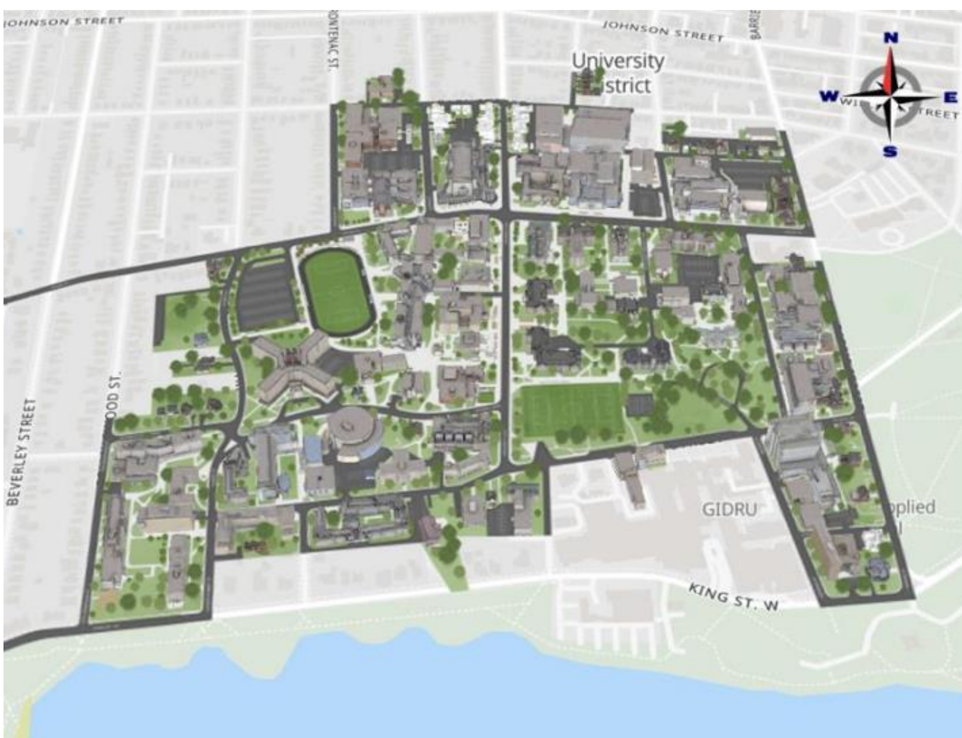

Figure 3: Queen's University Campus Facilities (Queen's University 2022a)

As of 2021, Queen's University is home to over 27,000 undergraduate students, 860 faculty members (Queen's University 2021), and 3,900 staff members (Forbes 2023). A large portion of undergraduate students reside in the area surrounding campus and use methods of AT to reach campus. From previous enrolment reports published by Queen's University, it was concluded that between the 2020 – 2021 academic years, student enrollment rose approximately four percent (Queen's University 2021), (Queen's University 2020). The subsequent year, the number of students enrolled at the University rose by approximately five percent (Queen's University 2022). Using a conservative estimate of enrollment growth of five percent, Queen's University can expect a student population of almost 35,000 students by 2025.

2.2 Queen's Facilities Campus Master Plan

The Campus Master Plan (CMP) at Queen's University is quoted as a "strategic milestone in the university's evolution" and has established a framework that guides how the campus physically transforms throughout the subsequent decades (Queen's University 2022b). The CMP investigates the land utilization, existing infrastructure condition, historical significance, and development capacity of the campus to develop a future vision of campus that is attainable. The proposed recommendations were in accordance with this vision and helped to enhance the campus experience, foster a more sustainable campus, and promote health and wellness (Queen's University 2022b). BGM²'s goal was to create a diversity of open spaces for students and faculty to enjoy and enhance campus safety through design.

2.3 Active Transportation

AT is defined as any method of travel that is human powered, such as walking, cycling, skateboarding, rollerblading, and running. AT methods help to promote a cleaner environment while also improving personal health. Many communities adopt an AT strategy with a goal of transforming an automobile reliant community into a community with improved environmental opportunities for travel that incorporate physical activity and increase the frequency of AT methods in daily life (The Centre of Active Transportation 2022). Pedestrian and cyclist patterns are impacted by the level of comfort provided through the infrastructure in place. Bike path width, distance from motorized vehicles, and bike network continuity change depending on bikeway facility types in place and affect the number of individuals who choose to cycle. Pedestrian comfort levels are altered depending on sidewalk width and isolation from motorized vehicles, cyclists, and skateboarders or roller-skaters. If bikeway and pedestrian facilities are safer and more accessible, more individuals will feel comfortable cycling and walking within the network.

Urban infrastructure's effectiveness at providing safe, accessible, and comfortable AT networks to community members is difficult to assess, as there are multiple social influences that must be considered. However, a quantitative method of evaluation that is commonly used in the transportation industry is a walkability score, which represents how feasible it is for an individual to accomplish all daily activities while limited to only walking as form of transportation. Walkability scores measure the walkability of any area using metrics such as intersection density and population density, Open Street Map, Google Maps and Census data (Walkability 2022). Scores are created by analysing hundreds of walking routes within a given area to nearby amenities, with points awarded based on distance. This was used as a baseline for potential improvements that may be implemented on campus.

The campus at Queen's University has a walkability score of 71 (out of 100), which is an adequate score by North American standards. Additionally, the campus also has a transit score of 59 and bike score of 75 (Walkability 2022). All three scores indicate that Queen's University currently offers effective and efficient transportation access to campus (Walkability 2022). The traffic study identified missing connections in bike paths and other AT commuting networks to improve the walkability of the campus and surrounding area. Walkable cities are proven to improve happiness and mental health, foster social inclusion, enhance a 'sense of place' in a community, and save lives from motor vehicle collisions (Steuteville 2021).

2.4 Complete Streets

A 'Complete Street' is a transportation policy and design approach that requires streets to be planned, designed, operated, and maintained to enable safe, convenient, and comfortable travel and access for users of all ages and abilities regardless of their mode of transportation. Components of a Complete Street may include sidewalks, bike lanes, comfortable and accessible public transit stops, special bus lanes, frequent safe crossing opportunities, accessible pedestrian signals, median islands, and curb extensions, seen in Figure 4 below (The Centre of Active Transportation 2022). The implementation of Complete Streets across communities helps to improve safety by lowering the risk of pedestrian and cyclist fatalities.

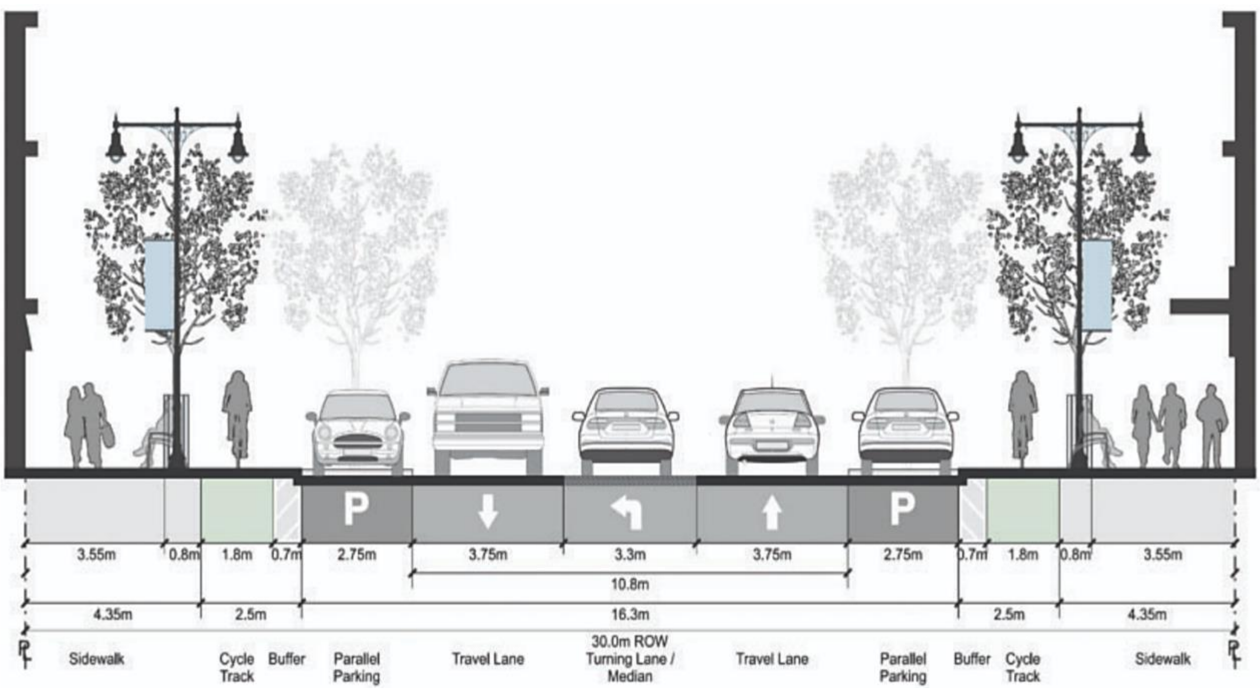

Figure 4: Cross-section of a Complete Street (The Centre of Active Transportation 2022)

Within the site limits previously discussed, there are eleven main streets used for motor vehicles and AT. None of those eleven streets contain the infrastructure required to be classified as a

Complete Street. Although some streets in the Greater Kingston Area have designated bike lanes, there is no continuous cycling network within the campus borders, making it difficult for cyclists to ride safely.

2.5 Union Station Revitalization Project Goal Alignment

Toronto, Ontario is home to a multi-modal transportation hub called Union Station, located at 65 Front St. West. The City of Toronto began the Union Station Revitalization Project (USRP) in 2010, which included the renovation of various components within the station and the revitalization of its entrance on Front St. West (City of Toronto 2017). The portion of Front St. West that borders Union Station was transformed to improve pedestrian access and aesthetics. Motor vehicle lanes were reduced to one lane each-way, frequent pedestrian crossing opportunities were added, and the sidewalks on both sides of the street were widened to accommodate over 300,000 daily public transit users (City of Toronto 2017). This transformation has improved both the accessibility of Union Station and the walkability of the surrounding Toronto area, shown in Figure 5 below.

Figure 5: Front St. West in Toronto, ON (Google Maps, 2022)

As of 2023, Toronto has a population of over 2.9 million (Toronto 2017) and is a city notorious for high levels of traffic congestion. However, two lanes on Front Street West were successfully removed and replaced with widened pedestrian pathways during the Union Station Revitalization Project without causing capacity issues on surrounding streets. The street improvements account for the needs of AT commuters and promote a sense of community in the area, with TD Canada Trust providing an ice-skating rink in the winter and a beverage patio in the spring at the entrance of Union Station (TD Union 2023). In contrast, Kingston has a population of under 650,000 and significantly less motor vehicle and pedestrian volumes than the province's capital (World Population Review 2023). As such, capacity issues resulting from lane closures within the site limits are unlikely. Many aspects of safe, comfortable, and aesthetic streets incorporated into this project were used as a source of inspiration for the team's final recommendations for Queen's University's campus.

3.0 Existing Conditions

This section further identifies technical aspects of Queen's University campus that are relevant to the traffic study. This section will explore the existing conditions of the campus at Queen's University and how it influenced the identification of planning and design alternatives.

3.1 Bike Paths and Storage

There are no bike lanes on Queen's University campus, however, bike paths run East and West above the campus on Brock St. and Johnson St. The only street that has a bike path running Southbound towards campus was University Ave., with the bike lane ending just above Union St. Queen's Facilities report that 400+ bike racks are available to use for free on campus (Queen's Facilities 2022). Queen's University also provides a secure bike storage location off University Ave., South of Union St., available for students and staff. Figure 6 presents the locations of bike racks that are accessible for all Queen's University visitors, faculty, and students (please note that this figure is not to scale).

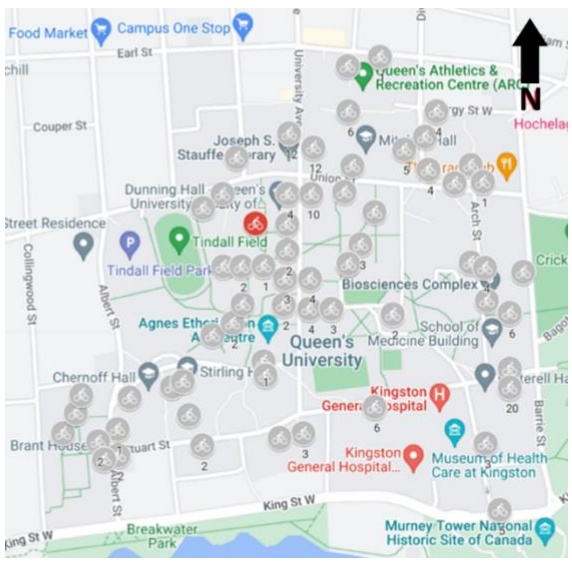

Figure 6: Bike Rack Locations (grey) and Secure Bike Parking (red) at Queen's University (Queen's Facilities 2022)

Bike lanes are an essential part of promoting AT in a community. Bike lanes were implemented on campus where there was adequate lane width and where there were opportunities to incorporate the Complete Streets approach to roads on campus. Although it may not be feasible to add a regular or protected bike lane, adding signage to indicate the road is a multi-use pathway was considered. Figure 7 below displays different types of bike lanes that could be used on campus. Low-volume, traffic-calmed streets, and separated bike lanes are the most comfortable for cyclists because they are designed to reduce driver-cyclist conflicts. When recommending bike lanes, BGM² considered all options to choose the most holistic solution.

Figure 7: Different Types of Bike Lanes Used in Transportation Planning and Design (City of Boston 2016)

3.2 Kingston Bus Routes

Kingston Transit uses two types of buses on its public transportation routes: a diesel-powered New Flyer Industries XD40, and a Nova Bus LFS, which is available in natural gas and electric model derivatives (Kingston Transit 2023). The Kingston bus routes run through Queen's University campus. The main routes are routes 1, 2 and 18 that come from Union St. near West Campus, turn right onto University Ave., and then continue to Kingston's downtown core after turning left on Stuart St. Figure 8 presents the path of the three main transit routes.

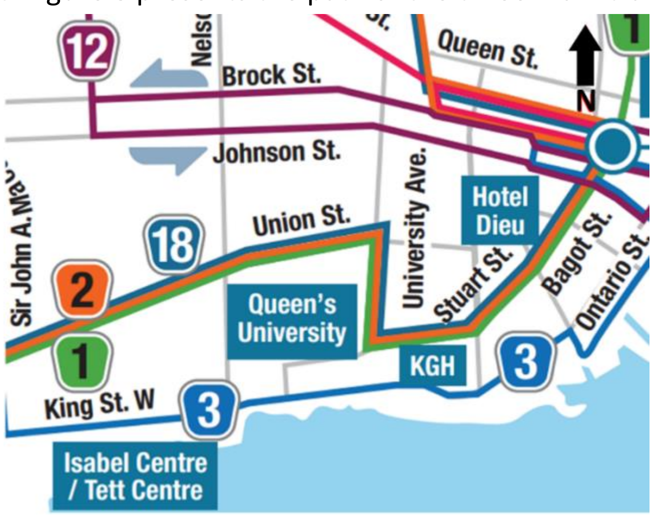

Figure 8: Kingston Transit Routes 1, 2 and 18 Operating Through Queen's University campus (City of Kingston 2022)

Kingston also has Express routes that run through campus. Express routes are bus routes that have fewer stops which reduces travel time while taking the bus. These routes include the 601/602 that lead to Montreal St., the 801/802 that connects to the East side of Kingston and the 501/502 that connects to the West side of Kingston are shown in Figure 9.

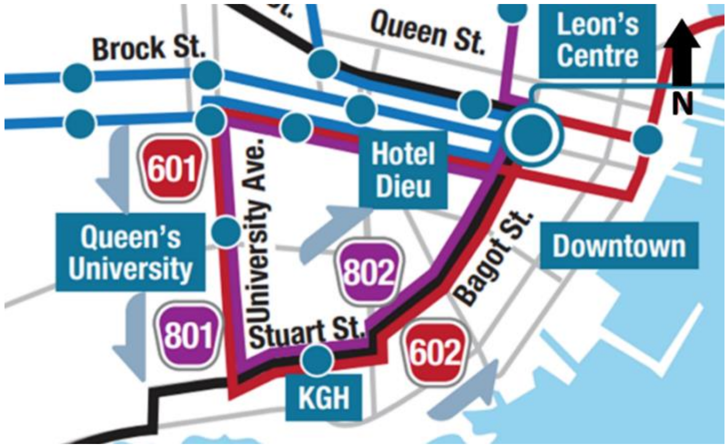

Figure 9: Kingston Transit Express routes 601, 602, 801 and 802 (City of Kingston 2022)

Design improvements and infrastructure changes on campus affect the transit routes currently in place. A consideration for this study included connecting with Kingston Transit to identify where transit routes may be changed and where transit routes are unlikely to be redefined. It is possible that recommendations may benefit Kingston Transit. As mentioned by the client, Queen's Facilities, the University Ave. & Union St. intersection is a cause for considerable transit delays due to the difficulty of making right or left turns to pass pedestrians. This was a factor in the recommendations to consider closing roads or changing intersections that may end up benefitting Kingston Transit routes.

3.3 Parking

Within the site limits of Queen's University's campus, street parking and parking lots are both available to students and staff. Depending on the owner of the parking meter or parking lot, permits or parking passes can be purchased from Queen's University or the City of Kingston. Although an abundance of parking spaces adds to the ease of finding a parking spot for commuters, adding parking availability on campus was not a priority when considering design alternatives. BGM² worked to maintain the current parking lot capacity and considered other options that maintain the level of parking already in place. Figure 10 presents the locations where parking is accessible for both visitors and long-term commuters. Street parking and parking meters on Bader Ln. and Albert St., highlighted in pink below, are controlled by Queen's University (Queen's University 2023). All other street parking meters are owned and operated by the City of Kingston.

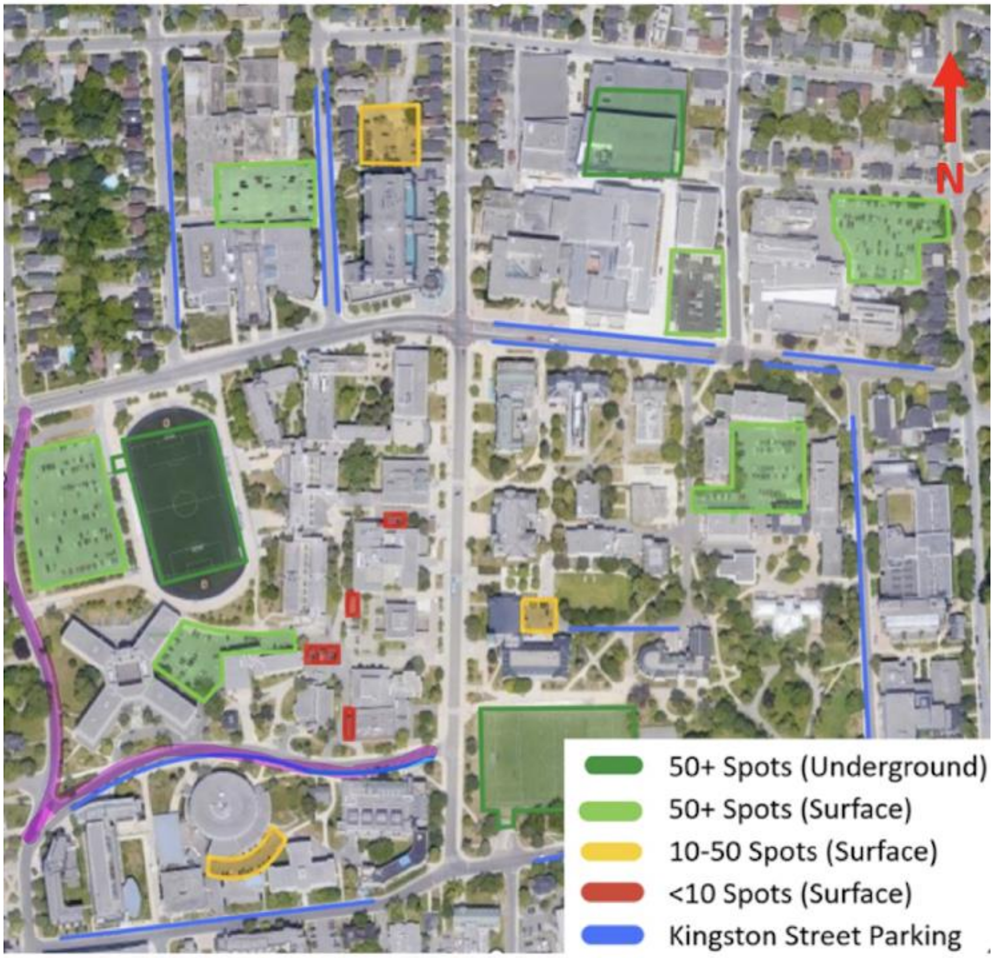

Figure 10: All Parking Locations on Queen's University campus (Google Maps 2022)

3.4 Site Access

Queen's Facilities' vehicles are permitted to drive on walking paths to access certain buildings. Some buildings on the Queen's University campus are not accessible to the public via road access. This was a factor when determining what areas of campus could benefit from additional infrastructure or greenery. Queen's Facilities must remain able to access all the necessary buildings to prevent daily work disruptions. BGM² avoided blocking these walking paths unless it was a necessary part of a design solution. If one path was blocked, another part of the design solution focused on an alternate route to reach the building for maintenance purposes.

3.5 Emergency Routes

Queen's Facilities provided the team with a map of the Queen's University campus detailing areas within the site limits that must remain free of motor vehicles in the case of emergency. Figure 48 in Appendix D: Current Queen's University Main Campus Fire Route highlights the emergency routes within the site limits. Fifth Field Company Ln. and the alleys behind Ellis Hall and Jeffrey Hall must always remain clear for service vehicles.

4.0 Traffic Study

The traffic study conducted by BGM² was completed in three phases. The first phase of the traffic study involved an examination of current traffic patterns within the site limits, an understanding of the inter-campus commuting trends of students and faculty as well as the identification of the main modes of transportation. The second phase of the traffic study involved determining the specific needs of students and staff at Queen's University through the identification of travel volumes at campus intersections. Upon further discussion with the client, a third phase of the traffic study was planned by the team which included traffic volume data collection on Bader Ln., as it is owned by Queen's University and improvements can more easily be implemented. With the data collected, the team can make better informed decisions when considering the possibility of road closures and the need for AT infrastructure.

4.1 Phase One – Survey

BGM² created an electronic survey using Google Forms that was sent to various students and faculty at Queen's University. Over two weeks, the survey garnered over 150 responses from students in varying years of undergraduate studies and faculty from multiple departments. Eight questions were included in the survey, allowing the team to gain an understanding of the preferred methods of transportation to commute to campus, the frequency of travel, and main entrance corridors of the campus. Additionally, the survey allowed the team to gain insight with how cycling patterns would change with safer bikeway facilities implemented. Only five of the eight questions asked in the survey provided the team with useful results. The survey questions are summarized in Table 2 below. The results obtained in the survey are shown in Figure 37 – Figure 41 of Appendix A: Survey Data.

Table 2: Questions Asked in Digital Survey

Survey Questions	
1.	How often do you go to the main campus at Queen's University?
2.	What time of day do you most often arrive at main campus?
3.	What streets to you most frequently ride on to get to campus? (Cycle, walk, drive, etc.)
4.	What is your preferred method of transportation to the main campus at Queen's University?
5.	Would you be more inclined to cycle to campus if safer/more comfortable bikeway infrastructure was in place?

4.1.1 Identification of Main Corridors

Using the AutoCAD drawings of campus provided by Queen's Facilities, BGM² was able to predict the main corridors used by motor vehicles within the site limits. University Ave., Albert St., Barrie

St., and Union St. were the roadways predicted to have the largest amount of vehicle traffic during peak morning and afternoon periods, due to their connections to surrounding intersections and the lived experience of the team at Queen's University. This prediction was validated in the first phase of the traffic study, through the electronic survey produced by the team. The team's survey displayed AT data that provided insight into the main throughways of campus. Based on the survey results, the main corridors for pedestrian and cyclist travel were proven to be Division St., Albert St., and University Ave.

4.1.2 Inter-campus Commuting Trends

The team's survey provided insight to the inter-campus commuting patterns and trends of students and faculty at Queen's University. As the height of the COVID-19 pandemic has passed, Queen's University has reintroduced an in-person format for all campus activity, which has allowed students and faculty to return to campus. Over 95% of all survey participants are entering campus every weekday, with over 85% arriving between 8:30am and 10:30am. Over 95% of survey participants used AT methods to travel to campus, with the vast majority walking from the surrounding areas. There is a complete network of sidewalks throughout campus that allows pedestrian travel to be moderately comfortable.

Despite the vast network of sidewalks, there are no continuous bike paths, as discussed in Section 2.4 Complete Streets. Approximately half of the participants stated their commuting habits may alter if safe and comfortable bikeway infrastructure was in place. The contributors were also asked to provide any suggestions for an improved commute to campus and the following submissions were provided: improved bike lanes and infrastructure, wider and better paved sidewalks, an increased number of crossing opportunities throughout campus, and an extension of Express transit routes to campus.

4.2 Phase Two – Traffic Data Collection

A traffic count is an important component to a transportation project as it provides an understanding of current travel volume in the study area. A traffic count was completed at the centre of campus, University Ave. & Union St., as well as at the following surrounding intersections: Barrie St. & Union St., Albert St. & Union St., and Stuart St. & University Ave. Figure 11 highlights the intersections included in the study. These locations were selected as they were the nearest intersections that border University Ave. & Union St. and have direct access into campus. A traffic study was not completed for Earl St. & University Ave., as no traffic can enter campus due to the current construction at John Deutsch University Centre (JDUC).

The team conducted the traffic study on Tuesdays, Thursdays, and Saturdays over the span of two weeks. At each intersection, the number of cars traveling through, turning right, and turning left were counted at each approach. The number of pedestrians and cyclists present at each intersection were also recorded.

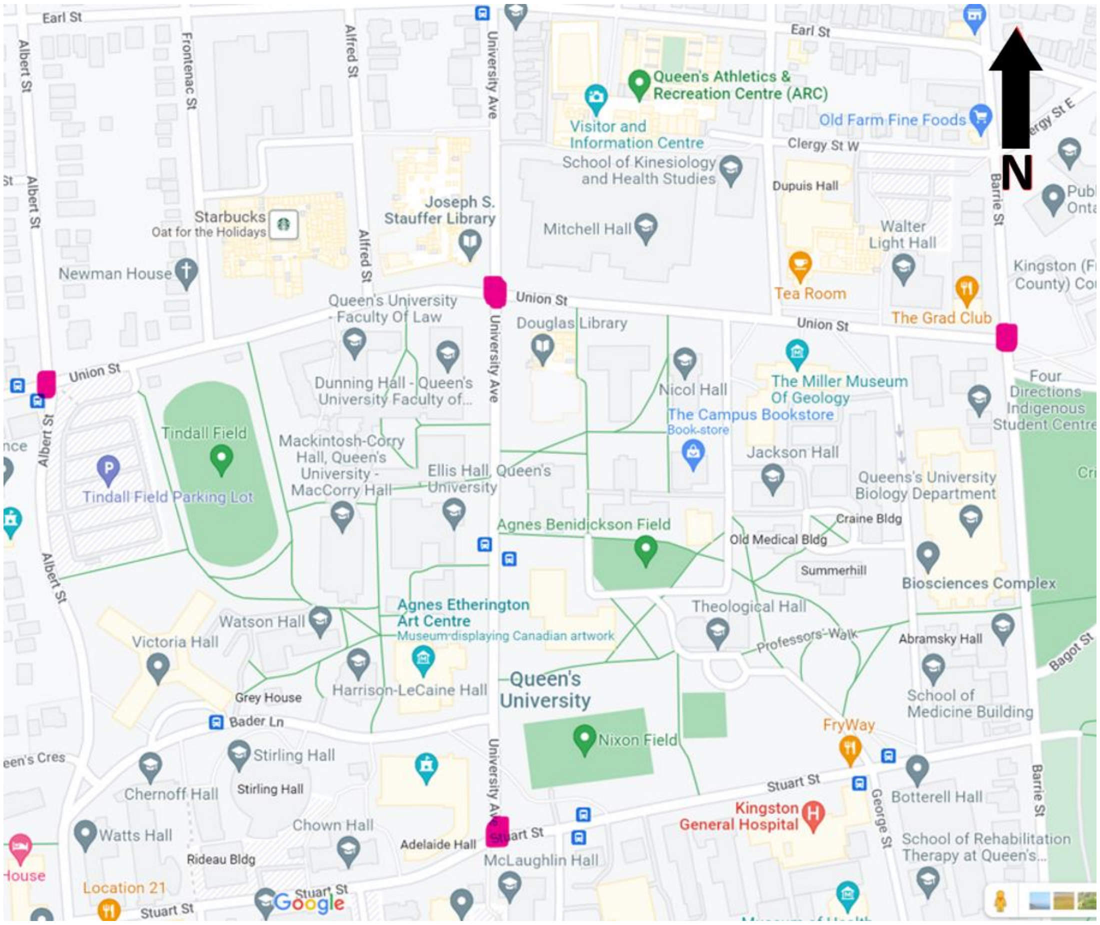

Figure 11: Intersections Involved in Traffic Study (Google Maps 2022)

4.2.1 Results

Table 12 – Table 15 in Appendix B: Traffic Count Data summarize the results of the traffic study. Upon analysis, various trends within the data were identified. Pedestrian traffic reached its peak between 4:00pm to 5:00pm at the University Ave. & Union St. intersection. Over 4,500 pedestrians were counted at the intersection within the hour, going various directions. On average, pedestrian traffic was consistently highest at the University Ave. & Union St. intersection, followed by Albert St. & Union St., Barrie St. & Union St., and Stuart St. & University Ave. On average, motor vehicle traffic was lowest towards the southern border of campus, near Stuart St. & University Ave. Motor vehicle counts at each approach did not reach higher than 60. Lastly, at the intersection of Barrie St. & Union St., levels of motor vehicle traffic were higher in the Northbound and Southbound directions, which do not contain traffic entering campus.

4.3 Phase Three – Bader Ln. Addition

Upon further discussion with the client, Queen's Facilities, information surrounding street ownership was provided to the team. All streets within the site limits of the campus at Queen's University are owned by the city of Kingston, except for Bader Ln. and Fifth Field Company Ln., which are owned by Queen's University. It was proposed by the client to expand the existing scope of the project to include traffic data collection on Bader Ln., as implementation on this street would be more feasible in the future. Streets owned by the City of Kingston require discussion and approval from the city before implementation and would result in a more time-consuming and intensive process. The scope was therefore expanded by the team to include Bader Ln. in its final design solutions.

4.3.1 Results

Table 16 and Table 17 in Appendix B: Traffic Count Data summarize the results of the third phase of the traffic study. Data was collected at the two intersections connecting Bader Ln. to surrounding roadways (University Ave. & Bader Ln. and Albert St. & Bader Ln.) at morning and afternoon peak periods on Tuesday, Thursday, and Saturday for two weeks. Pedestrian traffic reached its peak between 4:00pm to 5:00pm at the University Ave. & Bader Ln. intersection, experiencing pedestrian counts of over 2,000 individuals. Pedestrian traffic was consistently higher at the University Ave. & Bader Ln. intersection than the Albert St. & Bader Ln. intersection. Motor vehicle volumes counted at both intersections never exceeded 31 vehicles per hour (vph). The team continued to analyze this data while brainstorming design alternatives. The calculations to conduct a trip generation analysis were performed using the traffic flow rate collection. This trip generation analysis modelled the impact of various lane closures on surrounding streets. Considering the capacity of neighbouring roads, the capacities of surrounding roadways were analyzed to ensure rerouted traffic can be accounted for, especially during 4:00pm and 5:00pm on weekdays, where traffic volume was highest.

4.4 Phase Diagrams

Phase diagrams are often used in transportation projects to understand the possible vehicle movements at intersections. The following sections depict the phase diagrams for each intersection the team reviewed in the traffic study.

University Ave. & Union St. Intersection

The phase diagram for the University Ave. & Union St. intersection can been seen in Figure 12. Due to the JDUC construction, the Northbound approach is closed; therefore, vehicles can either travel along Union St., or turn onto the Southbound approach on University Ave.

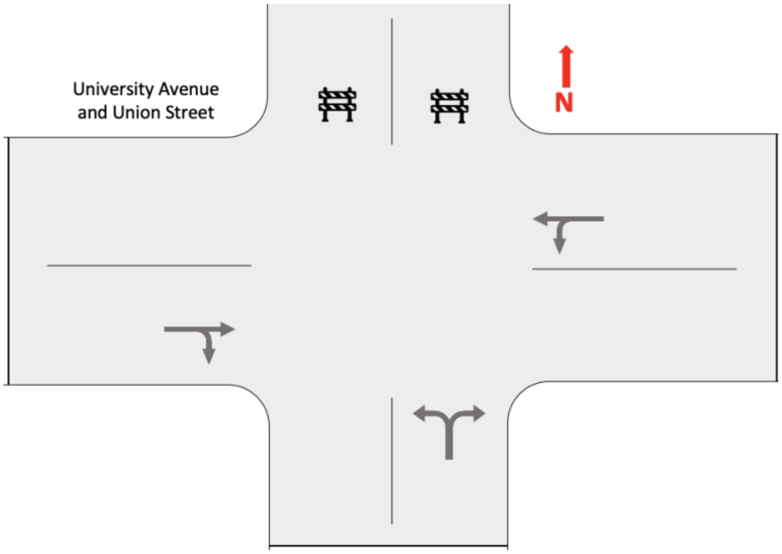

Figure 12: Phase Diagram of University Ave. (North and South) & Union St. (East and West) Intersection

Albert St. & Union St.

At the Albert St & Union St. intersection, there is a shared right, through and left lane at each approach as shown in Figure 13.

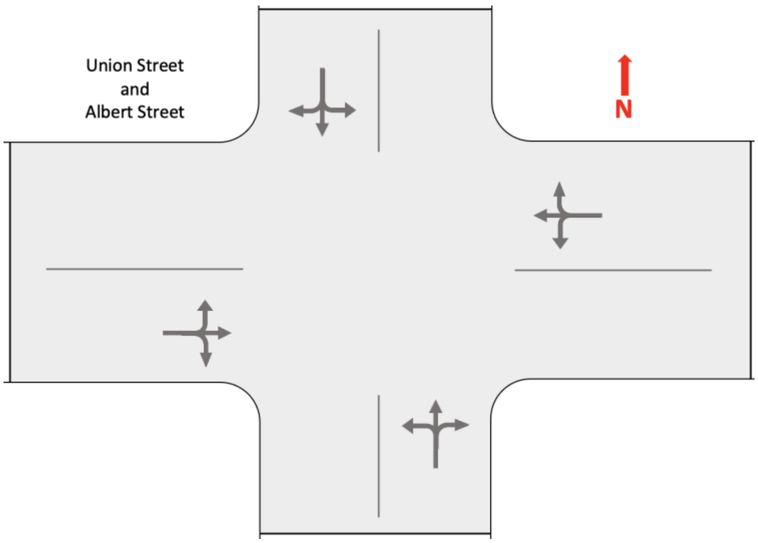

Figure 13: Phase Diagram of Albert St. (North and South) & Union St. (East and West) Intersection

Barrie St. & Union St.

The Barrie St. & Union St. intersection is considered an offset intersection as shown in Figure 14. There is a shared right, through and left lane at each approach.

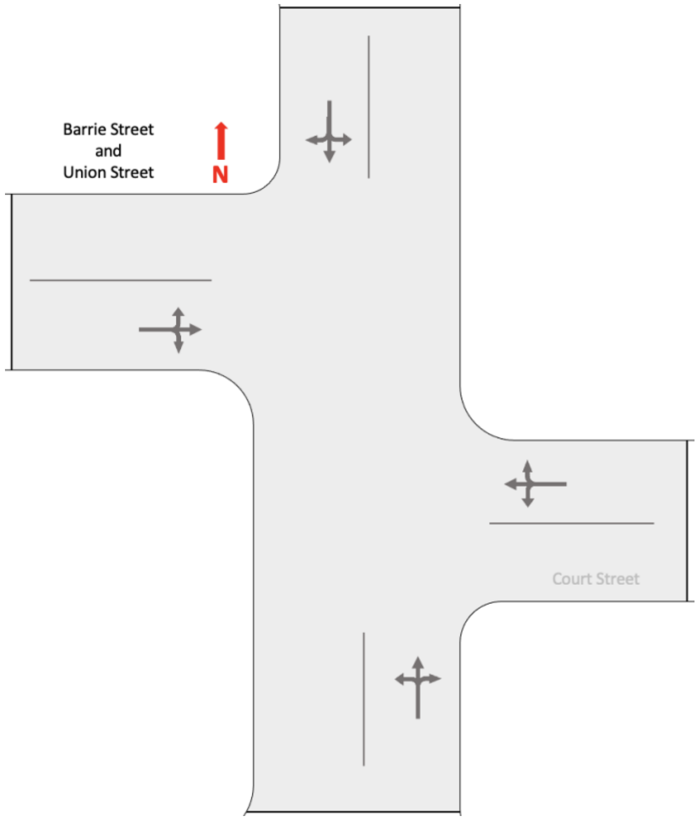

Figure 14: Phase Diagram of Barrie St. (North and South) and Union St. (East and West) Intersection

University Ave. & Stuart St.

The University Ave. & Stuart St. intersection is a T-Intersection as shown in Figure 15. At the East and West approach, motorists can travel through or turn onto University Ave. heading towards campus.

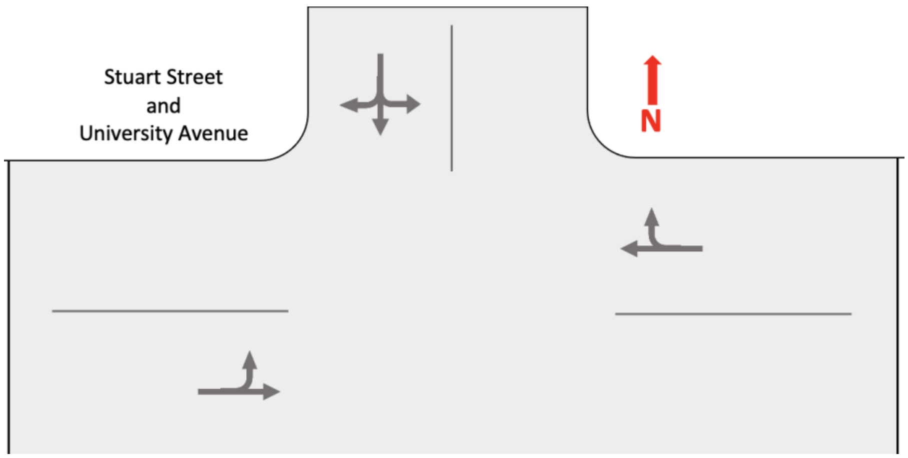

Figure 15: Phase Diagram of University Ave. (North) and Stuart St. (East and West) Intersection

University Ave. & Bader Ln.

The University Ave. and Bader Ln. intersection is a T-intersection as show in in Figure 16. Vehicles coming from Bader Ln. can either turn right or left onto University Ave.

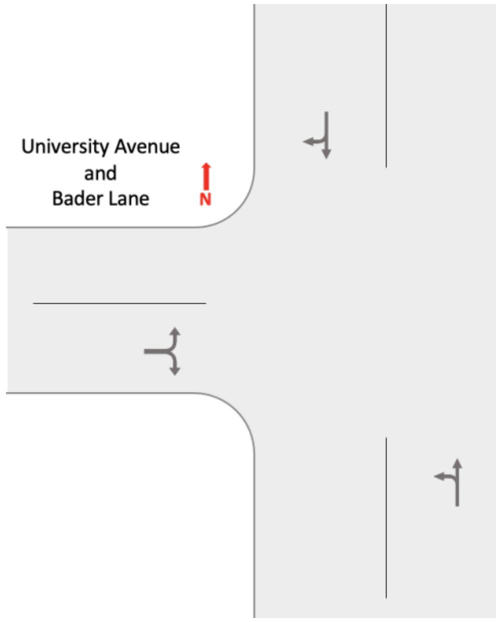

Figure 16: Phase Diagram of University Ave. (North) and Bader Ln. (West) Intersection

Albert St. & Bader Ln.

The Albert St. and Bader Ln. intersection is shown in Figure 17. As shown, this intersection does not follow the traditional four-way intersection and is similar to a roundabout. The unique layout increases the user workload as the movements do not follow a natural left, right or through path.

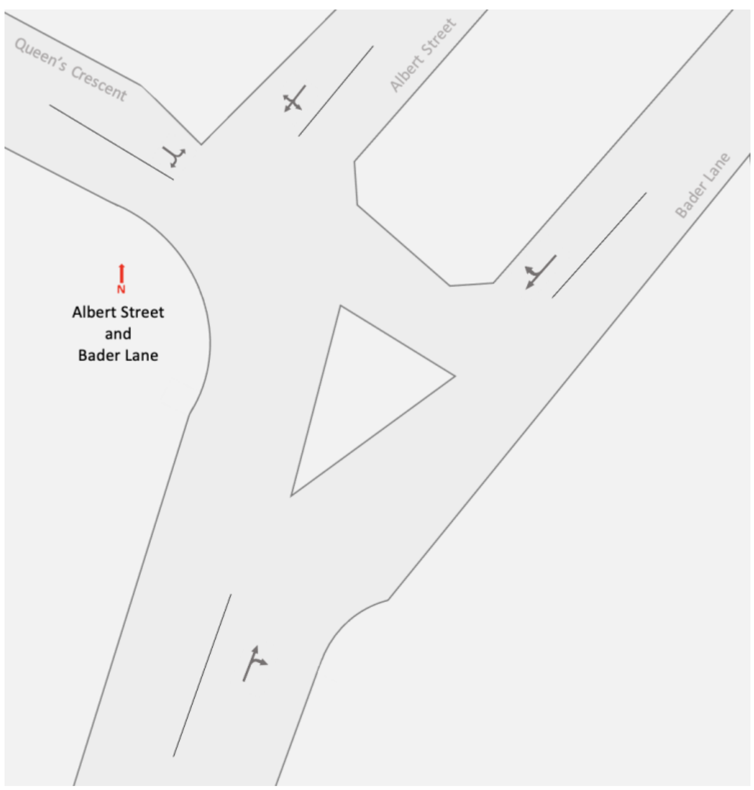

Figure 17: Phase Diagram of Albert St. and Bader Ln.

5.0 Specifications, Guidelines and Codes

In order to ensure the designs proposed by the team can be implemented in the future, it was essential to follow the specifications, guidelines and codes set by the City of Kingston. The following section outlines the specifications, guidelines and codes used for this project.

5.1 City of Kingston

The City of Kingston has design guidelines and specifications; however, they are not currently available to the public as the city is updating the current standards. During this update period, the previous guidelines are also unavailable.

5.2 TAC Guide

The Transportation Association of Canada (TAC) was used as the main guideline. TAC has provided recommended lower and upper limits for pedestrian through zones (i.e., sidewalks), unidirectional and bidirectional bike paths, delineator components and buffered bike lanes. These recommendations and definitions for each infrastructure type are shown in Table 3 and was used as a guide when creating the final designs (Michael Chiu et al. 2017a; b; c).

Table 3: TAC Guidelines by Infrastructure Type

Infrastructure Type	Definition	Recommended Lower Limit (m)	Recommended Upper Limit (m)
Pedestrian Through Zone	Area intended to be clear and navigable while free of permanent and temporary obstruction.	3.0	6.0
Unidirectional Bike Path	Two bike paths travelling in the direction of traffic, each located on opposite sides of the street.	1.8	2.5
Bidirectional Bike Path	Two bike paths travelling in opposite directions, each located on the same side of the street.	3.0	3.6
Delineator Component	Posts or bollards separating cyclists and vehicles to provide an additional safety measure.	0.3	1.0
Buffered Bike Lane	Pavement marking between cyclists and vehicles to provide an additional safety measure.	0.3	0.9

5.3 Ontario Traffic Manual

The Ontario Traffic Manual (OTM) provides additional information and guidance for transportation design with the goal of promoting uniform design. Book 18: Cycling Facilities was used as supplementary guideline to design the proposed cycling facilities on campus (Ministry of Transportation of Ontario 2021).

6.0 Technical Analysis

Aligning with the goals of the client, the team considered transitioning certain roadways within the campus at Queen's University to AT users only and restricting motor vehicle access, aiding a transition to a vehicle-free campus. As such, it was essential to understand if the surrounding roadways within the transportation network could account for the traffic rerouted around the campus. Technical analysis of the transportation infrastructure required the team to analyze the capacities of roadways within the site limits. The capacity of a roadway is a measurement of the maximum rate of motor vehicles that can pass through an intersection within an hour (U.S. Department of Transportation 2004). The maximum capacity of a small-sized signalized intersection, such as the University Ave. & Union St. intersection, is 1,400 vph (U.S. Department of Transportation 2004).

Using data collected during the second and third phases of the traffic study, the team calculated the critical approach volume of each intersection within the study. The critical approach volume was determined by comparing the flow rate of traffic travelling in each of the two opposing lanes and finding the peak motor vehicle volume at an intersection. This value was measured in vehicles per hour. Table 4 below summarizes the critical approach volume of the six intersections analyzed during the traffic study.

Table 4: Approach Vehicle Volume by Intersection

Approach Volume (vph)	Northbound	Southbound	Eastbound	Westbound	Critical Approach Volume (vph)
Albert St. & Union St.	210	130	230	370	**370**
University Ave. & Union St.	N/A	60	240	340	**340**
Barrie St. & Union St.	120	90	40	80	**120**
University Ave. & Stuart St.	50	N/A	60	70	**70**
University Ave. & Bader Ln.	21	25	31	N/A	**31**
Albert St. & Bader Ln.	16	16	N/A	21	**21**

6.1 University Ave. & Union St.

This intersection is the hub of campus and processes considerably high pedestrian traffic along with servicing vehicles, public transit, and cyclists. This intersection is pedestrian-focused, with long wait times of up to a minute for cars, bikes, and public transit buses, allowing pedestrians to cross the intersection safely. The data showed that the largest volume of pedestrians pass through this intersection on weekday afternoons, with an average of around 4,800 pedestrians crossing the intersection. On both weekdays and weekends, Union St. (East and West) experienced the highest volume of cars with a critical approach volume of 340 vph. The critical approach volume travelling along University Ave. (North and South) was 60 vph, with higher volumes travelling Northbound. Due to the closure of University Ave. above Union St. for construction, this data may change after construction ends and the connection from Union St. to Earl St. is available again.

6.2 Albert St. & Union St.

The Albert St. & Union St. intersection is the westmost intersection considered in this study. This intersection is located on the Northwest side of campus, bridging the gap between student residence buildings below Union St. and student houses above. This road saw the most traffic between 4:00pm and 5:00pm. The road with the highest volume during this time was Union St. (East and West), with a critical approach volume of 370 vph. Union St. saw more cars travelling East in the morning and West in the afternoon, indicating Union St. may be a commuter route for Kingston residents either travelling downtown or to Queen's University campus for the workday. This intersection saw the third highest volume of cyclists using this intersection at peak hours, indicating this intersection may not be cyclist friendly. The critical approach volume for Albert St. (North and South) was 210 vph travelling Northbound through the intersection. The critical approach volume was disproportionately higher than the approach volume travelling Southbound by a factor of 4. This may have been caused by vehicles exiting the large parking lot immediately South of the intersection after regular working hours.

6.3 Barrie St. & Union St.

This intersection is on the East end of campus and is adjacent to Kingston's City Park. This road is frequently used by emergency vehicles travelling between KGH and Kingston's downtown core. This intersection saw similar volumes in the morning and afternoon. The critical approach volume at this intersection was 120 vph travelling Northbound. This path ended up having a moderate amount of bike traffic as well, with the maximum number of bikes passing through this intersection being 47 bikes per hour on a Saturday afternoon.

6.4 Stuart St. & University Ave.

Stuart St. & University Ave. is the intersection South of the campus. This intersection was not dominated by one mode of transportation. The intersection supports traffic coming from KGH, an active bus route, first-year students walking to campus from the West side of Stuart St., and commuters passing through the intersection to reach Kingston's downtown core. The intersection is a three-way stop with no traffic signals. The critical approach volume for this intersection was running East and West on Stuart St., with less traffic travelling to and from University Ave. The critical approach volume was 70 vph travelling Eastbound on Stuart St. This intersection did not have a consistent level of cyclists passing through. The average volume of cyclists during weekday mornings and on weekends was 7 cyclists per hour. There was a spike seen on weekday afternoons with the average number of cyclists reaching 41 cyclists per hour.

6.5 University Ave. & Bader Ln.

Bader Ln. is a small side street off University Ave. that is home to buildings including but not limited to Ban Righ Dining Hall, Victoria Hall, Chernoff Hall, and Sterling Hall. The intersection is T-shaped, with Bader Ln. having a stop sign perpendicular to through traffic on University Ave. On average, the traffic volume was approximately 15 vph on Bader Ln., which was considerably lower than other intersections in the traffic study. The critical approach volume for this intersection was 31 vph travelling Eastbound on Bader Ln. and turning right onto University Ave. The intersection had a consistent amount of pedestrian traffic, reaching over 2,100 during peak periods. The intersection saw a consistent level of approximately 8 cyclists per hour, despite data collection being conducted on a particularly cold winter day.

6.6 Albert St. & Bader Ln.

The intersection of Albert St. & Bader Ln. is T-shaped, with Bader Ln. having a stop sign perpendicular to through traffic on Albert St. and includes a pedestrian island to aid AT users when crossing the street. Leonard Dining Hall and multiple first-year residences are on both sides of Albert St. surrounding the intersection, resulting in many pedestrians crossing the street at unsafe locations. The critical approach volume for this intersection was 21 vph travelling Westbound on Bader Ln. and turning left onto Albert St. The intersection saw a consistent amount of pedestrian traffic, yet slightly less than at the opposing end of Bader Ln. Pedestrian counts reached over 1,100 during peak periods. Additionally, there was a consistent level of approximately 7 cyclists per hour passing through.

6.7 Trip Generation

During the initial brainstorming phase, the team suggested restricting motor vehicle access on Bader Ln. and University Ave. Using the Critical Approach Volumes calculated for each intersection in the study, the impact the lane closures have on surrounding roadways within the network was analyzed to ensure surrounding roads can account for the rerouted traffic. The following subsections discuss the effects of specific lane closures on surrounding roadways within the transportation network.

6.7.1 University Ave. Lane Closure

Restricting motor vehicle access on University Ave. and allowing only AT and service vehicle travel would force motor vehicles to instead drive on Union St. and then turn onto Division St., Barrie St., or Albert St. Figure 18 below depicts the trip generation analysis performed by the team. The critical approach volume at the intersection of University Ave. & Union St. was 340 vph. To create a conservative estimate, this critical approach volume was applied to both the East and West segments of Union St. during the trip generation analysis. Following the simulated route, depicted in blue, critical approach volumes at subsequent intersections were added to ensure the maximum allowable traffic demands stays below the laneway capacity. The maximum motor vehicle volume experienced within the site limits was 1,102 vph, which is under the laneway capacity of 1,400 vph.

Figure 18: Trip Generation Analysis with University Ave. Lane Closure

6.7.2 Bader Ln. Lane Closure

Restricting motor vehicle access on Bader Ln. and allowing only AT and service vehicle travel would force motor vehicles attempting to cut from Albert St. to University Ave. to instead travel around using either Stuart St. or Union St. The critical approach volumes for the University Ave. & Bader Ln. and Albert St. & Bader Ln. intersections are 31 and 21 vph, respectively. The trip generation analysis performed by the team can be seen in Figure 19 below, with the simulated route depicted in blue. The maximum motor vehicle volume experienced within the site limits was 872 vph, which is under the laneway capacity of 1,400. Closing Bader Ln. is an appropriate design solution that would not result in traffic delays.

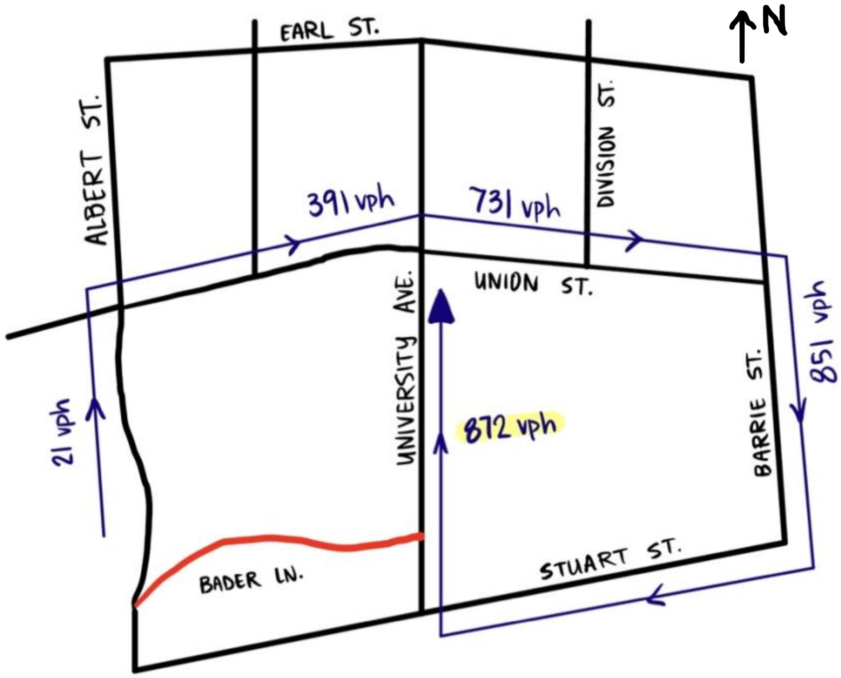

Figure 19: Trip Generation Analysis for Bader Ln. Lane Closure

6.7.3 University Ave. & Bader Ln. Closure

Restricting motor vehicle access on both University Ave. and Bader Ln. and allowing only AT and service vehicle travel would increase the traffic demand on the surrounding streets most significantly. As such, it was essential that laneway demand does not exceed its corresponding capacity at any point within the site limits. The critical approach volumes of the University Ave. & Union St. and Bader Ln. & University Ave. intersections were 340 and 31 vph, respectively. The motor vehicles were then rerouted to other roadways within the transportation network, and the traffic demand on each roadway was calculated. The maximum traffic demand experienced within the site limits was 1,102 vph. Figure 20 depicts the traffic volume demand within the site limits after lane closures at University Ave. and Bader Ln., with the simulated route depicted in blue.

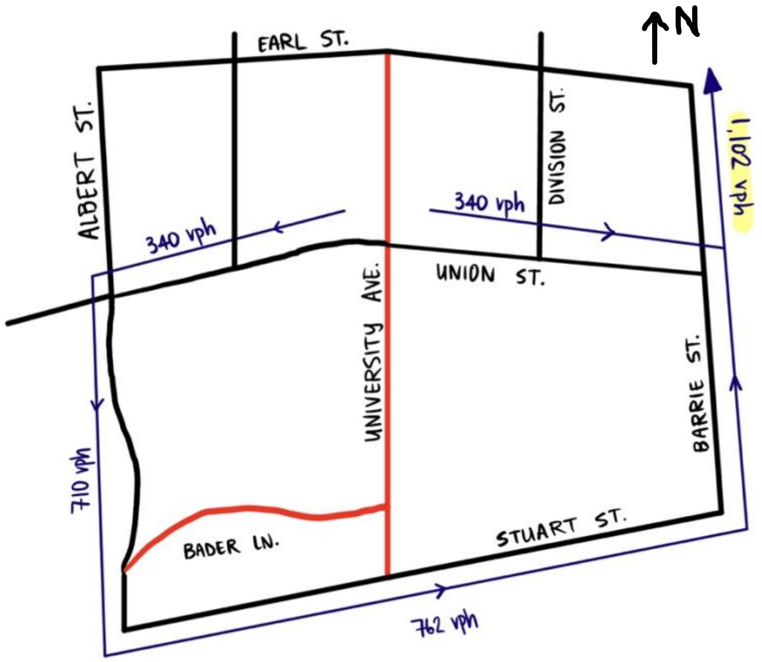

Figure 20: Trip Generation Analysis for Bader Ln. & University Ave. Lane Closures

7.0 Environmental Assessment Process

To determine an adequate solution for this project, an Environmental Assessment (EA) was used to assess possible design alternatives. The objective of an EA is to ensure environmental effects are minimized and applicable mitigations have been taken based on the identified effects (Michael Chiu 2022). The Canadian EA Act details the decision-making process that addresses the needs and environmental effects associated with a project. In transportation projects, the word 'environment' includes not only the natural environment, but also various social, economic, and technical considerations, cultural heritage, archaeology, and climate change.

The EA process steps used in this report are shown in Figure 21. The first step of the EA process involves generating possible planning alternatives based on the conducted background research and observations determined during the traffic study. Planning alternatives are possible options that can be used to improve the use and space of each street. These alternatives may include Complete Streets and Vehicle-Free Campus options. Those planning alternatives were assessed and evaluated, and the preferred alternative selected was based on different criteria which were developed using the project scope and constraints.

The second step of the EA process was to develop design alternatives. Design alternatives are a selection of design options where each include various features that could be implemented on campus. Design alternatives were selected based on the planning alternatives developed in the previous step. These design alternatives can then be assessed and evaluated, and a preferred design solution can be selected.

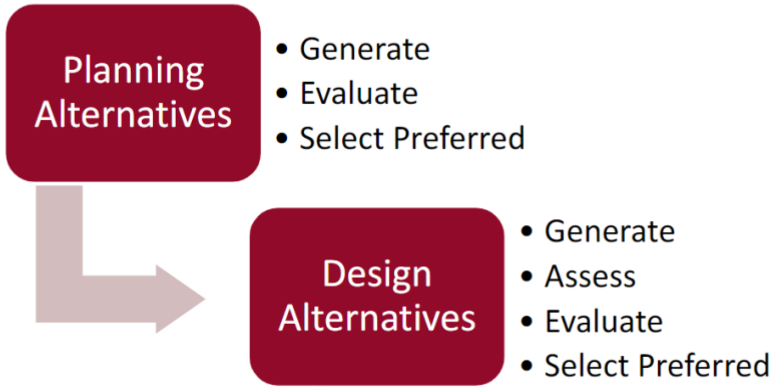

Figure 21: EA Process Used for Transportation Projects (Michael Chiu 2022)

8.0 Planning Alternatives

As part of the EA process, the first step involved the development of planning alternatives. The goal of this step was to generate a variety of ideas and solutions that can address the identified problem. It was important to brainstorm several options before narrowing the final design to ensure that all possible options were considered. This assessment consisted of generating planning alternatives and criteria which were then evaluated to select the preferred alternative. This process is completed below.

8.1 Generate

The planning alternatives developed for Queen's University's campus are outlined below:

- Complete Street
- Road Space Rationing
- Vehicle-Free Weekends
- AT & Low-Speed Electric Vehicles (LSEV) Only
- AT & Public Transit Only
- AT & Service Vehicles Only
- Do Nothing

These planning alternatives are defined in Table 5. The planning alternatives were selected based on the scope of the project, survey results and data collected during the traffic study.
Based on the survey, the preferred method of travel to Queen's University's campus was walking, while only a small portion indicated that biking was their main method of travel. Cyclists can be categorized based on their perception of adequate safety levels and reliance on bikeway infrastructure. As there are currently very limited bike paths offered within campus, only the "Strong and Fearless" individuals are willing to cycle with limited to no bikeway-specific

infrastructure in place (Alta 2017). However, as previously mentioned, the survey indicated that cycling traffic would increase if bikeway facilities were improved across campus. In addition, the survey results indicated that students and faculty travel to campus daily. Thus, while brainstorming potential planning alternatives, an emphasis was placed on the daily walking and cycling results, in order to diversify and promote all modes of AT in a safe manner within Queen's University's campus. The final planning alternatives are summarized and explained in detail in Table 5 below.

Table 5: Planning Alternatives and Explanations

Planning Alternatives	Explanations
Complete Street	A Complete Street is designed to consider the needs of all users regardless of age, level of mobility or mode of travel (The Centre of Active Transportation 2022). Refer to Section 2.4 Complete Streets for details regarding this planning alternative.
Road Space Rationing	Road space rationing is a planning alternative that helps to encourage and influence commuters to use the existing infrastructure more efficiently. Although many road space rationing initiatives exist, this alternative considers the restriction of motor vehicle access on University Ave. during certain hours of the day when pedestrian traffic is high.
Vehicle-Free Campus*	A vehicle-free campus would prohibit the access of motor vehicles of any type including private vehicles, public transportation, or service vehicles. In the case of an emergency, ambulances, police, or fire services are permitted.
AT & LSEV Only*	AT is the main source of travel for the campus community and will also allow only the use of LSEVs. In this planning alternative the implementation of LSEVs will be used as opposed to the current service vehicles. LSEVs typically travel up to a maximum of 65 kilometers per hour (kph) and rely on electricity to operate. In the case of an emergency, ambulances, police, or fire services are permitted.
AT & Public Transit Only*	AT and Kingston public transit is the main source of travel for the campus community. There will be no private or Queen's Facilities vehicles permitted on campus in this option. In the case of an emergency, ambulances, police, or fire services are permitted.
AT & Service Vehicles Only*	This option restricts commuter traffic from entering roadways, and only permits AT and service vehicles such as Queen's Facilities or delivery trucks. In the case of an emergency, ambulances, police, or fire services are permitted.

Planning Alternatives	Explanations
Do Nothing	The do-nothing approach is the alternative which does not include any changes to the current conditions on campus.

*Kingston municipal vehicles are permitted to complete maintenance tasks.

The planning alternatives were evaluated using a reasoned method approach, using the criteria outlined in Table 6 below. Each criterion used in the evaluation is defined, and the team's rationale for judgement is explained.

Table 6: Planning Alternative Evaluation Criteria Definitions

Criterion	Definition
Environment	The planning alternative reduces Greenhouse Gas (GHG) emissions and increases the greenspace on campus.
Sustainability	The planning alternative can be implemented for the long-term without disrupting the current campus atmosphere.
Innovation	The planning alternative introduces new ideas or methods that bring value to Queen's University.
Safety	The planning alternative is safe for all users including but not limited to pedestrians, cyclists, and motorists.
Accessibility	The planning alternative is accessible for all users regardless of level of ability or mobility.
User Workload	The planning alternative reduces the effort and attention needed for the users to complete a task such as crossing a road.
Comfort	The planning alternative increases the ease of travel for all commuters. In addition, this alternative helps foster a more inclusive and welcoming campus atmosphere.
Feasibility	The planning alternative is practical and achievable given the identified constraints.

8.2 Evaluate

Table 7 was used to evaluate different planning alternatives against relevant criteria for this study. Planning alternatives are displayed in the left column and the criteria used for evaluating are displayed along the top row of the table. Each planning alternative was given a score out of three, with a score of three representing excellent performance and a score of one representing poor performance. Criterion with a dash (-) indicates the criterion does not address or contribute to the planning alternative and criterion with a N/A are not applicable for that alternative.

Table 7: Evaluates Each Planning Alternative Against the Defined Criterion

Criterion / Planning Alternative	Environment	Sustainability	Innovation	Safety	Accessibility	User Workload	Comfort	Feasibility
Complete Street	✓✓	✓✓✓	✓	✓✓	✓✓✓	✓✓	✓✓	✓✓✓
Road Space Rationing	✓✓	✓	✓✓	✓✓	-	-	✓✓	✓✓
Vehicle-Free Campus	✓✓✓	-	✓✓	✓✓✓	-	✓✓✓	✓✓✓	-
AT & LSEV Only	✓✓✓	✓	✓✓✓	✓✓	✓	✓✓	✓✓	-
AT & Public Transit Only	✓✓	✓✓	-	✓	✓✓	✓	✓✓	✓
AT & Service Vehicles Only	✓✓	✓✓	✓	✓✓	✓✓	✓✓	✓✓✓	✓
Do Nothing	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Legend

✓ : Poor Performance

✓✓ : Moderate Performance

✓✓✓ : Good Performance

- : Does not address criteria

N/A : Not Applicable

The planning alternatives were evaluated using a reasoned argument method, which allowed for human rationale to play an important role in the decision-making process. This method allowed each planning alternative to be evaluated relative to one another and relative to a baseline "Do Nothing" approach. Each planning alternative's evaluation is argued below.

8.2.1 Complete Street

This planning alternative scored a moderate level of performance when addressing environmental initiatives, as it worked to promote AT but fails to reduce GHG emissions. This alternative also addresses safety, user workload, and comfort at moderate levels. Implementing design measures essential for Complete Streets such as connected bike networks, median islands, safe and frequent pedestrian crossing opportunities, and wide sidewalks only served to make moderate improvements in these categories when compared to other alternatives. This planning alternative addressed sustainability, feasibility, and accessibility. Elements of Complete Streets would allow the campus at Queen's University to be accessible to individuals of all ability and mobility levels and could feasibly be implemented without disrupting campus atmosphere in the long-term. Alternatively, this planning alternative addressed innovation poorly. Complete Streets are a common design goal that have been adopted by many cities across Ontario and is increasingly seen as a transportation planning norm.

8.2.2 Road Space Rationing

This planning alternative scored a moderate level of performance when addressing environmental initiatives, innovation, safety, comfort, and feasibility. Restricting motor vehicle access during peak AT periods would help reduce the GHG emissions from motor vehicles within campus. This planning alternative was moderately innovative, as it was not used as frequently in transportation design and was a newer Traffic Systems Management initiative. Additionally, this alternative would improve the comfort levels of commuters using AT during restricted periods and could be implemented easily upon approval from the City of Kingston. This alternative garnered poor performance levels when addressing sustainability as the motor vehicle restrictions at varying times may frustrate commuters long-term. Lastly, this planning alternative did not address the user workload and accessibility needs of commuters as public transportation within campus was restricted as there were multiple roadway closures.

8.2.3 Vehicle-Free Campus

This planning alternative experienced good performance when addressing environmental initiatives, safety measures, user workload, and user comfort. Transitioning Queen's University's campus to an entirely vehicle-free campus would reduce GHG emissions and improve the air quality (Erickson 2017). Additionally, this option would increase the space available for landscaping and green spaces on campus. A vehicle-free campus would increase the safety of commuters using AT and decrease the workload needed to ensure safety when travelling. This alternative would also provide exceptional comfort to commuters, with large multi-use pathways free of motor vehicles. This planning alternative earned a moderate score when addressing innovation, as this was an initiative previously explored by other Universities and by Queen's University in the past. Lastly, this planning alternative did not address the accessibility needs of all commuters, and was, therefore, not a feasible long-term solution.

8.2.4 AT & LSEVs Only

This planning alternative scored a good level of performance when addressing environmental initiatives and innovation. Reducing roadways on campus to only permit AT and LSEVs would eliminate GHG emissions on campus produced by motor vehicles. Designing for the use of LSEVs was innovative, however, it was not sustainable as this alternative would create a discontinuity between Queen's University and Kingston. As LSEVs can only travel at low speeds, it would be challenging for users to travel outside of Queen's University campus where speed limits are higher. This alternative scored a moderate level of performance when addressing safety as LSEVs can still cause potential collisions. User workload was also scored as moderate as users would still need to be aware of vehicles. In addition, comfort was scored as moderate as this planning alternative still maintained various transportation modes. Lastly, this planning alternative scored a poor level of performance when addressing accessibility and, thus, was not feasible.

8.2.5 AT & Public Transit Only

This planning alternative scored a moderate level of performance when addressing environmental initiatives. As transportation would only be limited to AT and public transit, GHG from vehicles would be reduced. The use of AT and Public Transit Only also addressed sustainability, accessibility, and comfort at a moderate level. This alternative was sustainable; however, it may be challenging to implement as many individuals are vehicle dependent and are unwilling to change transportation modes. This option would cause some accessibility disruption to the population using private motor vehicles to commute, but still received a moderate level because the campus was still accessible to commuters via public transit. Furthermore, this alternative scored a poor level of performance when addressing safety, user workload, and feasibility. Safety was scored as poor since there would be an increase in AT commuters which could increase the bus collision rates. As buses are larger than vehicles, these collisions may pose a higher risk to AT commuters. User workload was poor as AT commuters and buses would need to be cautious in order to reduce collision rates. Lastly, feasibility scored poor as individuals are reliant on vehicles.

8.2.6 Do Nothing

This planning alternative did not improve any of the assessed criteria and thus was not applicable in the scoring matrix.

8.3 Select Preferred

Based on the results obtained in Table 7, the Complete Street alternative scored the highest number of checkmarks which were also well distributed across all criteria. Therefore, this alternative addressed all the defined criteria, as a score of at least one checkmark was allocated to each criterion.

Through the traffic count, it was determined that not all roads are suitable for the same design as each street includes different road components. This can make it challenging to strictly design all roads on campus as Complete Streets since there are varying space limitations. Thus, a second alternative was also selected to address the needs of Queens' students and staff. The AT & Service Vehicle Only alternative was selected as this alternative scored the second highest number of checkmarks which were also well-distributed amongst each criterion. Therefore, the Complete Street and AT & Service Vehicle Only alternatives were selected as both options fulfill the set criterions and were suitable to implement on campus.

9.0 Design Alternatives Assessment

As previously mentioned, the second step of the EA process is the design alternatives assessment. This assessment consists of generating design alternatives and criteria for the chosen planning alternatives which can then be assessed and evaluated to select the preferred one. This process is completed below.

9.1 Generate

To determine which of the two preferred planning alternatives should be implemented on the streets of study, an evaluation matrix was used. The streets of study were assessed based on their pedestrian capacity, cyclist capacity, car capacity, and pedestrian access to buildings, as defined in Table 8. These criteria were selected as they demonstrate which modes of transportation were predominately used on each respective street. As a result, a better understanding of whether the street is dominated by vehicles or AT modes can be gained.

Table 8: Design Criteria and Definitions

Criterion	Weight	Definition
Pedestrian Capacity	5	Number of pedestrians at the intersections of the selected street based on the traffic study completed.
Cyclist Capacity	4	Number of cyclists at the intersections of the selected street based on the traffic study completed.
Car Capacity	2	Number of vehicles at the intersections of the selected street based on the traffic study completed.
Pedestrian Access to Buildings	3	Number of Queen's University buildings where the main entrance is accessible directly off the selected street.

9.1.1 Weight Rationale

Each criterion was weighted based on its importance in the evaluation. Pedestrian capacity was given the highest weight of 5 as pedestrians represent the largest percentage of commuters.

Cyclist capacity was weighted as a 4, as the traffic study indicated that if better cycling facilities were provided, more students would use cycling as their main form of transportation. These two criteria were also weighted the highest in priority as they addressed the goal of encouraging AT. The pedestrian access to building criterion was ranked as 3. As the majority of the commuters' destinations were expected to be a campus building, the criterion would demonstrate if the street would be frequented by pedestrians. For example, a street with more buildings would naturally have more commuters. Lastly, vehicle capacity was ranked as the lowest weight of 2 since improvements made to campus should be more centered towards a vehicle-free approach based on the scope of the project.

9.1.2 Scoring Rationale

First, to determine what range of values correspond to a score, the data collected during the traffic count was utilized. The maximum count for each criterion was determined and divided by four to create the scoring ranges. For example, the highest count of cyclists (i.e., 94) was divided by four to create four equally distributed scoring ranges. The ranges were 0-23, 24-47, 48-71, and 72+ and correspond to a score of 1, 2, 3, and 4, respectively.

A score of 4 would indicate that the street required appropriate infrastructure to accommodate the high volume of pedestrians and cyclists, and access to buildings. In terms of vehicle capacity, a score of 4 represented low flow of traffic. Therefore, higher scores would rationalize that a vehicle-free design should be implemented to the street. Alternatively, when pedestrian and cyclist capacity was low while vehicle capacity was high, a score of 1 would be allocated. This indicated that a vehicle-free design was unsuitable, and thus a Complete Street would be implemented.

The highest and lowest total score that could be allocated to a street was 56 and 14, respectively. Using an arbitrary score of 3 for each criterion, a total score of 42 was calculated. This score determined whether a vehicle-free (greater than 42) or Complete Street design (less than 42) should be implemented. A score of 3 was chosen because as shown in Table 9, there was a 1:2 ratio between vehicle capacity and pedestrian capacity, which indicated that at this score, over half of commuters were represented by pedestrians. Thus, additional safety measures and infrastructure catered to pedestrians and cyclists was prioritized.

Table 9: Criteria and Scoring Template

Criterion	Weight	Score			
		1	2	3	4
Pedestrian Capacity	5	200 Pedestrians/hour	400 Pedestrians/hour	600 Pedestrians/hour	800+ Pedestrians/hour
Cyclist Capacity	4	0-23 Cyclists /hour	24-47 Cyclists /hour	48-71 Cyclists /hour	72+ Cyclists /hour

Criterion	Weight	Score			
		1	2	3	4
Car Capacity	2	500+ Vehicles /hour	400 Vehicles /hour	300 Vehicles /hour	200 Vehicles /hour
Pedestrian Access to Buildings	3	0-3 Buildings	4-6 Buildings	7- 9 Buildings	10+ Buildings

9.2 Assess

Table 10 assessed the streets included in the study to identify which selected planning alternative was most suitable for each street. Since the traffic count was conducted on Tuesday, Thursday and Saturday mornings and afternoons, the highest count recorded for each criterion was selected in order to be conservative and was considered the "worst-case scenario". Furthermore, since the traffic count was completed at intersections, additional analysis was completed to determine the number of commuters on each street. For example, along University Ave., both the Union St. & Stuart St. intersections were analyzed. All vehicles turning on University Ave. were added at both intersections to determine the number of vehicles travelling on University Ave.

Table 10: Evaluation Matrix of Each Street vs. Criteria

Street \ Criterion	Pedestrian Capacity	Cyclist Capacity	Car Capacity	Access to Buildings	Total Score
Albert St.	15	8	2	6	**31**
University Ave.	20	16	6	12	**54**
Barrie St.	5	12	4	3	**24**
Stuart St.	10	4	8	9	**31**
Union St.	20	16	2	12	**50**
Bader Ln.	20	12*	2	12	**46**

*Assumption has been made as stated in Section 9.3.

9.3 Evaluate

Albert St., Barrie St., and Stuart St. scored less than 42, indicating that a Complete Street design should be implemented. University Ave., Union St. and Bader Ln. scored greater than 42, indicating that a vehicle-free design should be implemented. As previously mentioned, a numerical evaluation did not consider human rationale, which is an important aspect to transportation projects. Therefore, based on Table 10 and human rationale, it was determined that it would not be feasible to restrict vehicle access on both University Ave. and Union St. simultaneously.

The results of the matrix showed a score of 6 and 2 respectively for car capacity on University Ave. & Union St., demonstrating that Union St. was one of campus' main vehicular corridors. This implied it would not be sustainable to restrict vehicle access on both these roads and thus a vehicle-free design would only be implemented on University Ave. It should be noted that after further discussion with the client, Bader Ln. was added to the traffic study. As a result, the traffic count for Bader Ln. was completed during winter months, when AT patterns are reduced due to weather conditions. The pedestrian capacity was still ranked as a 20 as this road is a prime area for students living in residences. However, the snow along Bader Ln. was not adequately plowed for students to safety cycle, therefore, very few students were cycling during the traffic count. Thus, an assumption of 12 was made for cycling capacity as the large number of students cycling along University Ave. would have travelled on Bader Ln. from residences, campus buildings, or student housing on Beverly St. and Collingwood St.

9.4 Select Preferred

Based on the analysis completed, it was determined that Albert St., Barrie St., Stuart St. and Union St. would be designed as Complete Streets. Since it was demonstrated that there was a high pedestrian capacity on University Ave. and Bader Ln., these streets were designed as an AT & Service Vehicles Only Street. Based on the technical analysis completed, by restricting both these streets to private vehicles, there would be a significant increase in the number of vehicles on the surrounding streets. However, this design would be much safer for pedestrians and cyclists and would promote the use of AT as it would take longer to travel by vehicle.

10.0 Final Design Solutions

The following section outlines the conceptual design for the streets included in the study. The existing cross-section dimensions are shown in Figure 42 – Figure 47 of Appendix C: Existing Cross-section Dimensions.

10.1 Complete Street Design

A Complete Street design was created for Albert St., Stuart St., Barrie St., and Union St. Through initial analysis of road dimensions, it was determined that Albert St. and Stuart St. shared similar road and sidewalk dimensions. These streets had the same total vehicle travel lane width of 10 meters (m) but had slightly varying sidewalk widths (See Table 18, Appendix C: Existing Cross-section Dimensions). In addition, both of these streets had street parking lanes on both sides of the roads while Barrie St. had street parking along one side of the road. Figure 22 depicts the current cross-section for Albert St. and Stuart St. Figure 23 and Figure 24 depict the current cross-sections for Barrie St. and Union St., respectively. It was assumed that sidewalks on Albert St., Stuart St. and Barrie St. had the same dimension.

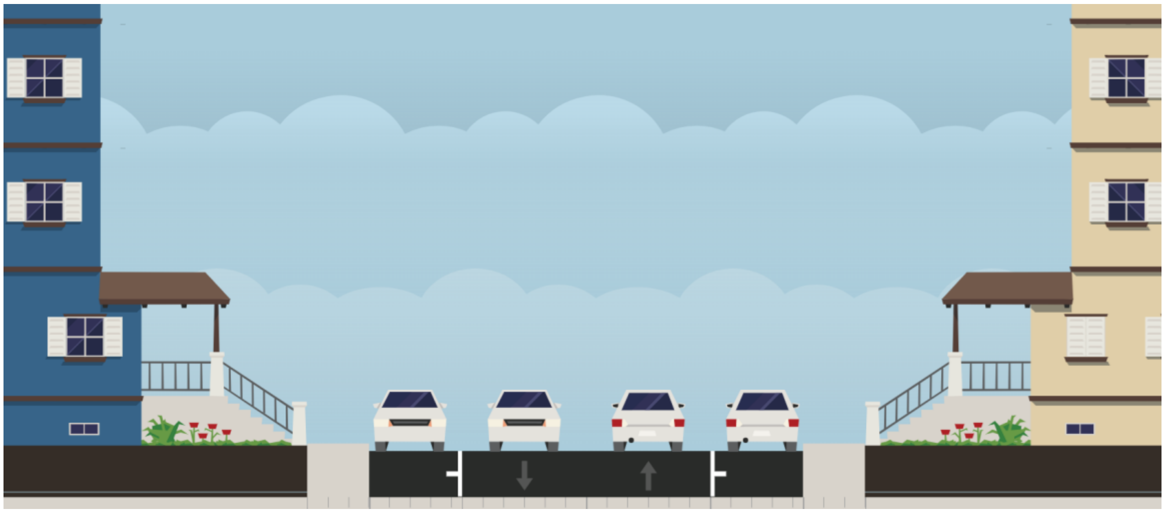

Figure 22: Existing Albert St. and Stuart St. Cross-section (Streetmix 2023)

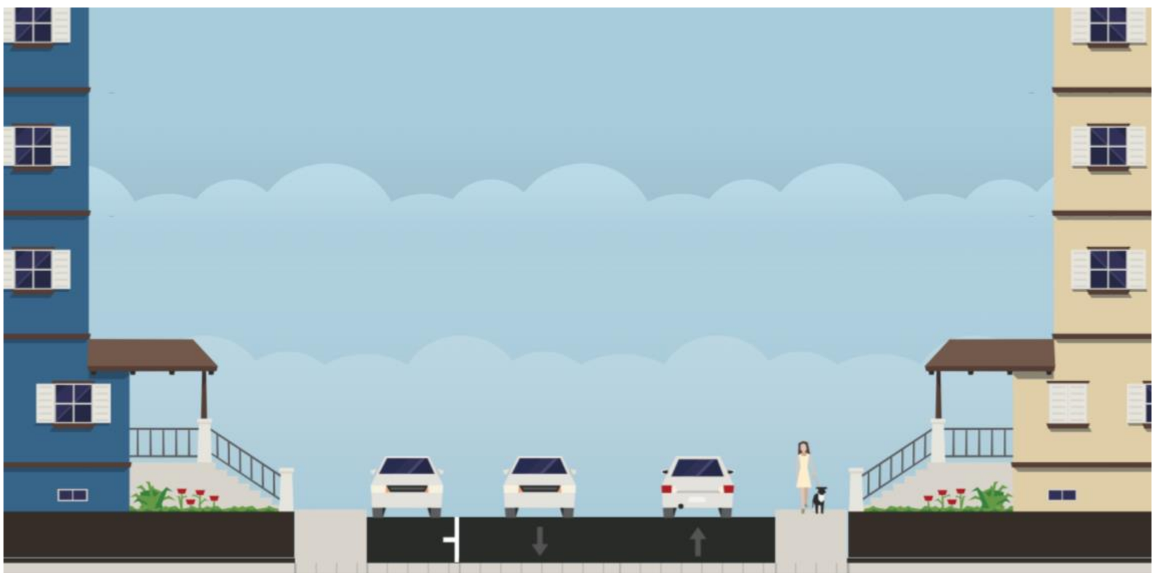

Figure 23: Existing Barrie St. Cross-section (Streetmix 2023)

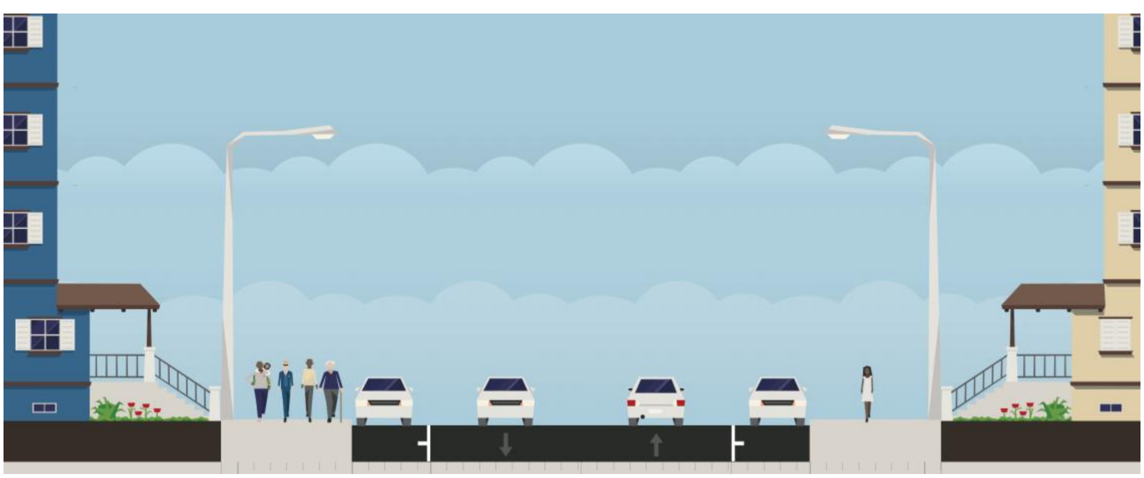

Figure 24: Existing Union St. Cross-section (Streetmix 2023)

10.1.1 Complete Street: Barrie St., Stuart St., and Albert St.

A component of Complete Streets is ensuring that there are safe facilities for individuals to travel using the transportation mode of their choice. The traffic study indicated that more individuals would be inclined to cycle if safe cycling infrastructure was implemented throughout campus. Currently, there are no cycling lanes on Albert St., Barrie St., or Stuart St., which reduces the number of cyclists to only those who are confident to cycle with vehicular traffic. To address this gap, a bi-directional cycling lane was recommended for the three streets. A bi-directional cycling lane has two bike paths, separated by bollards, on the same side of the street. A bollard to separate the bike lane and vehicles was also suggested to ensure that there was clearance space if a vehicle swerves towards the bike lane.

According to TAC and to accommodate the street space restriction, the recommended lower limit of 3 m for the cycling lane was suggested. In addition, the two bollard lanes were each 0.3 m to provide a separation between cyclists and vehicles (Michael Chiu et al. 2017a). The bollards were spaced at 10 m apart along each street. This spacing was within the Ontario Traffic Manual's recommendation of spacing bollards 6 m to 12 m apart (Ministry of Transportation of Ontario 2021). Additionally, the 2.25 m street parking lanes were removed to provide more space. This resulted in two vehicular travel lanes that were each 3.2 m in width. Although the vehicle travel lanes are narrower than the current road-way conditions, there are associated road calming benefits in which narrow widths lead to a reduction of speed. Sidewalks were kept at their current width dimensions as it was observed that it provided sufficient clearance for pedestrians to walk. Figure 25 illustrates the previously described design recommendations. With this design of a Complete Street, cyclists, pedestrians, and motorists are all accommodated to travel safely.

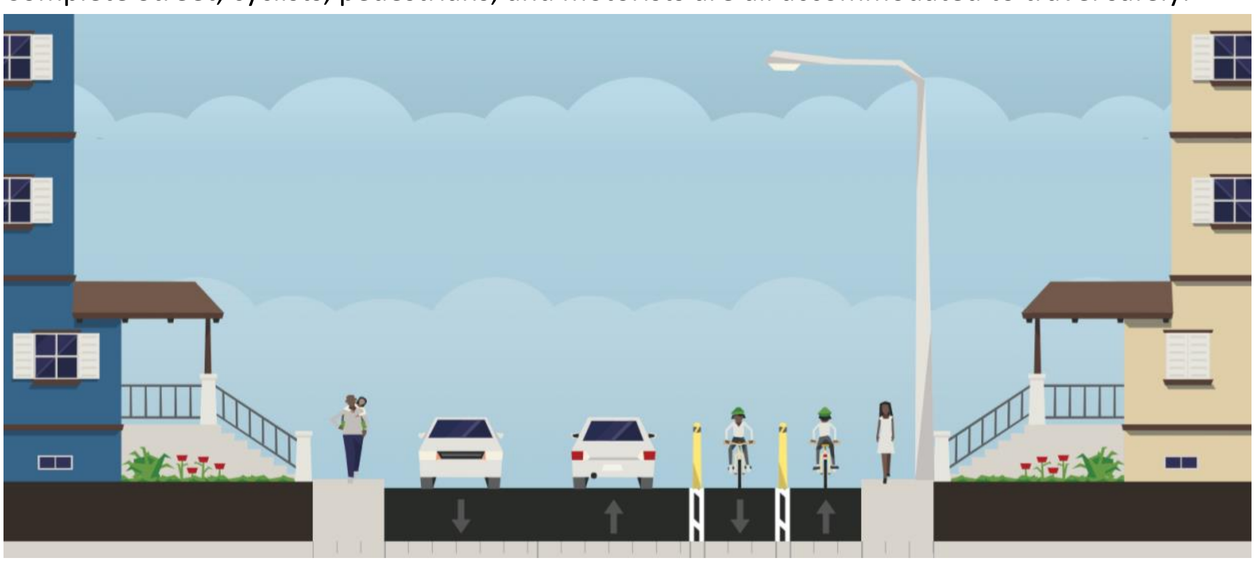

Figure 25: New Albert St., Barrie St., and Stuart St. Cross-section with Complete Street Design (Streetmix 2023)

10.1.2 Complete Street: Union St.

The current cross-section for Union St. included a parking lane on each side, where there were two driving lanes and sidewalks. The traffic count revealed that Union St. was used as a multi-modal street with high volumes of cyclists, pedestrians, and motorists; therefore, implementing infrastructure that can promote safe commuting was important.

Cycling Infrastructure

To accommodate cycling infrastructure on Union St., the team recommended the removal of street parking. It was determined that jaywalking often occurs on this road, particularly near the entrance of Mitchell Hall. Although jaywalking is not illegal in Canada, it is an unsafe practice. The current street parking limits pedestrian sight distances, as parked cars block the view of incoming traffic. Thus, the combination of jaywalking and street parking pose a safety risk for both pedestrians and motorists.

To replace the current street parking, a 2 m unidirectional bike lane was proposed for Union St. According to TAC, a 2 m lane can better accommodate for varying cycling speeds as there is sufficient room for cyclists to pass if necessary (Michael Chiu et al. 2017b). To serve as an additional safety measure, a 1 m delineator with bollards was also implemented. The benefits associated with this design change are summarized below.

- Safe cycling infrastructure for current cyclists.
- Encourages AT practices as adequate and safe infrastructure is in place.
- A continuous flow of cyclists in the lane will reduce jaywalking.
- Removes the sight distance risk caused by parked vehicles.

Streetscaping

To further enhance the atmosphere of Queen's University campus, aesthetic improvements were completed through streetscaping efforts. The addition of trees, benches and planters throughout Union St. were recommended to improve the street's appeal. As a result, current and prospective students could better appreciate campus.

Pedestrians Through Zone

The pedestrian through zone was increased to 5 m on each side from its original 4 m width. This is within the TAC suggested pedestrian through zone domain. A larger width can accommodate larger groups of pedestrians, as well as be more accessible for individuals using mobility devices. For example, a minimum width of 1.5 m is required for two pedestrians, or for wheelchair users to comfortably turn 180 degrees (Michael Chiu et al. 2017c). Finally, a larger sidewalk would be beneficial during snow clearing operations as there is clearance in the case a snow pile accumulates on the sidewalk (Michael Chiu et al. 2017c).

The increase of width in the pedestrian through zone, resulted in a decrease of the driving lane width. The driving lane width was 3 m as opposed to its original width of 4.6 m. It should be noted that 3 m is still an appropriate lane width (City of Toronto 2017a). This change will increase safety on Union St. as narrower lanes result in drivers slowing down. Figure 26 displays the design changes for Union St.

Figure 26: New Union St. Cross-section with Complete Street Design (Streetmix 2023)

10.2 AT & Service Vehicles Only Design

An AT & Service Vehicles Only Design was created for University Ave. between Stuart St. and Earl St. as well as the entirety of Bader Ln. A cross-section of the existing design for University Ave. is shown in Figure 27. The new cross-section design of University Ave. is illustrated in Figure 28.

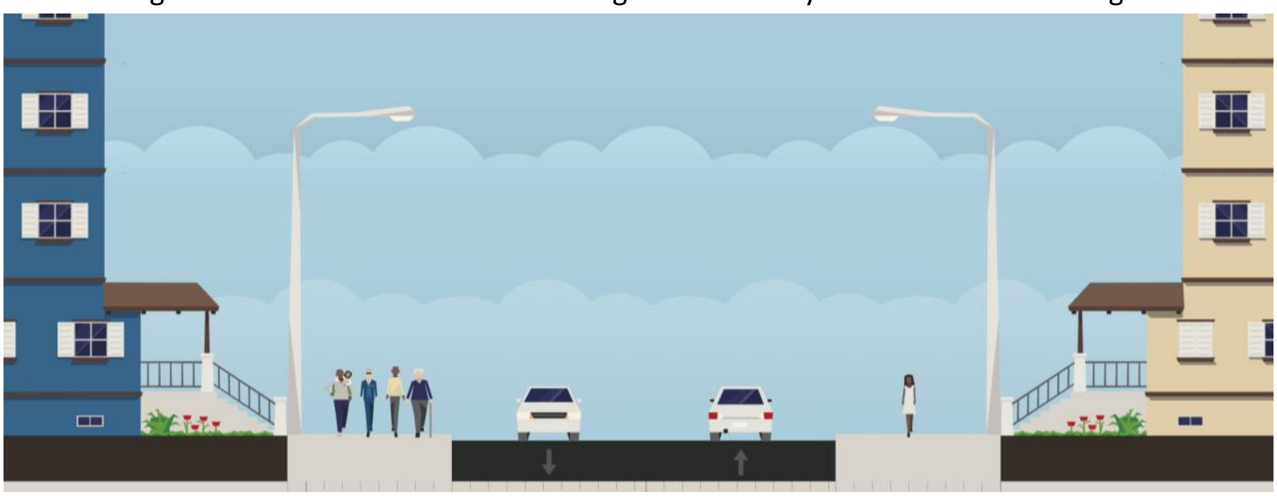

Figure 27: Existing University Ave. Cross-section (Streetmix 2023)

Figure 28: New University Ave. Cross-section with AT & Service Vehicles Only Design (Streetmix 2023)

Figure 29 and Figure 30 illustrates the existing and new cross-sections of Bader Ln., respectively. To maintain cohesiveness across campus, both AT & Service Vehicles Only designs are similar but adjusted to account for the space limitations. It should be noted that street parking is currently available on Bader Ln.

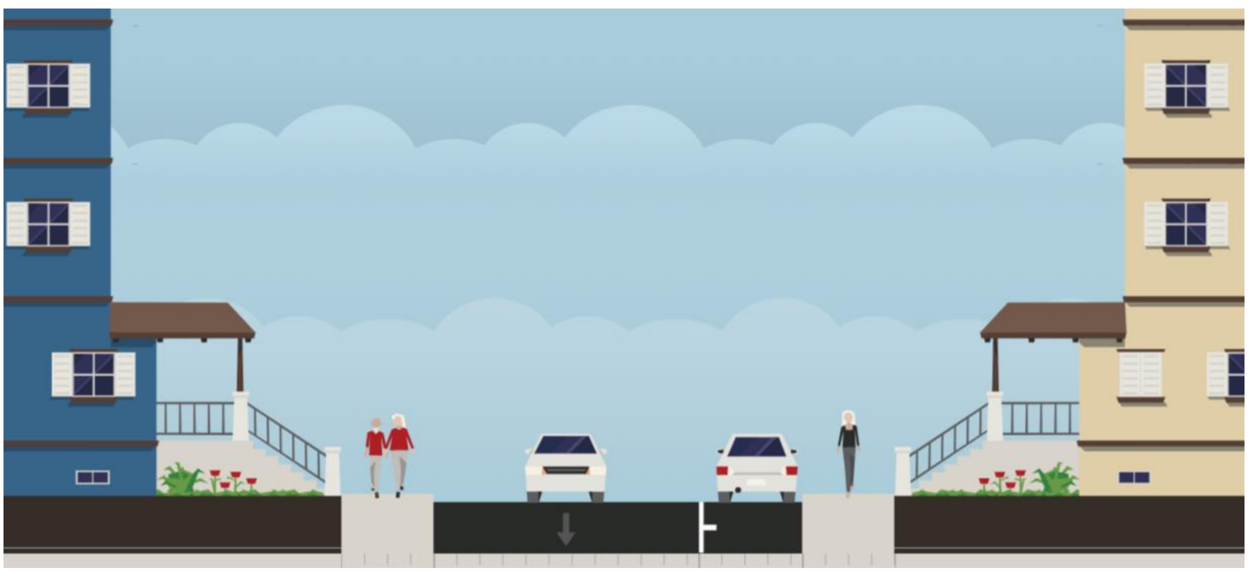

Figure 29: Existing Bader Ln. Cross-section (Streetmix 2023)

Figure 30: New Bader Ln. Cross-section with AT & Service Vehicles Only Design (Streetmix 2023)

10.2.1 Cycling infrastructures

Cycling paths were not provided along University Ave. and Bader Ln.; however, commuters may still choose to bike to campus, which can be unsafe as cyclists must share the road with vehicles. In order to provide a more vibrant and safer street for all commuters, unidirectional bike lanes with bollards were added to the new design. These bike lanes measure 1.8 m which is the recommended lower limit as stated in Table 3 (Michael Chiu et al. 2017b). The recommended lower limit was used as there was a much larger number of commuters that walk to campus rather than bike based on the traffic study. Therefore, a sufficient amount of space must be provided for pedestrians along University Ave. and Bader Ln. without interfering with cycling infrastructure. As the minimum recommended limit was included in the design for bike lanes, the recommended upper limit of 0.3 m for delineator components (i.e. bollards) was used. This design provided sufficient space and, thus, enough time for commuters to assess and react to potential hazards.

Additionally, the cobblestone that was on University Ave. was removed for both cycling lanes and replaced with asphalt to provide more comfortable riding conditions. This improved commuter and pedestrian safety as the areas on either side of the cycling lanes were elevated by a curb. Thus, pedestrians would have to take an additional step and be more attentive before crossing cycling lanes which could minimize collisions. It should be noted that the elevated sidewalk would not affect stormwater design as runoff would drain to the existing catch basins on University Ave. and Bader Ln. Furthermore, all curb cuts along University Ave. and Bader Ln. would remain the same in the new designs. An existing curb cut along University Ave. is shown in Figure 31. This feature would ensure that cyclists could access the sidewalks without needing to bike over the curb.

Figure 31: Crosswalk and Curb Cuts on University Ave. (Google Earth 2022a)

Since protected cycling lanes were incorporated in the design, students and faculty members would be encouraged to bike to campus. Thus, additional bike racks must be installed to ensure there are a sufficient number of bike racks for all cyclists. If not enough bike racks are provided, commuters may be less willing to bike to campus which in turn could result in commuters not using the cycling infrastructures provided.

10.2.2 Greenspace and Streetscaping

To promote AT along University Ave. and Bader Ln., greenery and streetscaping were incorporated into the new design. Large trees were included in order to provide a more pleasant environment. These large trees, as opposed to small trees, were included as they allow for all commuters to still have a clear sight vision of pedestrians, cyclists and potential vehicles coming ahead. Benches were also added along University Ave. and Bader Ln. to enhance the community.

10.2.3 Pedestrian Through Zone

Currently, sidewalks of approximately 4 m and 2 m were provided on both sides of University Ave. and Bader Ln., respectively. In order to provide more space for the number of pedestrians that travel along University Ave., 4.7 m sidewalks on both sides were suggested in the new design. Similarly, 3 m sidewalks were added to the new Bader Ln. design. These new designs met the recommended lower limit for pedestrian through zones. As public vehicles no longer have access to this street, an additional pedestrian through zone was provided between both cycling paths. This through zone measured 5 m for University Ave. and would remain as cobblestone. It should be noted that, currently, the cobble stone was replaced with concrete where existing crosswalks and curb cuts are located. This design would remain the same to reduce implementation cost and ensure all sidewalks are easily accessible for all. To provide more space for the through zone on Bader Ln., street parking would be removed, allowing a 3 m through zone to be incorporated into the design. Cobble stones would also be added to Bader Ln. to ensure continuity between both roads. This would also remind the public that both these roads are no longer accessible to private vehicles.

10.2.4 Service, Municipal and Emergency Vehicles

Two vehicle lanes were present along University Ave. and Bader Ln. Since the traffic study indicated that a low number of vehicles were travelling along University Ave. and Bader Ln., both lanes on these roads were closed to the public to provide more space for pedestrians. As previously mentioned, an additional pedestrian through zone was added between the cycling lanes in both designs. It should be noted that service, municipal, and emergency vehicles still have access to this through zone. Sufficient space for two vehicles to travel along this through zone was provided in the design. Road access to service vehicles were included along University Ave. and Bader Ln. as the road included many buildings which may require maintenance and deliveries. Thus, it would be unfeasible to not allow service vehicles to access this street. These vehicles could access buildings using the existing curb cuts. Municipal vehicles could also continue to have access to University Ave. as this street is not owned by Queen's University, thus, snow plowing, lawn mowing, and other forms of maintenance are still needed. Lastly, emergency vehicles must have access to University Ave. and Bader Ln. as these roads are a fast corridor to residences. As previously mentioned, existing curb cuts remained the same in the new design. This allowed vehicles to access necessary buildings and sidewalks.

Since certain vehicles still have access to University Ave. and Bader Ln., the road cannot be blocked off which could cause some confusion. Therefore, street signs would be included at each intersection along University Ave. to ensure private vehicles do not accidentally turn onto the street. Further implementations and initiatives may be necessary if street signs are not sufficient. Such implementation could include, larger signs, town hall meetings to educate the public and retractable steel bollards at the intersections.

11.0 Maintenance and Operations

To ensure the upkeep and usability of the proposed design, the following maintenance procedure is recommended by BGM^2.

11.1 Winter Bikeway Maintenance

As part of the proposed road infrastructure improvements, BGM^2 has considered how snow removal during the winter months may affect the usability of the proposed bike lanes. Small snow removal vehicles, which are available from several manufacturers, are able to plow snow for a narrow, protected cycle track such as the ones proposed in the design. The investment into this equipment by Queen's Facilities was proposed as these vehicles are typically equipped with mechanisms to remove both light snow and relocated heavy snowfalls (Cebe 2014). Union St., University Ave., and Bader Ln. bike and delineator lanes provide sufficient width that allows for functionality in the event that plowed snow may narrow the bike lane (Cebe 2014). However, the proposed design for Barrie St., Albert St., and Stuart St. includes bi-directional bike lanes separated by bollards. For winter months between December to February, BGM² proposes the removal of bollards for these streets to facilitate plowing. As cyclists and bike lane usage decrease during winter months, the removal of bollards will allow the lanes to be more easily maintained in the case commuters choose to cycle. Furthermore, de-icing is another important component in a winter maintenance program. As Queen's Facilities already applies de-icing material to campus roadways before a known snow event, this proactive measure was also suggested to be continued for the new design. De-icing before the weather event can minimize the need for plowing and decrease the amount of de-icing material used post snowstorm (Cebe 2014).

11.2 Landscaping Maintenance

The team suggests the continued maintenance and upkeep process for landscaping as new greenery is implemented. Routine monitoring especially during the initial implementation of greenery, was suggested. Routine monitoring can inform what specific maintenance practices may be required for the client. For the trees, maintenance can include ensuring there is enough soil volume for tree watering, as well as mulching and pruning as required (City of Toronto 2021). For other greenery implemented such as planting beds, they should be monitored to remove any undesired vegetation or litter.

12.0 Innovation

This section outlines BGM²'s innovative approaches for the traffic study. The team identified three ways to include innovative design solutions in the study, including the addition of permeable pavement in two locations on campus, the implementation of LSEVs and the opportunity to introduce a Limited Mobility Vehicle to help remove the barrier of navigating campus on a wheelchair. BGM² believes these innovations are a unique way for Queen's Facilities to be climate resilient, reduce carbon emissions and improve accessibility for those with limited mobility.

12.1 Permeable Pavement

Permeable pavement is a type of porous pavement that works to restore the earth's natural water cycle by slowly letting water infiltrate through pavement into the native soil below (Sustainable Technologies 2019). When considering modifications to campus at Queen's University, permeable pavement is an innovative addition to the final design. Different kinds of permeable pavement include porous concrete and plastic grid systems. Porous concrete is a concrete mix that only contains coarser aggregates, allowing water to filter through the void spaces and into the soil below. Plastic grid systems consist of pavement that interlocks around patches of grass or permeable gravel. This system allows for a large amount of void space while maintaining stability and preventing settlement of the area (Sustainable Technologies 2019). Figure 32 is an example of porous concrete and a plastic grid system.

Figure 32: Porous Concrete (left) and a Plastic Grid System (right) (Permeable Concrete 2022)

Another consulting team hired by Queen's Facilities, named Only Paves, has specialized in permeable pavement and has developed a report that outlines the recommended use of permeable pavement on Queen's University campus. The report prepared by Only Paves outlines test sites for permeable pavement around campus, runoff calculations, and recommendations for adding permeable paving to asphalt-covered locations on campus. Although the team's work does not directly impact the roads that BGM^2 are recommending to modify, the recommendations are relevant to the transportation project and should be mentioned as another way Queen's Facilities can reduce the impact of climate change on campus.

Only Paves recommended adding permeable pavement to two locations: Fifth Field Company Ln. and Tindall Field parking lot on the West side of campus (OnlyPaves 2023). Figure 33 displays the location of the recommended sites.

Figure 33: Permeable Pavement Test Location (Google Maps 2022)

After researching and reviewing three different types of permeable paving options, Low Impact Development (LID) Permeable Paving was chosen as the pavement of choice to replace the traditional asphalt in the two test locations. To calculate runoff for the two new test locations, Only Paves estimated the area of Tindall Field parking lot and Fifth Field Company Ln. to determine the average area that will be covered with LID Permeable Paving. The calculation compared the pre-development runoff with conventional asphalt to the predicted runoff that will be achieved with the LID Permeable Paving. Only Paves concluded that the runoff was reduced by 51.52% compared to pre-development asphalt. Reducing runoff was a necessary consideration as Queen's University campus is close to Lake Ontario and is therefore more prone to flooding. Overall, the mix of the two design solutions provided by BGM² and Only Paves are an innovative approach that Queen's Facilities can take to help manage the predicted consequences of global warming.

12.2 Low-Speed Electric Vehicles (LSEVs)

LSEVs use electricity for power and typically travel on roads with a maximum speed up of to 65 kph (Government of Ontario 2022). The Government of Ontario launched a Low-Speed Vehicle Pilot Program in 2017 that allows low-speed vehicles to be used in Ontario up to a maximum speed limit of 50 kph (Government of Ontario 2022). Queen's Facilities uses gas-powered vehicles to operate the grounds and service the infrastructure of Queen's University. As indicated by the client, Queen's Facilities has 81 service vehicles in their fleet. One potential innovation for the project was to replace these vehicles with LSEVs to perform maintenance tasks. This would significantly reduce the environmental impact of Queen's Facilities' fleet and promote the use of

Electric Vehicles (EV) on campus. The average cost of a LSEV is $20,000 (Katie Fehrenbacher 2021). Figure 34 is an example of a LSEV that displays the average size of this type of vehicle.

Figure 34: Photo Depicting the Average Size of a LSEV (Katie Fehrenbacher 2021)

12.3 Limited Mobility Vehicles (Kenguru)

The Kenguru is a single-occupancy EV made specifically for wheelchair users. It is fully electric and can be operated using handlebars instead of a traditional steering wheel with pedals. This vehicle can travel up to 45 kph and has a range of up to 109 kilometers (Clean Fleet Report 2021). Figure 35 presents how a user enters and exits the Kenguru.

Figure 35: Limited Mobility Vehicle, the Kenguru, in Use (Clean Fleet Report 2021)

Introducing a self-driving wheelchair on campus could provide many benefits, including the ability for wheelchair users to self-drive around campus. The wheelchair is fully electric and is an innovative solution to help combat accessibility issues for students, locally and globally. It may even set a precedent for other universities to follow suit. There are several drawbacks that need to be considered before implementation. First, there would be a need for charging infrastructure to support the EV. Second, additional testing for safety would be required as there is limited information available on the innovation. Third, a training program would be necessary to ensure that users can operate the wheelchair safely. Finally, this innovative solution would require significant investment, and the vehicle would only be available for people who already own wheelchairs. The wheelchair's availability may be limited to only Queen's University campus, and there is limited information on the supply and availability of the product.

As this innovation is not currently for sale to the public, it may be of interest for Queen's Facilities to task a Queen's University design team to create this product. There are electric car design teams across North America working on various EV projects that allow for students to get hands-on experience with EVs and give them the opportunity to cultivate new ideas within the electric car industry. One design team, named Queen's Relectric Car Team, may be interested in pursuing this idea to add to their battery-powered electric fleet. If the team's scope of knowledge and interest does not align with the idea of an accessible EV, Queen's Facilities could offer funding to allow a new design team to form for this specific purpose. BGM² is open to discussing how these connections can be made past the project timeline.

13.0 Climate Change

This section discusses how the project considered potential impacts on carbon emissions while making decisions and how the project will affect climate change. The primary goals of the proposed recommendations are to promote active transportation, reduce congestion and encourage the use of EVs on campus. These goals all work to reduce the University's carbon emissions both on an individual and community level. The section also outlines how the project fits within the recommendations of the latest Intergovernmental Panel on Climate Change (IPCC) report.

13.1 IPCC Report Summary

The latest IPCC Report, published in 2022, outlines the observed and projected impacts and risks of climate change progressing in the future, future adaptation measures and the adoption of climate resilient development practices. The IPCC report for North America goes into detail about the short and long-term risks for the continent and how policymakers and designers can work to mitigate these risks. The IPCC report states that global warming reaching 1.5°C in the near term would pose a multitude of risks to humans and ecosystems and cause an unavoidable increase in climate hazards. In the long-term, depending on the severity of global warming beyond 2040, climate change will lead to risks for all natural and human systems. In the long-term, the current risks identified by the IPCC are multiple times more severe than what is currently observed. The rate of change of global warming and the severity of the impact heavily depends on near-term mitigation strategies and actions (Intergovernmental Panel on Climate Change 2022).

13.2 Overview of Energy Distribution and Consumption in Kingston

Ontario gets its energy from a combination of power generation stations. In 2019, 92% of electricity production came from renewable energy sources, with the two highest electricity producers being hydroelectric and nuclear plants (Government of Canada 2023). The transmission grid operates on a provincial level, meaning the transmission grid is connected across the province. The province also has connections to transmission grids outside of the province, including connections to Quebec, Manitoba, Michigan, Minnesota, and New York. These exterior and intra-provincial connections allow for a company named the Independent Electricity System Operator (IESO) to manage the transmission grid and balance the electricity supply with user demand across the entire province (Government of Canada 2023). Figure 36 provides a summary of all electricity generation sources in Ontario.

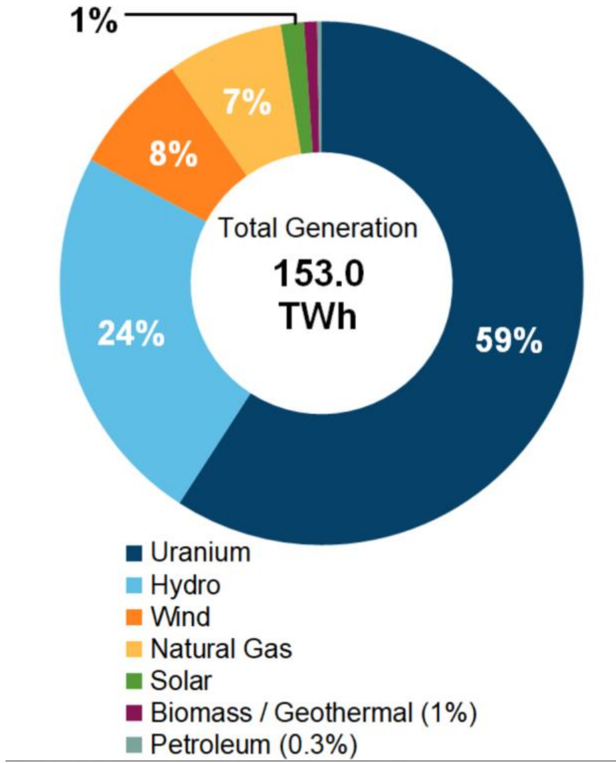

Figure 36: Summary of All Electricity Generation in Ontario (Government of Canada 2023)

Queen's University receives its electricity from Kingston Hydro, an Ontario Energy Board-licensed distributor of electricity in Kingston (Kingston Hydro 2023). Kingston Hydro connects to the provincial transmission grid and therefore receives energy from a combination of energy sources produced in Ontario and connecting provinces. Kingston's energy supply was important to consider when recommending LSEV's to replace Queen's Facilities vehicles. The electric charging stations would not be supplied by 100% renewable energy, and therefore are not completely reversing the impact of fuel-powered vehicles.

13.3 Carbon Impact on a Community Level

On the community level, important changes that this design addresses include the increase in greenspace, the replacement of the Queen's Facilities Fleet where applicable, and the promotion of AT on campus. These changes will reduce Queen's University's carbon emissions and will have a positive impact on climate change. Increasing greenspace is a way to give Queen's University natural shade, which reduces the impact of the heat island created by the heavily concreted campus. As climate change continues to progress, extreme weather events that cause larger floods will become more common. Adding more trees to line the streets will help drainage and reduce flooding on campus, although on a small scale, will help mimic the earth's natural drainage and reduce the potential for flooding on campus. For large-scale drainage improvements, the implementation of permeable paving, as described in Section 12.0 Innovation, will have a positive impact on the reduction of runoff on campus. The study performed by Only Paves was a pilot study and only considered permeable paving for two locations on campus (OnlyPaves 2023). If the study's recommendations are implemented and are successful, the hope would be to expand the study area and implement LID Permeable Paving in more areas of campus where the runoff from flood events would have the greatest impact.

13.4 Carbon Impact on an Individual Level

Members of the Queen's University community are influenced by the infrastructure around them. For example, if there is a surplus of bike lanes and the campus promotes the use of other forms of AT or transit, members will be more likely to choose less emissive forms of travel. Commuters using the infrastructure, especially students, will want to choose the most convenient and cost-effective way of travel. If the most convenient way of travel also has low carbon impact, it will decrease the carbon emissions of students and faculty all over campus. This aligns with the goals of the IPCC report to reduce carbon emissions and create more resilient urban ecosystems. The IPCC report summary states that inclusive and integrated decision making when it comes to urban infrastructure will ultimately benefit and increase the adaptive capacity of urban areas (Intergovernmental Panel on Climate Change 2022). This was taken into account during phase one of the traffic study where students, faculty and staff at Queen's University were asked through the survey to provide their opinion on the ways Queen's Facilities can help improve campus. Inviting members of the community helped to consider an integrated design that will benefit the community as a whole.

14.0 Cost Estimates

A cost assessment of the conceptual design was performed. Costs were estimated using construction sources online and estimates of distances and areas from Google Earth. Engineering judgement and conservative estimates were used to help develop costs that could not be quantified through online research. All costs presented are in Canadian Dollars (CAD). Table 11 summarizes the cost analysis performed for the design.

14.1 Greenery and Pedestrian Space

This section outlines the cost estimates related to adding greenery and pedestrian-focused infrastructure.

14.1.1 Trees

As previously mentioned, trees are to be added along University Ave. BGM² estimates there will be a large tree planted every 40 m on each side of University Ave. With an approximate distance of 540 m, University Ave. between Bader Ln. and Earl St. will have approximately 40 m on the West and East side of the road, totaling to 27 trees. With an estimate of $2,250 to purchase and install a large tree in an urban area, the total cost to add trees along University Ave. will be $128,250 (Glenda Taylor 2021).

14.1.2 Seating Benches

Seating benches are to be added along the length of University Ave. & Union St. There are existing seating areas currently lining both sides of University Ave. and Union St., but these are concrete and not ergonomically designed. The team has decided there will be an additional two benches for each large campus building accessible by both streets. This will provide comfortable outdoor seating for students and faculty entering or exiting the main buildings on campus. There are a total of 18 large buildings along University Ave., and Union St. within the project borders. This means there will be a total of 36 benches along University Ave. & Union St. If the cost of a steel and timber outdoor bench is $1000, the total unit cost of adding seating areas on campus is $22,000 (Rigg Limited 2022).

14.1.3 Additional Sidewalk Width

As previously mentioned, an additional 0.7 m of sidewalk will be added to University Ave. The average cost of a concrete sidewalk is $8.63 per square foot, or $93 per square meter ($m^2$) (LawnStarter 2022). If there are 0.7 m of sidewalk added on the East and West side of University Ave., the total area of concrete needed is approximately 756 m^2. These dimensions, including unit cost and installation of the concrete, will cost $70,308 to replace. This estimate excludes the cost of removing the interlocking pavement and other construction costs surrounding the street upgrades.

14.2 Bike Lanes

This section outlines the cost estimates related to the addition of bike lane infrastructure.

14.2.1 Asphalt Installation

Additional asphalt is not needed on Union St., Barrie St. and Stuart St. but is needed to replace the interlocking pavement on University Ave. to add bike lanes along the street. The average cost for asphalt paving is $33 to $55 per m^2, however, a conservative estimate of $55 per m^2 will be used (Rich Jarvis 2023). The width of each lane will be approximately 1.8 m. With an approximate length of 540 m, the total unit cost for the installation of 1944 m^2 of asphalt paving is $106,920.

14.2.2 Bollards

A bollard is a rigid or flexible post commonly used to separate bike lanes from regular vehicle lanes to protect cyclists and reduce collisions. Flexible bollards were selected as the bollard type for the conceptual design. Flexible bollards, unlike rigid steel or concrete bollards, will not cause significant harm to a cyclist or driver if the collision were to occur, yet they are still effective at creating a separation barrier. The unit cost for a flexible bollard is $57 (Uline 2022). BGM² estimates a single bollard will cost $100 per bollard, including unit cost and installation cost. Bollards will be installed on Albert St., Barrie St. and Union St. The total length of these three streets combined is 1930 m. Using a 10 m spacing for bollards beside each lane, the total number of bollards needed will be 384, with a total cost of $38,400.

14.2.3 Narrow Width Snowplows

BGM² recommends investment in Ventrac Sidewalk Snow Vehicles (SSV). These machines are small snowplows with a width of 1.2 m that are built to effectively remove snow within the narrow bike lane. The snowplow and attachment start at a total price of $15,400 USD ($21,137 CAD) (Ventrac 2023). BGM² recommends the client should invest in two of these snowplows. Although one snowplow would be sufficient to cover the small strip of bike lanes, having two would reduce the likelihood of not having a functional plow for the road, as if one requires maintenance, the other plow can be used. The total cost to purchase the two Ventrac SSVs is $42,274 CAD.

14.3 Total Cost Estimate

The final cost of the project is estimated to be $280,318, which includes the cost of greenery, pedestrian spaces, and bike lanes. Table 11 below includes a summary of the total cost for the final recommendations provided by the team.

Table 11: Summary of Costs for Preliminary Design

Feature	Item	Unit Cost (CAD)	Total Cost (CAD)
Greenery	Large Tree	$2,250/unit	$60,750
Pedestrian Space	Bench	$1000/unit	$22,000
Pedestrian Space	Sidewalk Paving	$93/m²	$70,308
Bike Lanes	Bollard	$100/unit	$38,400
Bike Lanes	Asphalt	$55/m²	$106,920
Bike Lanes	Snowplows	$21,137/unit	$42,274
		Total Cost	**$340,652**

15.0 Risk Management

Risk management is the process of identifying, assessing, and prioritizing risks to minimize their impact on the project's objectives. A risk is a situation involving exposure to danger, likelihood is the probability of an event occurring, and severity describes the impact of the event on both individuals and the environment. This process involves understanding the nature of the risks, evaluating their likelihood and severity, and developing strategies to mitigate them. By identifying these risks early, it allows both BGM² and the client to reduce the likelihood of financial loss, damage to the environment, or loss of human life.

15.1 Health and Safety

Managing risks associated to health and safety are essential when proposing traffic-related design solutions, and is especially important on Queen's University's campus, where the AT user population is incredibly high. This involves the identification of any potential risks associated with the project, including accidents, collisions, or injuries, and developing a strategy to mitigate them. Transportation infrastructure impact the health and safety of individuals in two distinct ways: motor vehicle accidents or collisions, and traffic-related air pollution.

15.1.1 Motor Vehicle Collisions

The city of Kingston sees over 300 collisions resulting in injury, and approximately 3 fatalities per year due to motor vehicle accidents. To combat this statistic, the city has implemented the Vision Zero Road Safety Plan (RSP) to work towards eliminating all fatal and injury collisions (source). Completed in 2019, the RSP works to combat distracted, aggressive, and impaired driving, and improve the safety levels of AT infrastructure (City of Kingston 2023). In 2012, a female pedestrian was struck by a motor vehicle in the early afternoon at the corner of University Ave. & Bader Ln. (Hales and Shouldice 2012). By removing motor vehicles on both University Ave. and Bader Ln., this lessens the risk of motor vehicle collisions significantly and greatly reduces the likelihood of a collision resulting in injury on campus like the incident in 2012. The final design solutions proposed by the team attempt to aid a transition to an entirely vehicle-free campus in the future, by prohibiting motor vehicle transportation on Bader Ln. and University Ave.

15.1.2 Traffic Related Air Pollution (TRAP)

Traffic-related air pollution (TRAP) has been associated with a wide range of health effects, and most Canadians are exposed to considerable amounts during daily activities (Matz et al. 2019). TRAP consists of motor vehicle exhaust, secondary pollutants formed in the atmosphere, and non-combustion emissions, and have been linked to lung cancer mortality, asthma onset, and lower respiratory functions in adolescents (Matz et al. 2019). Estimates suggest that over 21,000 premature deaths in Canada are attributed to TRAP which accounts for nine times more deaths than motor-vehicle accidents across the country (Brauer et al. 2013). By reducing the number of motor vehicles within the campus at Queen's University, pedestrian exposure to TRAP would be reduced, mitigating the health risks associated with the pollution.

15.2 Environment

Addressing and mitigating the risks associated with environmental harm was an important step in the team's decision-making process. Traffic-related air pollution not only is harmful to the health of individuals, but also has major environmental repercussions. Air pollution and climate change are closely related, and greenhouse gas emissions from motor vehicles greatly contribute to the effects of climate change. The team has attempted to reduce the number of motor vehicles present within the site limits by restricting their access on both University Ave. and Bader Ln. This will reduce the amount of TRAP within the campus of Queen's University and improve the environmental conditions within the area.

16.0 Next Steps

In order to ensure these designs are possible to implement, Queen's Facilities will need to receive approval from the City of Kingston. As Bader Ln. is the only road that is owned by Queen's University, any changes to University Ave., Albert St., Barrie St., and Stuart St. must first be approved by the city. Such changes include the addition of cycling lanes, landscaping, greenery, and road/sidewalk adjustments. In addition, since the street parking has been removed in all new designs, the City of Kingston will no longer make a profit from the metered street parking.

Kingston Transit will also need to approve of these changes as they will affect the current bus routes. There is currently only one bus stop along University Ave. (i.e., Ellis Hall/Grant Hall station). Buses 1,2 and 18 stop at this station and, therefore, these routes will be redirected to Albert St. These buses will instead come from Union St. near West Campus, turn right onto Albert St., and then continue to Kingston's downtown core after turning left on Stuart St. These changes will improve the current delays due to the difficulty of making right or left turns to pass pedestrians on University Ave. Similarly to buses 1, 2, and 18, the express routes (i.e. buses 501/502, 601/602, and 801/802) will also be redirected. These buses will also travel along Albert St. instead of University Ave. This change will encourage more students to use the Kingston transit as the new station for these bus routes will be closer to residences and student housing.

Similar to the JDUC Renovations, students and faculty members will need to approve this project as well. This will involve a survey where students and faculty will have the opportunity to express their concerns and comments as well as their interest in support of this project. Depending on their input, there may be an increase in the current undergraduate student fee in order to collect funds for this initiative. Queen's University may also need to identify outreach opportunities for alumni and donors to support the project. By doing so, approval will be needed by the Board of Trustees as they oversee financial matters at Queen's University. This in turn will involve the aid of Alma Mater Society (AMS), and the Society of Graduate and Professional Students (SGPS). As this project involves roads owned by the city, Kingston residents will also be given the opportunity to weigh in on these changes. This can be completed by conducting town hall meetings (Queen's Gazette 2021).

Although emergency routes will remain the same on all roads, it will be important to update emergency services on the changes and potential detours that may be needed during the construction phase. Additionally, discussion with the Queen's Relectric Car Team would be of value to pursue the idea of limited mobility electric vehicles on Queen's University campus. Once approvals have been received, the implementation and construction phases will begin. Contractors will need to be hired to complete this work. BGM² recognizes that the contents of this report may be utilized by future consulting teams, and therefore the team is open to collaborating as required to ensure a smooth transition after the completion of the 2022 – 2023 academic year.

17.0 Team Logistics

17.1 Tasks

The Work Breakdown Structure (WBS) shown in Figure 49 of Appendix E: Work Breakdown Structure illustrates the necessary tasks as determined by the team that were needed to complete the project. These tasks were changed throughout the duration of the project as the team continued further discussions with the client. Such changes included completing a traffic volume study on Bader Ln. and acquiring the emergency routes from Queen's Facilities to ensure these routes were incorporated into the design process.

Tasks were split into four general sections: problem definition, research, analysis, and final design. Each section included sub-tasks that were outlined as important milestones to be completed. The problem definition section included key components of this project that were determined prior to beginning research. The second section summarized the research phase of the project, which involved the collection of all data. Before collecting the data, key elements were determined to understand the ideal locations to complete the traffic volume research. This section took many weeks to complete as multiple intersections and days were needed to obtain accurate data. Although this process was completed at the beginning of the project, due to a change in scope, this section was completed a second time for Bader Ln. The third section included steps for the analysis process of this report. Once the data was collected, this data was analyzed using Excel and evaluation matrices using an EA process to determine planning and design alternatives for this project and choose the ideal solution. Lastly, the final design section entailed further analyzing the chosen solution to update certain components and provide a final design. The fourth phase of the WBS focused on iterating and refining the proposed design solution and presenting the final project designs. This WBS was an excellent tool and guide for the team throughout this project. In addition, a Responsibility Assignment Matrix (RAM) found in Table 19 of Appendix G: Responsibility Assignment Matrix was used to determine which team member or client was Responsible, Accountable, Informed and/or Consulted for each sub-task listed in the WBS.

17.2 Timeline Estimates

A full, detailed schedule of the work completed by BGM² can be found in Figure 50: BGM²'s Gantt Chartof Appendix F: Gantt Chart. The chart outlines all key academic deliverables completed by the team throughout the eight-month contract with Queen's Facilities, as well as all meetings held with the internal team, the TA, and the client. The team completed the work in three succinct phases. The first two phases of the project included preliminary background research and data collection and were completed by the team by November 25, 2023. Phase three of the project included a deliberation period, and additional background research and traffic data collection acquired by the team. The fourth phase of the project included redeveloping, re-evaluating, and finalizing the team's final recommendations with the client before creating the final report for the client. Detailed timelines for all requirements essential to each phase of the project are provided. These timelines were subject to change since they were initially created in September. These dates were put in place to ensure the team met all deadlines and was not intended to be completely rigid.

17.3 Plan for Completing Work

As previously mentioned, BGM² used the Gantt Chart, WBS and the RAM as a guide when completing all deliverables. Deliverables were divided equally amongst each team member. These deliverables were completed 24 hours before the due date to ensure there was enough time to review and finalize any last-minute changes. If a team member was unable to complete their section of the deliverable by this time, they communicated this to the entire team. In addition, if a team member was overwhelmed or stressed, other team members ensured support was always provided. Figure 51 – Figure 54 of Appendix I: Team's Hour Logs includes each team member's hour logs.

17.4 Meetings

The team organized bi-weekly meetings on Tuesdays at 2:30pm prior to the winter break. During these meetings, BGM² reviewed the Gantt Chart and the WBS to ensure alignment. A roundtable discussion allowed each team member to discuss their tasks as well as address any questions and issues. The team met with the client to discuss the final recommendations and address any questions and/or comments Queen's Facilities had for the team. Additional meetings were booked as needed should there be any questions or issues that needed to be addressed prior to the next client meeting. After the winter break, the team met weekly with the teaching assistant, Amanda Fawley, on Tuesdays at 10:30am. All meeting minutes can be found in Appendix H: Meeting Minutes.

18.0 Conclusions

BGM² conducted a three-phase traffic study reviewing the existing AT demands and intercampus commuting trends of students and faculty at the main campus at Queen's University. An electronic survey was created by the team to identify main corridors within the site limits and commuting trends, followed by traffic data collection at five intersections across the main campus: University Ave. & Union St., Albert St. & Union St., Barrie St. & Union St., Bader Ln. & Albert St., Bader Ln. & University Ave., and University Ave. & Stuart St. Due to the high volumes of AT users at all intersections of interest, the team prioritized safer, more accessible, and more comfortable pedestrian and bikeway infrastructure on all roadways within the site limits. Using the traffic data collected by the team, critical approach volumes were calculated at each intersection to be subsequently used in trip generation analysis to ensure all roadways within the site limits remain under capacity and do not produce any traffic delays. Following the EA process commonly used in transportation design, BGM² generated, evaluated, and selected preferred planning alternatives and design alternatives before developing a complete final design solution.

Final recommendations made by the team included the addition of Complete Street infrastructure, including isolated bike lanes and narrowed motor vehicle lanes to Albert St., Barrie St., and Stuart St. Additionally, road access on both Bader Ln. and University Ave. was changed to provide only AT and service vehicle access. These changes improved the aesthetic of the streets, as well as the availability for greenspace and streetscaping. Furthermore, the comfort and accessibility for AT users has been greatly increased across the main campus, as complete connected bikeway infrastructure is provided, and pedestrian comfort is prioritized. BGM² ensured that final recommendations align with Queen's Facilities' vision and the Campus Master Plan and identified three unique ways to include innovative design solutions. These innovative design components included the addition of permeable pavement in two locations on campus, and the implementation of LSEVs and Limited Mobility Vehicles (Kenguru). A detailed cost analysis was conducted by the team, to estimate the material, installation and maintenance costs associated with the project. BGM² has presented the final recommendations in the content of this report for review by the client in hopes of future implementation. The team recognizes that Queen's Facilities will require approval from the City of Kingston, and students and faculty members at Queen's University to begin implementation.

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Appendix A: Survey Data

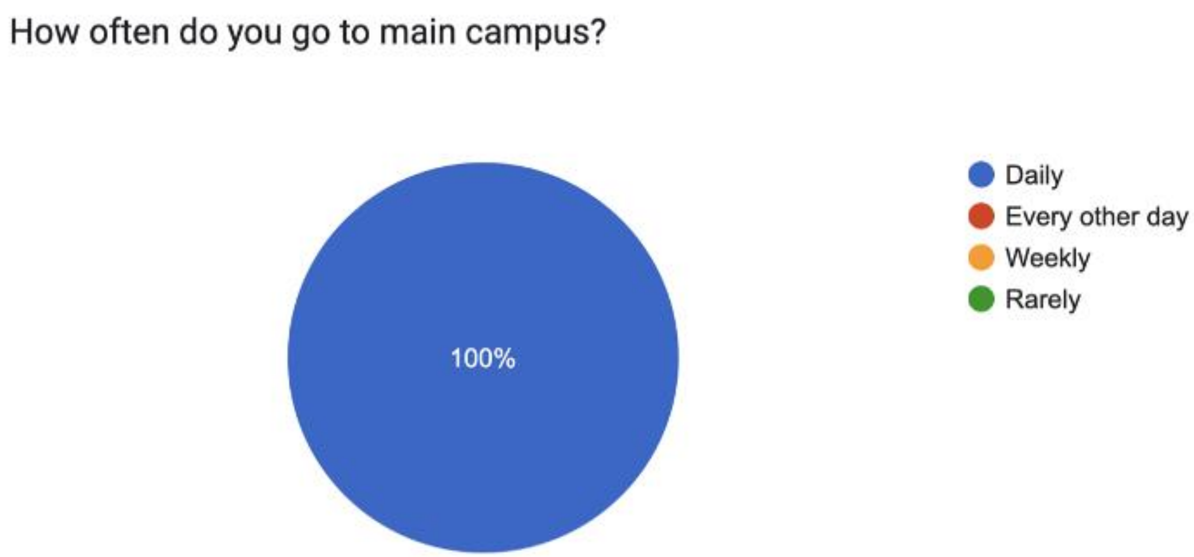


Figure 37: One of Traffic Study-survey Results

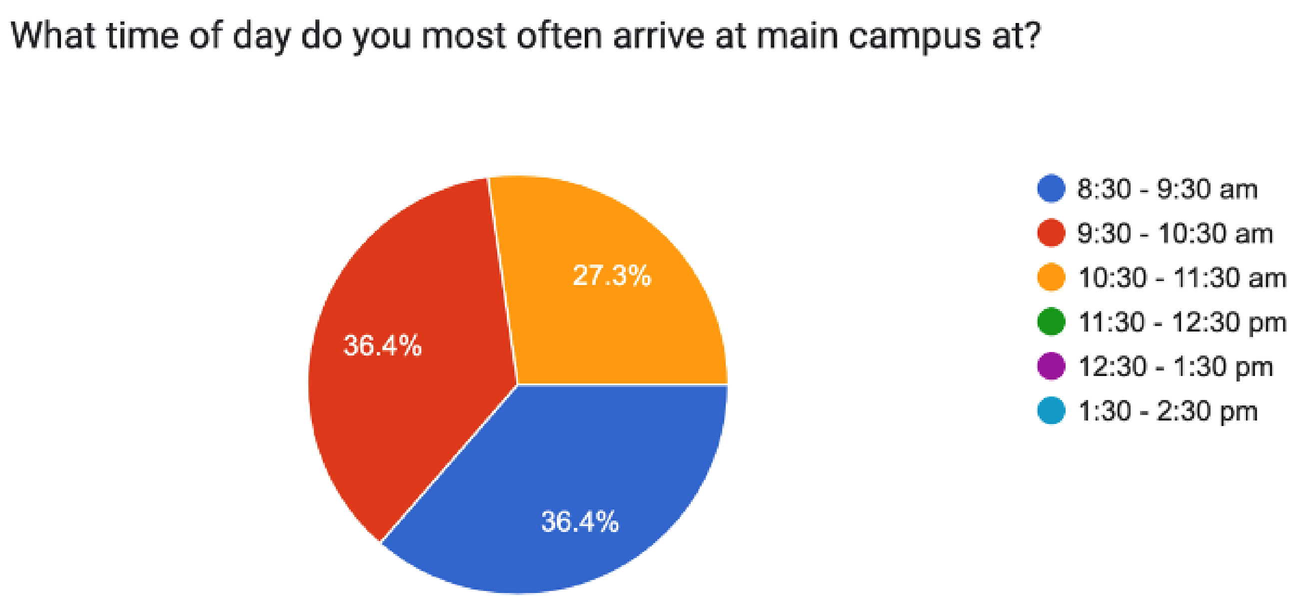


Figure 38: Phase One of Traffic Study-survey Results

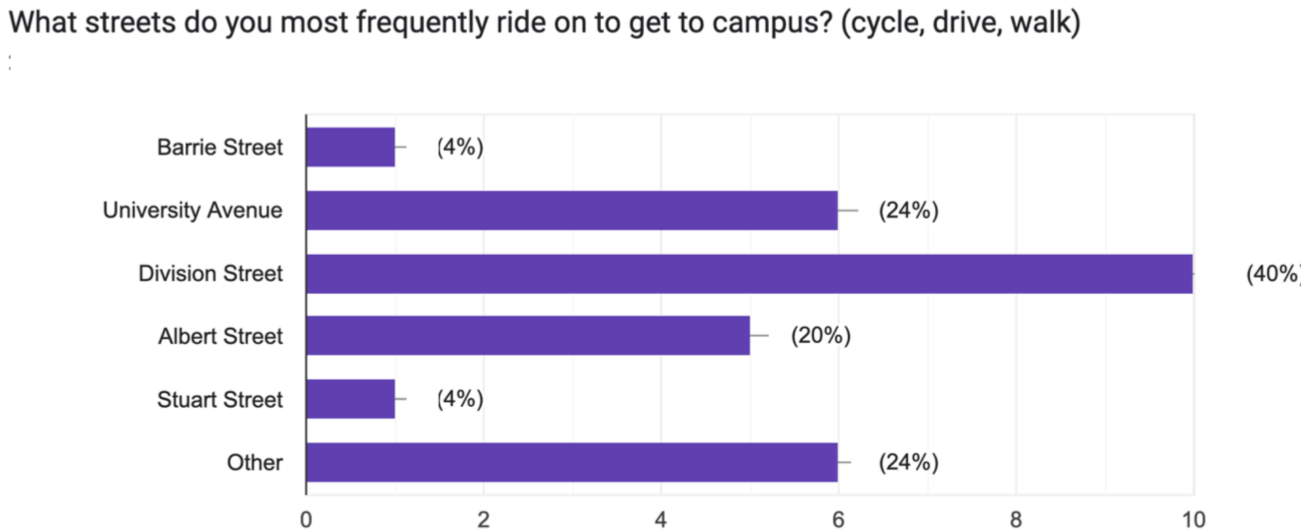


Figure 39: Phase One of Traffic Study-survey Results

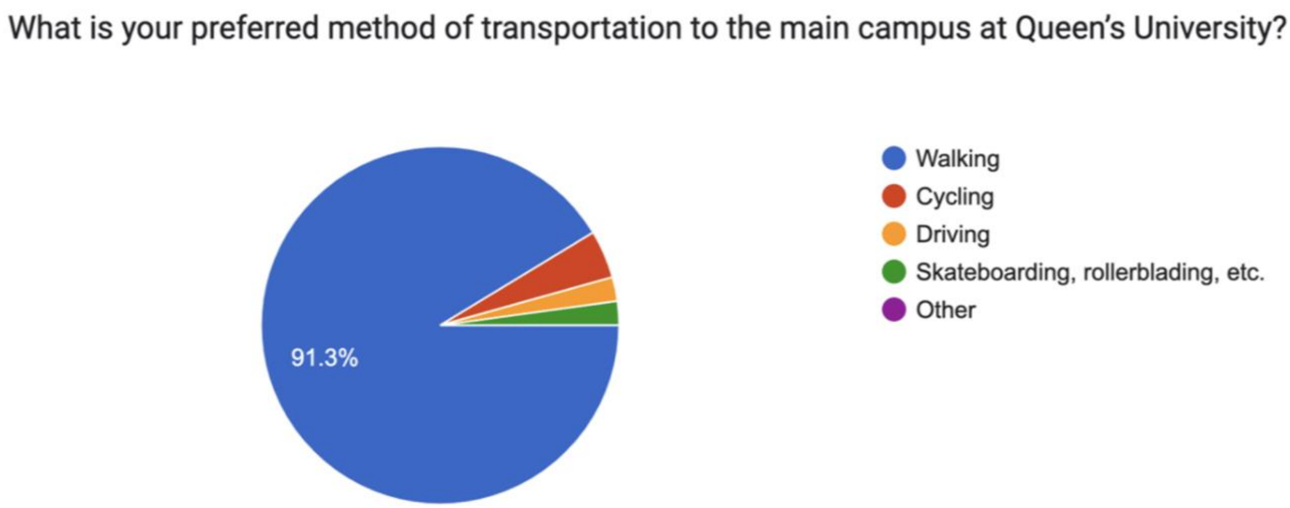


Figure 40: Phase One of Traffic Study-survey Results

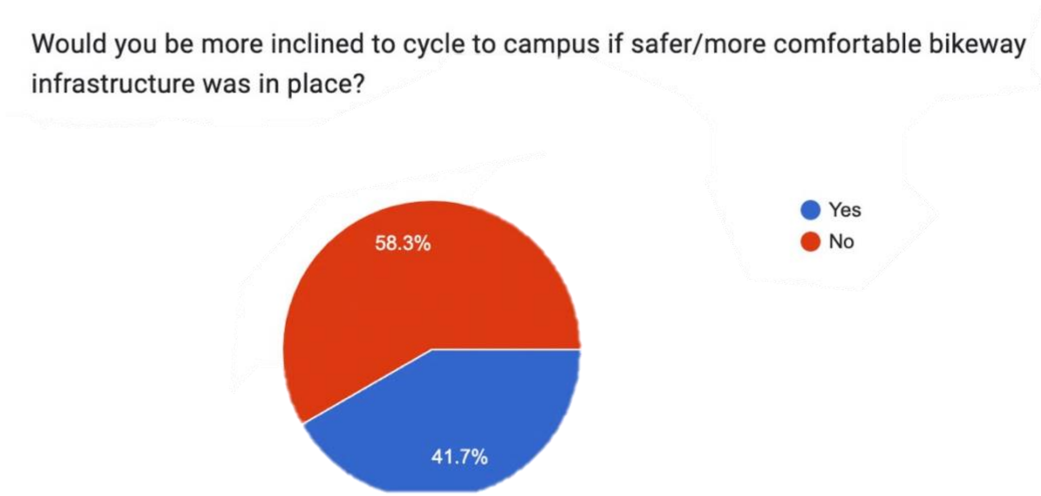


Figure 41: Phase One of Traffic Study - Survey Results

Appendix B: Traffic Count Data

Table 12: Traffic Count data at the University Ave. & Union St. Intersection from 8:00am to 9:00am and 5:00pm to 6:00pm on Tuesday, Thursday, and Saturday

Uni and Union - Tuesday - 8am-9am (1hr)					
	Pedestrians	Bike	NB	EB	WB
	1784	72			
Through			NA	106	90
Right			26	37	NA
Left			31	NA	26

Uni and Union - Tuesday 4pm-5pm (1hr)					
	Pedestrians	Bike	NB	EB	WB
	4668	86			
Through			NA	180	266
Right			33	38	NA
Left			61	NA	25

Uni and Union - Saturday - 8am-9am (1hr)					
	Pedestrians	Bike	NB	EB	WB
	198	8			
Through			NA	80	40
Right			13	8	NA
Left			8	NA	21

Uni and Union - Saturday - 4pm-5pm (1hr)					
	Pedestrians	Bike	NB	EB	WB
	506	30			
Through			NA	81	273
Right			39	34	NA
Left			30	NA	46

Uni and Union - Thursday - 8am-9am (1hr)					
	Pedestrians	Bike	NB	EB	WB
	1649	89			
Through			NA	85	73
Right			21	31	NA
Left			39	NA	19

Uni and Union - Thursday - 4pm-5pm (1hr)					
	Pedestrians	Bike	NB	EB	WB
	4917	94			
Through			NA	174	278
Right			39	27	NA
Left			66	NA	31

Uni and Union - Saturday - 8am-9am (1hr)					
	Pedestrians	Bike	NB	EB	WB
	134	11			
Through			NA	68	45
Right			12	9	NA
Left			8	NA	32

Uni and Union - Saturday - 4pm-5pm (1hr)					
	Pedestrians	Bike	NB	EB	WB
	664	6			
Through			NA	101	59
Right			51	24	NA
Left			35	NA	42

Table 13: Traffic Count data at the University Ave. & Stuart St. Intersection from 8:00am to 9:00am and 5:00pm to 6:00pm on Tuesday, Thursday, and Saturday

Stuart and Uni - Tuesday - 8am-9am (1hr)					
	Pedestrians	**Bike**	**SB**	**EB**	**WB**
	638	6			
Through			NA	26	33
Right			18	NA	31
Left			41	9	NA

Stuart and Uni - Tuesday - 4pm-5pm (1hr)					
	Pedestrians	**Bike**	**SB**	**EB**	**WB**
	206	30			
Through			NA	36	60
Right			11	NA	42
Left			14	12	NA

Stuart and Uni - Saturday - 8am-9am (1hr)					
	Pedestrians	**Bike**	**SB**	**EB**	**WB**
	70	2			
Through			NA	10	21
Right			10	NA	40
Left			3	5	NA

Stuart and Uni - Saturday - 4pm-5pm (1hr)					
	Pedestrians	**Bike**	**SB**	**EB**	**WB**
	122	12			
Through			NA	29	37
Right			23	NA	51
Left			14	17	NA

Stuart and Uni - Thursday - 8am-9am (1hr)					
	Pedestrians	**Bike**	**SB**	**EB**	**WB**
	721	6			
Through			NA	20	26
Right			26	NA	32
Left			43	15	NA

Stuart and Uni - Thursday - 4pm-5pm (1hr)					
	Pedestrians	**Bike**	**SB**	**EB**	**WB**
	415	51			
Through			NA	42	52
Right			23	NA	31
Left			27	11	NA

Stuart and Uni - Saturday - 8am-9am (1hr)					
	Pedestrians	**Bike**	**SB**	**EB**	**WB**
	82	6			
Through			NA	14	22
Right			9	NA	48
Left			5	11	NA

Stuart and Uni - Saturday - 4pm-5pm (1hr)					
	Pedestrians	**Bike**	**SB**	**EB**	**WB**
	157	7			
Through			NA	18	29
Right			32	NA	46
Left			26	13	NA

Table 14: Traffic Count data at the Barrie St. & Union St. Intersection from 8:00am to 9:00am and 5:00pm to 6:00pm on Tuesday, Thursday, and Saturday

Barrie and Union - Tuesday - 8am-9am (1hr)						
	Pedestrians	**Bike**	**NB**	**EB**	**WB**	**SW**
	232	24				
Through			64	8	50	58
Right			12	76	6	30
Left			26	32	4	4

Barrie and Union - Thursday - 8am-9am (1hr)						
	Pedestrians	**Bike**	**NB**	**EB**	**WB**	**SW**
	284	17				
Through			73	16	47	62
Right			18	63	9	41
Left			23	41	12	9

Barrie and Union - Tuesday - 4pm-5pm (1hr)						
	Pedestrians	**Bike**	**NB**	**EB**	**WB**	**SW**
	254	34				
Through			70	18	18	58
Right			2	24	0	24
Left			26	36	6	8

Barrie and Union - Thursday - 4pm-5pm (1hr)						
	Pedestrians	**Bike**	**NB**	**EB**	**WB**	**SW**
	254	34				
Through			82	26	24	69
Right			6	19	8	33
Left			33	47	9	11

Barrie and Union - Saturday - 8am-9am (1hr)						
	Pedestrians	**Bike**	**NB**	**EB**	**WB**	**SB**
	104	24				
Through			48	4	16	88
Right			8	24	0	32
Left			32	4	4	0

Barrie and Union - Saturday - 8am-9am (1hr)						
	Pedestrians	**Bike**	**NB**	**EB**	**WB**	**SB**
	89	16				
Through			56	12	13	92
Right			12	23	0	37
Left			41	7	7	1

Barrrie and Union - Saturday - 4pm-5pm (1hr)						
	Pedestrians	**Bike**	**NB**	**EB**	**WB**	**SB**
	273	51				
Through			69	17	29	98
Right			15	37	3	52
Left			48	12	13	5

Barrrie and Union - Saturday - 4pm-5pm (1hr)						
	Pedestrians	**Bike**	**NB**	**EB**	**WB**	**SB**
	178	42				
Through			72	23	21	111
Right			19	32	2	52
Left			61	9	14	5

Table 15: Traffic Count data at the Albert St. & Union St. Intersection from 8:00am to 9:00am and 5:00pm to 6:00pm on Tuesday, Thursday, and Saturday

Albert & Union -Tuesday- 8am-9am (1hr)						
	Pedestrians	Bike	NB	EB	WB	SB
	424	38				
Through			36	154	104	32
Right			8	34	10	20
Left			32	12	4	4

Albert & Union -Thursday- 8am-9am (1hr)						
	Pedestrians	Bike	NB	EB	WB	SB
	562	29				
Through			41	160	115	37
Right			8	37	18	17
Left			42	21	9	7

Albert and Union - Tuesday- 4pm-5pm (1hr)						
	Pedestrians	Bike	NB	EB	WB	SB
	718	52				
Through			152	198	296	48
Right			4	50	24	12
Left			40	16	30	16

Albert and Union - Thursday - 4pm-5pm (1hr)						
	Pedestrians	Bike	NB	EB	WB	SB
	738	61				
Through			169	202	308	43
Right			9	59	31	19
Left			57	27	28	25

Albert & Union - Saturday 8am-9am (1hr)						
	Pedestrians	Bike	NB	EB	WB	SB
	248	17				
Through			40	92	62	24
Right			24	20	35	56
Left			64	4	6	32

Albert & Union - Saturday 8am-9am (1hr)						
	Pedestrians	Bike	NB	EB	WB	SB
	307	28				
Through			43	89	84	29
Right			24	28	17	53
Left			76	9	14	41

Albert & Union- Saturday 4-5 pm (1 hr)						
	Pedestrians	Bike	NB	EB	WB	SB
	327	26				
Through			53	108	89	29
Right			33	24	64	62
Left			61	9	4	41

Albert & Union- Saturday 4-5 pm (1 hr)						
	Pedestrians	Bike	NB	EB	WB	SB
	369	31				
Through			47	112	84	33
Right			39	29	44	80
Left			58	11	8	47

Table 16: Traffic Count data at the Bader Ln. St. & University St. Intersection from 8:00am to 9:00am and 5:00pm to 6:00pm on Tuesday, Thursday, and Saturday

Bader & Uni -Tuesday- 8am-9am (1hr)					
	Pedestrians	Bike	NB	EB	SB
	931	6			
Through			NA	NA	NA
Right			NA	9	17
Left			15	11	NA

Bader & Uni -Thursday- 8am-9am (1hr)					
	Pedestrians	Bike	NB	EB	SB
	857	7			
Through			NA	NA	NA
Right			NA	12	21
Left			17	15	NA

Bader & Uni - Tuesday- 4pm-5pm (1hr)					
	Pedestrians	Bike	NB	EB	SB
	2319	8			
Through			NA	NA	NA
Right			NA	31	25
Left			17	29	NA

Bader & Uni - Thursday - 4pm-5pm (1hr)					
	Pedestrians	Bike	NB	EB	SB
	2106	11			
Through			NA	NA	NA
Right			NA	25	24
Left			21	28	NA

Bader & Uni - Saturday 8am-9am (1hr)					
	Pedestrians	Bike	NB	EB	SB
	77	3			
Through			NA	NA	NA
Right			NA	8	3
Left			4	5	NA

Bader & Uni - Saturday 8am-9am (1hr)					
	Pedestrians	Bike	NB	EB	SB
	85	2			
Through			NA	NA	NA
Right			NA	10	4
Left			4	7	NA

Bader & Uni- Saturday 4-5 pm (1hr)					
	Pedestrians	Bike	NB	EB	SB
	132	6			
Through			NA	NA	NA
Right			NA	11	10
Left			8	15	NA

Bader & Uni - Saturday 4-5 pm (1hr)					
	Pedestrians	Bike	NB	EB	SB
	157	4			
Through			NA	NA	NA
Right			NA	14	9
Left			6	17	NA

Table 17: Traffic Count data at the Bader Ln. St. & Albert St. Intersection from 8:00am to 9:00am and 5:00pm to 6:00pm on Tuesday, Thursday, and Saturday

Bader & Albert -Tuesday- 8am-9am (1hr)					
	Pedestrians	**Bike**	**NB**	**WB**	**SB**
	895	2			
Through			NA	NA	NA
Right			12	4	NA
Left			NA	3	16

Bader & Albert - Thursday- 8am-9am (1hr)					
	Pedestrians	**Bike**	**NB**	**WB**	**SB**
	931	3			
Through			NA	NA	NA
Right			16	5	NA
Left			NA	7	14

Bader & Albert - Tuesday- 4pm-5pm (1hr)					
	Pedestrians	**Bike**	**NB**	**WB**	**SB**
	1137	5			
Through			NA	NA	NA
Right			10	15	NA
Left			NA	17	9

Bader & Albert - Thursday - 4pm-5pm (1hr)					
	Pedestrians	**Bike**	**NB**	**WB**	**SB**
	1206	4			
Through			NA	NA	NA
Right			15	16	NA
Left			NA	21	9
		0			

Bader & Albert - Saturday 8am-9am (1hr)					
	Pedestrians	**Bike**	**NB**	**WB**	**SB**
	503	1			
Through			NA	NA	NA
Right			7	3	NA
Left			NA	2	11

Bader & Albert - Saturday 8am-9am (1hr)					
	Pedestrians	**Bike**	**NB**	**WB**	**SB**
	558	2			
Through			NA	NA	NA
Right			6	8	NA
Left			NA	2	10

Bader & Albert - Saturday 4-5 pm (1hr)					
	Pedestrians	**Bike**	**NB**	**WB**	**SB**
	719	7			
Through			NA	NA	NA
Right			8	6	NA
Left			NA	4	13

Bader & Albert - Saturday 4-5 pm (1hr)					
	Pedestrians	**Bike**	**NB**	**WB**	**SB**
	689	4			
Through			NA	NA	NA
Right			11	6	NA
Left			NA	8	16

Appendix C: Existing Cross-section Dimensions

Table 18: Current Cross-section Dimensions for the Streets of Study

Width Measurement	University Ave.	Bader Ave.	Union St.	Albert St.	Barrie St.	Stuart St.
Total Sidewalk (m)	9	4	8	3	3.5	3.5
Total Driving Lane (m)	10.5	5.75	9.5	5.5	7.75	5.5
Total Street Parking (m)	-	2.25	4.5	4.5	2.25	4.5
Total Right of Way (m)	19.5	12	22	13	13.5	13.5

Figure 42: Current Cross-section Dimensions for University Ave. (Google Earth 2022a)

Figure 43: Current Cross-section Dimensions for Union St. (Sidewalks are the same dimension on both sides) (Google Earth 2022b)

Figure 44: Current Cross-section Dimensions for Albert St. (Sidewalks are the same dimension on both sides) (Google Earth 2022c)

Figure 45: Current Cross-section Dimensions for Barrie St. (Sidewalks are the same dimension on both sides) (Google Earth 2022d)

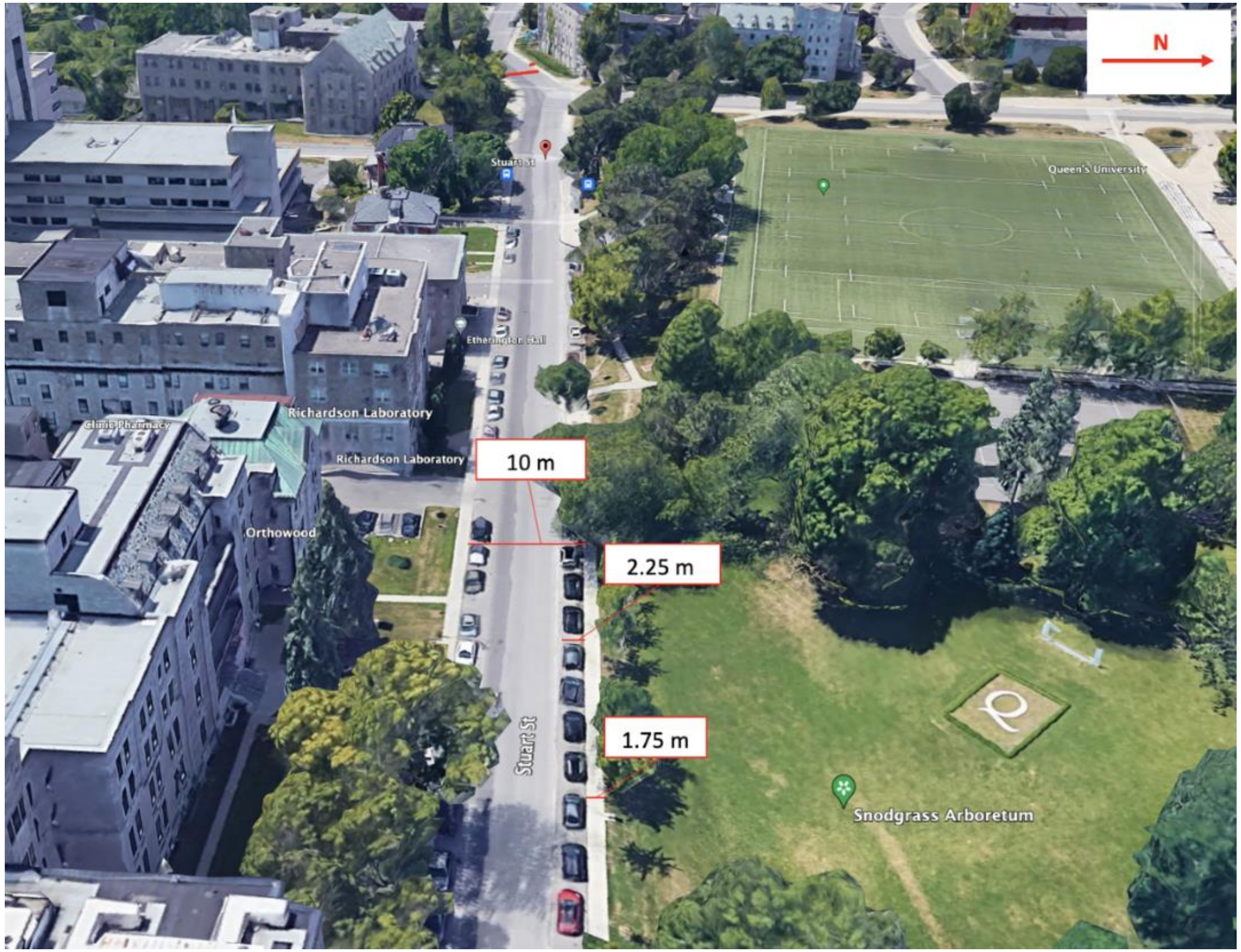


Figure 46: Current Cross-section Dimensions for Stuart St. (Sidewalks are the same dimension on both sides) (Google Earth 2022e)

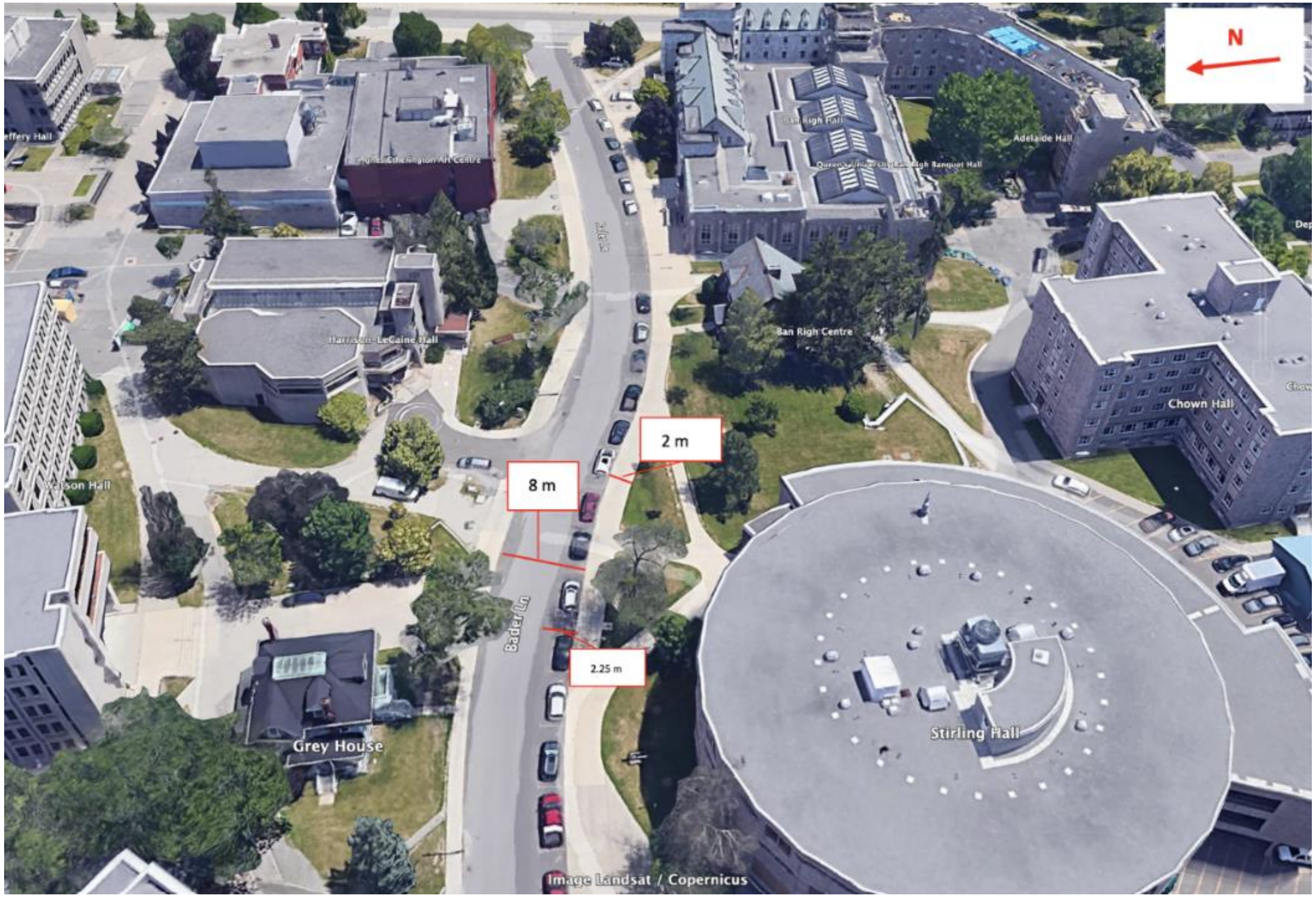


Figure 47: Current Cross-section Dimensions for Bader Ln. (Sidewalks are the same dimension on both sides) (Google Earth 2022f)

Appendix D: Current Queen's University Main Campus Fire Route

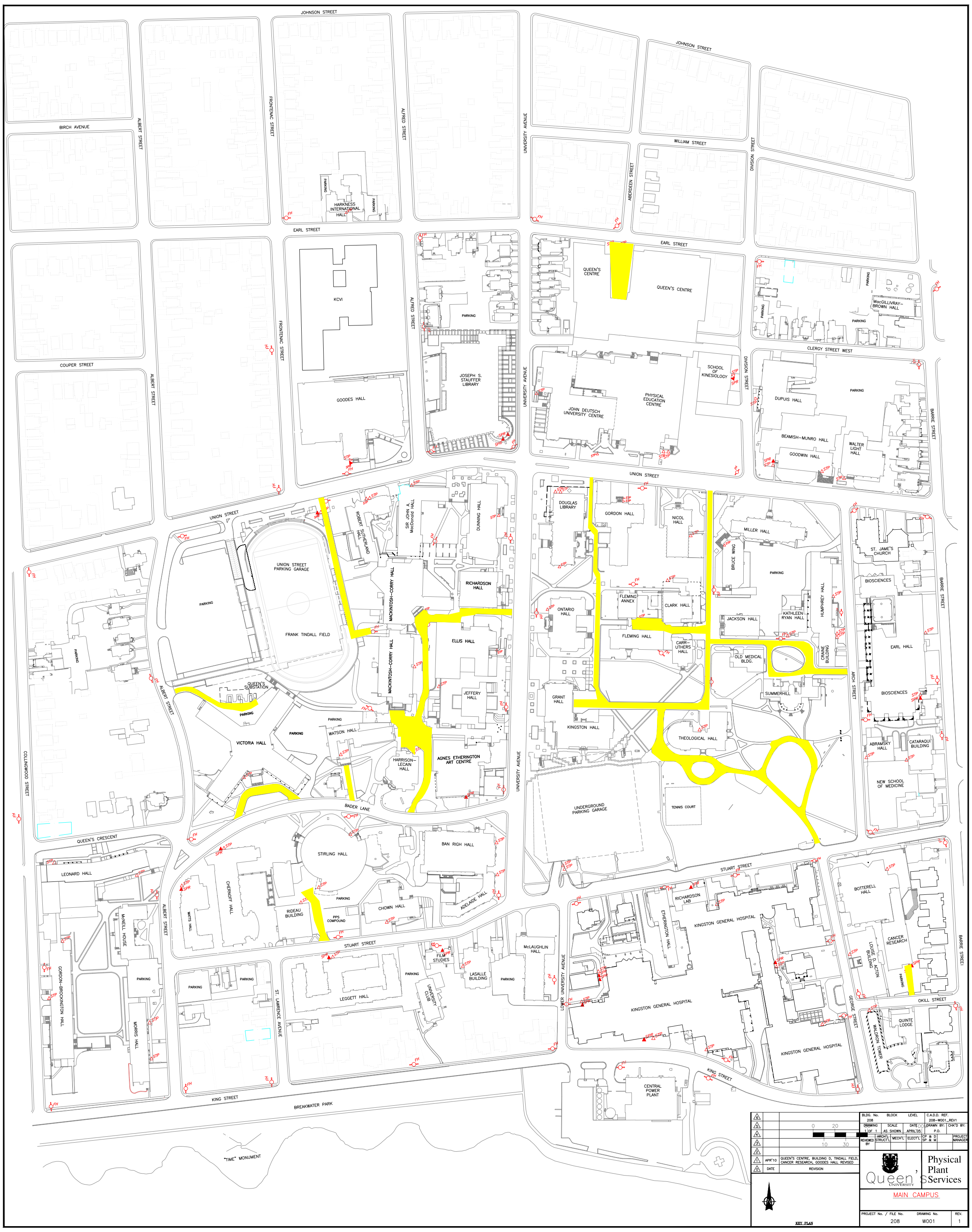


Figure 48: Current Queen's University Main Campus Fire Route (Peet 2023)

Appendix E: Work Breakdown Structure

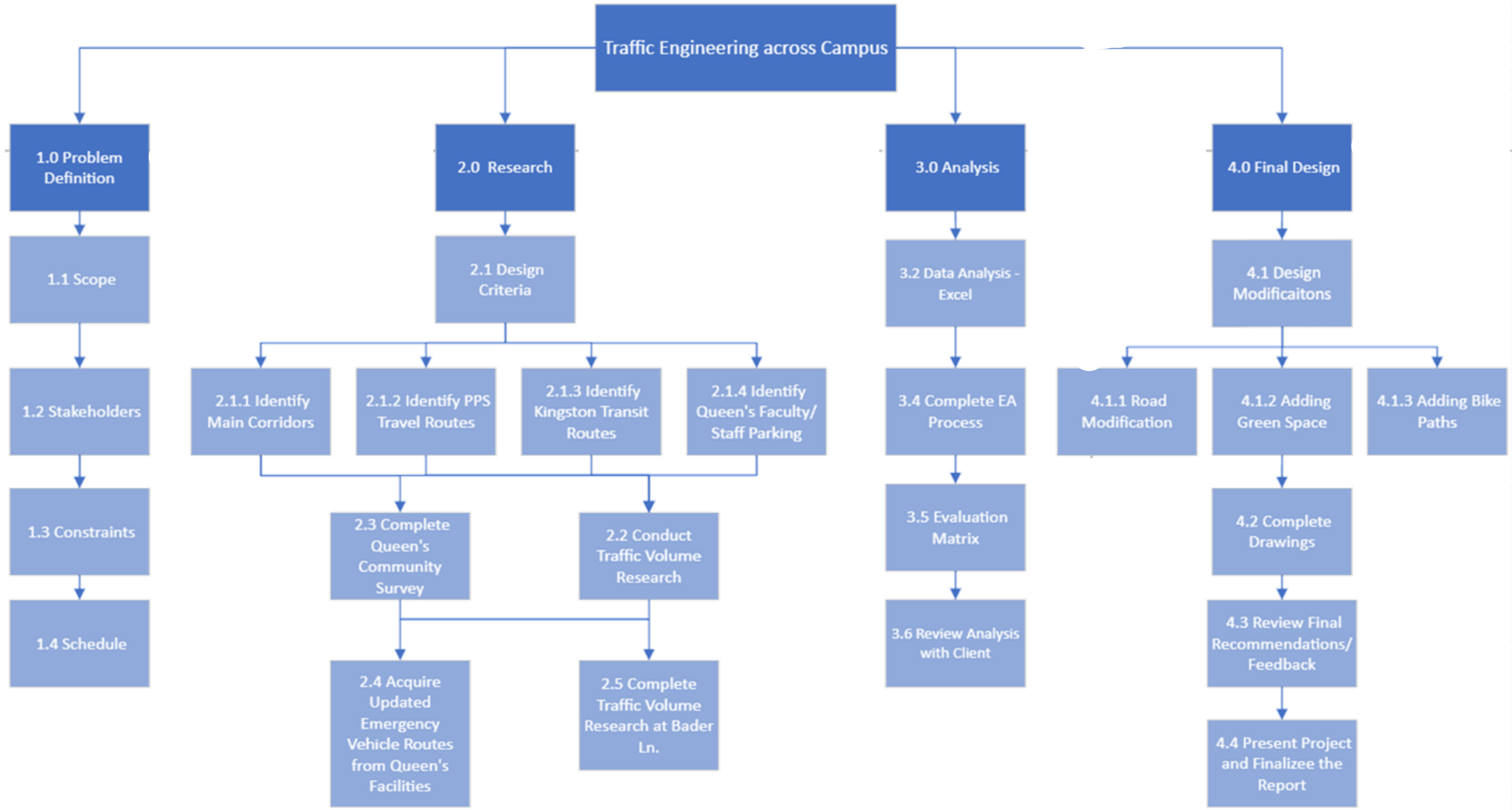
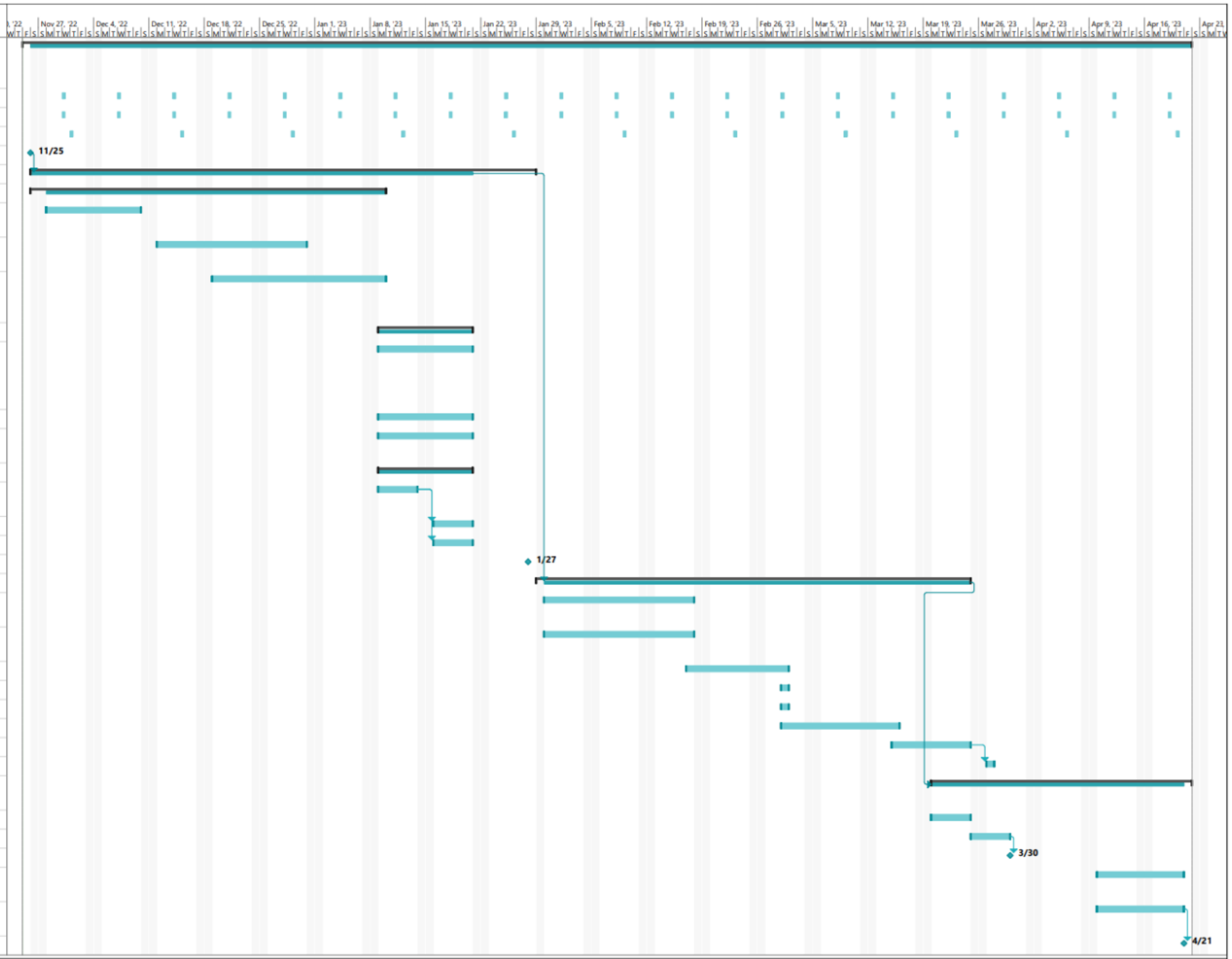


Figure 49: Work Breakdown Structure Outlining Main and Sub-tasks Completed by the Team

Appendix F: Gantt Chart

ID	Task Name	Duration	Start	Finish	Predecessors
1	**CIVL 460: Traffic Engineering Across Queen's University Campus**	**107 days?**	**Fri 11/25/22**	**Fri 4/21/23**	
2	**Team Meeting**	**101.13 days**	**Wed 11/30/2**	**Wed 4/19/23**	
24	**TA Meeting**	**101.06 days**	**Wed 11/30/2**	**Wed 4/19/23**	
46	**Client Meeting**	**101.13 days**	**Thu 12/1/22**	**Thu 4/20/23**	
58	Progress Report	0 days	Fri 11/25/22	Fri 11/25/22	
59	**Phase Three**	**46 days?**	**Fri 11/25/22**	**Sat 1/28/23**	**58**
60	**Deliberation Period**	**31 days?**	**Fri 11/25/22**	**Mon 1/9/23**	
61	Present Design Alternatives to Client	10 days	Mon 11/28/22	Fri 12/9/22	
62	Brainstorm New Alternatives	15 days	Mon 12/12/22	Fri 12/30/22	
63	Update Alternatives Based on Client's Feedback	16 days	Mon 12/19/22	Mon 1/9/23	
64	**Research**	**10 days?**	**Mon 1/9/23**	**Fri 1/20/23**	
65	Acquire Updated Emergency Vehicle Routes from Queen's Facilities	10 days	Mon 1/9/23	Fri 1/20/23	
66	Contact Kingston Services	10 days	Mon 1/9/23	Fri 1/20/23	
67	Meet with MPL Master's Students	10 days	Mon 1/9/23	Fri 1/20/23	
68	**Traffic Study**	**10 days?**	**Mon 1/9/23**	**Fri 1/20/23**	
69	Conduct Traffic Count @ Bader Lane Intersection	5 days	Mon 1/9/23	Fri 1/13/23	
70	Conduct Traffic Analysis	5 days	Mon 1/16/23	Fri 1/20/23	69
71	Conduct Risk Assessment	5 days	Mon 1/16/23	Fri 1/20/23	69
72	Poster Presentation	0 days	Fri 1/27/23	Fri 1/27/23	
73	**Phase Four**	**40 days?**	**Sat 1/28/23**	**Fri 3/24/23**	**59**
74	Finalize Final Design With Client	15 days	Mon 1/30/23	Fri 2/17/23	
75	Finalize Ideas and Recommendations	15 days	Mon 1/30/23	Fri 2/17/23	
76	Deliberation	9 days	Fri 2/17/23	Wed 3/1/23	
77	Begin Writing Report	1 day	Wed 3/1/23	Wed 3/1/23	
78	Split Up Parts of Report	1 day	Wed 3/1/23	Wed 3/1/23	
79	Write Report	11 days	Wed 3/1/23	Wed 3/15/23	
80	Edit and Format Report	8 days	Wed 3/15/23	Fri 3/24/23	
81	Draft Final Report	1 day	Mon 3/27/23	Mon 3/27/23	80
82	**Phase Five: Final Recommendations**	**25 days?**	**Mon 3/20/23**	**Fri 4/21/23**	**73**
83	Create Final Presentation	5 days	Mon 3/20/23	Fri 3/24/23	
84	Rehearse Final Presentation	4 days	Sat 3/25/23	Wed 3/29/23	
85	Oral Presentation	0 days	Thu 3/30/23	Thu 3/30/23	84
86	Update Report Based on TA and Professor Feedback	9 days	Mon 4/10/23	Thu 4/20/23	
87	Finalize Recommendations with Client	9 days	Mon 4/10/23	Thu 4/20/23	
88	Final Report to Client	0 days	Fri 4/21/23	Fri 4/21/23	87



Project: updated460
Date: Fri 11/25/22

Task · Split · Milestone · Summary · Project Summary · Inactive Task · Inactive Milestone · Inactive Summary · Manual Task · Duration-only · Manual Summary Rollup · Manual Summary · Start-only · Finish-only · External Tasks · External Milestone · Deadline · Progress · Manual Progress

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Figure 50: BGM²'s Gantt Chart

Appendix G: Responsibility Assignment Matrix

Table 19: Responsibility Assignment Matrix Illustrating Who is Responsible, Accountable, Consulted, and Informed

Tasks	Natalie	Megan	Adrianne	Julianna	Client
Problem Definition					
1.1 Scope	A/C/I	A/C/I	R	A/C/I	C/I
1.2 Stakeholders	A/C/I	A/C/I	R	A/C/I	C/I
1.3 Constraints	A/C/I	A/C/I	R	A/C/I	C/I
1.4 Schedule	R	A/C/I	A/C/I	A/C/I	I
Research					
2.1 Design Criteria					
2.1.1 Identify Main Corridors	R/A	R/A	R/A	R/A	C/I
2.1.2 Identify Queen's Facilities Travel Routes	R/A	R/A	R/A	R/A	C
2.1.3 Identify Kingston Transit Routes	R/A	R/A	R/A	R/A	-
2.1.4 Identify Queen's University Faculty/Staff Parking	R/A	R/A	R/A	R/A	-
2.2 Conduct Traffic Volume Research	R/A	R/A	R/A	R/A	I
2.3 Conduct Queen's University Community Survey	R/A	R/A	R/A	R/A	I
2.4 Acquire Updated Emergency Vehicle Roues from Queen's Facilities	R/A	R/A	R/A	R/A	I
2.5 Complete Traffic Volume Research at Bader Ln.	R/A	R/A	R/A	R/A	I
3.0 Analysis					
3.2 Data Analysis - Excel	A/C/I	A/C/I	R	R	-
3.3 Complete EA Process	A/C/I	R	A/C/I	A/C/I	
3.4 Evaluation Matrix	A/C/I	A/C/I	R	R	C/I
3.5 Review Analysis with Client	A/C/I	A/C/I	R	R	C/I
4.0 Final Design					
4.1 Design Modifications					
4.1.1 Road Modification	A/C/I	A/C/I	R	R	C/I
4.1.2 Add Green Space	A/C/I	A/C/I	R	R	C/I
4.1.3 Add Bike Paths	A/C/I	A/C/I	R	R	C/I
4.2 Complete Drawings	A/C/I	A/C/I	R	R	I
4.3 Review Final Recommendations/Feedback	A/C/I	A/C/I	R	R	C/I
4.4 Present Project and Finalize the Report	R/A	R/A	R/A	R/A	C/I

Appendix H: Meeting Minutes

Meeting Minutes

Date: September 14, 2022

Time: 11:00am

Teams Meeting

Meeting called by:	Nathan Splinter	**Type of meeting:**	Introductory Client Meeting

Attendees: Megan Grosso, Adrianne Matacot, Julianna Moore, Natalie Bot, Nathan Splinter.

Minutes

Discussion:

- Nathan manages sustainability, energy and central heating plant and refrigeration teams on campus. This includes all the built environment and the campus grounds and all infrastructure. He has a team of 200 custodians.
- He wants our report to be a snapshot of campus now and where it can be. Pedestrian friendly, walkable, improve things for commuters.
- Look into Queen's Master Plan, meet with Master's students as they would be good contacts for our project.
- Defined boundaries as Earl St., Albert, Union and Division,
- Weekly meetings will be set up. Team will send an appropriate time.

Action items	Person responsible	Deadline
Reach out to Master's students	Team	
Send AutoCAD map	Nathan	

Meeting Minutes

Date: September 14, 2022
Time: 11:45am
Teams Meeting

Meeting called by:	Amanda Fawley	**Type of meeting:**	TA Weekly Meeting

Attendees: Megan Grosso, Adrianne Matacot, Julianna Moore, Natalie Bot, Amanda Fawley.

Minutes

- Discussed scope and work plan.

Action items	Person responsible	Deadline
Update timesheet.	Team	End of Week

Meeting Minutes

Date: September 21, 2022
Time: 11:45am
Location

Meeting called by:	Amanda Fawley	**Type of meeting:**	TA Weekly Meeting

Attendees: Megan Grosso, Adrianne Matacot, Julianna Moore, Natalie Bot, Amanda Fawley.

Minutes

- Discussed scope and work plan.

Meeting Minutes

Date: September 28, 2022
Time: 11:45am
Location

Meeting called by:	Amanda Fawley	**Type of meeting:**	TA Weekly Meeting

Attendees: Megan Grosso, Adrianne Matacot, Julianna Moore, Natalie Bot, Amanda Fawley.

Minutes

- Discussed scope and work plan.

Meeting Minutes

Date: October 5, 2022
Time: 11:45am
Location

Meeting called by:	Amanda Fawley	**Type of meeting:**	TA Weekly Meeting

Attendees: Megan Grosso, Adrianne Matacot, Julianna Moore, Natalie Bot, Amanda Fawley.

Minutes

- Discussed scope and work plan.

Meeting Minutes

Date: October 19, 2022
Time: 11:45am
Location

Meeting called by:	Amanda Fawley	**Type of meeting:**	TA Weekly Meeting

Attendees: Megan Grosso, Adrianne Matacot, Julianna Moore, Natalie Bot, Amanda Fawley.

Minutes

- Discussed scope and work plan.

Meeting Minutes

Date: October 26, 2022
Time: 11:45am
Location

Meeting called by:	Amanda Fawley	**Type of meeting:**	TA Weekly Meeting

Minutes

- Discussed scope and work plan.

Meeting Minutes

Date: November 2, 2022
Time: 11:45am
Location

Meeting called by:	Amanda Fawley	**Type of meeting:**	TA Weekly Meeting

Attendees: Megan Grosso, Adrianne Matacot, Julianna Moore, Natalie Bot, Amanda Fawley.

Minutes

Discussion:

- Team: Met and split up work. Will be recording traffic data this afternoon, tomorrow and on the weekend. We are brainstorming a survey as well.
- Adding assumptions?:
  - She used assumptions for structural analysis for her capstone.
- Do we need a section for assumptions?
  - Amanda: People put in constraints or bringing it up as needed. We have to clearly state them and the process and thinking behind it.
  - General assumptions can be put underneath constraints, in its own sub-heading or not.
- Amanda: you guys provided an example of deliveries and such. We should provide two or three more examples for this PPS constraint. It never hurts to provide more than one example. We may need to identify them earlier on so we don’t have to identify them later.
- Stakeholders in chart in appendix or in main report instead of a paragraph? Amanda: either ideas work, format table in certain way where we can provide enough detail for each stakeholder then that’s fine.
- Are full sentences in a table good practice? Or should it be bullet points?
  - Amanda: full sentences are fine. Its good if its in the main body of the report and not the appendix.
- Adding a period??
  - Amanda: Just be consistent with periods or no periods.
- Amanda: We can keep using the enter thing, it just has to be consistent for each transition point. There should be a little space between the caption and the figure.
- Subheaders?
  - Amanda: we used the subheaders well. It’s also okay to have a sentence or two under each subheader to introduce the thing. She has used one sentence under a subheader before.
- Inconsistencies?
  - Amanda: neither comments are necessarily wrong or right, we can discuss comments that are conflicting with both of them.
- Sean watt's scope comment:
  - Amanda: we should add more about what we are going to be doing and the different tasks associated during the stages.
  - We can do this with bullet points. This question is something we can talk about with Sean. Because Amanda thought it was well-written. Sean might have a different opinion with his professional experience.

Meeting Minutes

Date: November 10, 2022
Time: 11:45am
Teams Meeting

Meeting called by:	Amanda Fawley	**Type of meeting:**	TA Weekly Meeting

Attendees: Megan Grosso, Adrianne Matacot, Julianna Moore, Natalie Bot, Amanda Fawley.

Minutes

Discussion:

- Team Updates:
  - We are adding a case study to look at. Now we are looking for different design alternatives for the evaluation matrix, continuous crosswalk that has motion sensors.
- Amanda: We should include the word innovation somewhere, we could include an innovation subheading, or it could be scattered throughout the report, talking about it is very important.
- Are we making justified engineering solutions?
  - Amanda: We have to verify that its correct and have the proper references and bylaws, we can analyze the solution by calculation or getting quantities.

Meeting Minutes

Date: November 10, 2022
Time: 11:45am
Teams Meeting

Meeting called by:	Nathan Splinter	**Type of meeting:**	TA Weekly Meeting

Attendees: Megan Grosso, Adrianne Matacot, Julianna Moore, Natalie Bot, Tony Gkotsis

Minutes

Discussion:

- Tony is university planner.
- Tony deals with campus master plan (renewal of plan).
- They will have traffic data (city of Kingston).
- They may have data for the way transit will be going.
- Can they move it away from University Ave. That may not be the ideal transit route. Priority transitioning for emergency vehicles. Vehicle access. Service and fire vehicle road only.
- People use university to get to parking. Wherever there is loading required.
- Service vehicles are different obviously.
- Turn it into one-way with service vehicles only.
- Have to analyze where the traffic will go. Modelling what will happen.
- Fifth field company will have almost no impact.
- Hospital project: KHSC will expand and demolish some buildings.
- No signalization there, wait limits of up to 20 minutes.
- Interesting place to study is around Agnes Etherington center (near Bader and Uni).

- More space for a geothermal well field along Bader.
- All deliveries come off Stuart St.
- Bader Ln. is owned by Queen's. what happens to Stuart and surrounding if we close that street off.
- Set up biweekly meetings with everyone.
- What is our scope and what is our outcome goal.
- Don't need findings or recommendations yet.
- Creating awareness with our facilities team. We have to do a final presentation as well with them (smaller than capstone requirements).
- Mix of people parking on campus. Many staff went to remote work.
- About 200 people using the app. Its construction workers, kgh people, queens remote workers coming to work 1-2days per week. It used to be very difficult to find a parking spot. Partly administrative people moving off remote work.
- With parking there's an exclusion zone. (Princess and sir john A). where you can't buy a permit. Tindall field parking lot, first year students can park here. Nobody that lives on campus needs a car in his opinion. There is capacity to take on more people in the underground lots if we stopped selling to first years to promote public transit and walking.
- Is parking necessary on union? If we have the capacity at Tindall field.
- More parking on university to reduce traffic.
- Medians not meters.
- **Where we can do the most potentially is on Bader Ln. because university owns that. We don't own university and union**.
- Bader Ln., Fifth Field Company Ln., (bookstore and Jackson hall), arch street is city-owned.
- Bio-sci is owned by Queen's. that is wide enough for service vehicles.

Meeting Minutes

Date: November 16, 2022

Time: 11:45am

Teams Meeting

Meeting called by:	Amanda Fawley	**Type of meeting:**	TA Weekly Meeting

Attendees: Megan Grosso, Adrianne Matacot, Julianna Moore, Natalie Bot, Amanda Fawley.

Minutes

Discussion:

- Put Pass/fail in the matrix.
- This is interesting apparently for the evaluation matrix.
- If it's well put together, traceable, and justified, then its fine.
- They are expecting numerical evaluation matrices, Amanda will be reaching out to Sean about this.
- For report review:
- Amanda will scan for formatting.
- She does look at content.
- She will do her best to read top to bottom.
- Won't be grammar edits.
- She expects it to be edited further after the week.
- They know that the rubric has to be bent a bit for different types of projects.

Meeting Minutes

Date: November 23, 2022

Time: 11:45am

Location

Meeting called by:	Amanda Fawley	**Type of meeting:**	TA Weekly Meeting

Attendees: Megan Grosso, Adrianne Matacot, Julianna Moore, Natalie Bot, Amanda Fawley.

Minutes

Discussion:

- Reviewed Amanda's comments and clarified. Comment discussion was recorded in Word document and not in Meeting Minutes.

Meeting Minutes

Date: January 17, 2023

Time: 10:30am

Teams Meeting

Meeting called by:	Group S	Type of meeting:	TA Check-In Meeting

Attendees: Amanda Fawley, Megan Grosso, Adrianne Matacot, Julianna Moore, Natalie Bot.

Minutes

Discussion:

- Poster presentation completion:
  - It is self-led work this semester so we should be setting our own schedule.
  - Poster presentation is like the CIVL500 thesis where groups stand beside the poster and groups walk around.
  - We will have to present to Sean and we will be evaluated by at least 2 other Tas.
- We will receive grades for progress report by end of January.
- Referencing technical standards?
  - Sean said that we didn't reference technical standards but we had mentioned it throughout the report. We are wondering if this will affect our grades or if he will be doing another readthrough. Amanda says that it depends and she is not sure how much Sean had taken off for that part.
  - Amanda says she can bring it up with him to double check about the comment. As long as we have done that, we are justified to ask him as well. Amanda will send an email to Sean today.
- Poster Presentation
  - Ideally everyone will say something in the presentation.
  - When will we know about timing? We will not know timing or when we will find out if it is week 3 or not.
  - Assume it will be next week (Week 3).
- Final Report: since we chose a final design what else is Amanda expecting?
  - Expanding on Bader Ln because that's where the client is most interested.
  - Finer details.
  - Elaborating on further specifications, like painting road lines or bike symbols.
  - Working out as many details as we can.
  - Standard content report document that provides an outline of what they are looking for.
- Amanda is 6h ahead. Amanda will be back in March when we are closer to the final report deadline.

Action items	Person responsible	Deadline
Set up recurring weekly meetings	Team	-

Meeting Minutes

Date: January 31, 2023

Time: 10:30am

Teams Meeting

Meeting called by:	Group S	Type of meeting:	TA Check-In Meeting

Attendees: Amanda Fawley, Megan Grosso, Adrianne Matacot, Julianna Moore, Natalie Bot.

Minutes

Discussion:

- Team is recording traffic data on Bader Ln this afternoon.
- Running thru rubric together:
    - Rubrics are general.
    - Prob. Definition, being able to outline the definition of our project very effectively.
    - We should be proud of our work and it is very hard to get a good grade. We have to go beyond to get the 10/10.
    - We could request a meeting with Prof. Watt to ask him how we can present these things
    - He may have been caught off guard of the way we have to present our evaluation and how its different from the other reports.
- Grading:
    - 10-15% in A+ range.
    - Meeting expectations will give us a low to mid B grade.
    - We should look at the rubric for final report, its same rubric but different weightings. Now technical analysis is weighed the most.
- Innovation:
    - Innovation is one of the hardest categories. Because it depends on the project. We should talk to Sean Watt about innovation and potentially sprinkle it through the whole report instead. We could put the innovation part in the evaluation matrices.
    - New idea to implement the same thing, just with a unique side.
- We still have the final presentation, its an actual PowerPoint presentation and not the walk around format. Its 5-15% of the final grade.

Action items	Person responsible	Deadline
Reach out to meet with Sean Watt	Team	-

Meeting Minutes

Date: February 7, 2023

Time: 10:30am

Teams Meeting

Meeting called by:	Group S	Type of meeting:	TA Check-In Meeting

Attendees: Amanda Fawley, Megan Grosso, Adrianne Matacot, Julianna Moore, Natalie Bot.

Minutes

Discussion:

- Amanda is flying back to Canada on March 9th. Plan to send the report the week before or after
- Include in final report:
    - Thorough discussion of final design, any calculations.
    - Any discussion of implementation of the design, and if it's not in the scope to fully develop it, at least have some considerations about pros and cons, any difficulties with implementation and things like that.
    - General cost estimate for the final design.
    - Along with any innovative aspects as well, we should further develop innovation.
    - We should make sure innovation is appropriately discussed in relation to our final design.
    - Up to date Gantt chart, discuss how we followed the engineering design process.
- (For example, maybe relate our design process to the engineering design process).
- We could add progress report and work plan in appendix if we make huge changes to the design.
    - E.g. Things might flow better if we reword/rephrase things differently, or if we made different conclusions.
- They don't expect us to have the exact headers from the sections, and they want us to add more sections depending on our own project.

Action items	**Person responsible**	**Deadline**
Confirm draft final report internal deadline	Team	-

Meeting Minutes

Date: February 10, 2023

Time: 1:45pm

Teams Meeting

Meeting called by:	Group S	Type of meeting:	TA Check-In Meeting
Attendees:	Prof. Watt, Megan Grosso, Adrianne Matacot, Julianna Moore, Natalie Bot.		

Minutes

Discussion:

- Innovation:
  - Can only get to a 3 for progress report, no clear answer doesn't know what a 5 is until he sees it. For final report if you have an innovative project and discuss innovative initiatives (research), that's good.
- Process:
  - Good process, don't have comments – two matrices was a good idea, would need to just refine info to get a 10.
- Technical Analysis:
  - Expecting more calculations. Kind of difficult to do well since this is the beginning of the technical analysis, all would be included in final report. Cost estimation is not included in this section.
- Specs:
  - Expected us to use Kingston Specs. Need to write this: "We thinks Kingston probably have design guidelines, as far as we know these are not available to us. We are going to rely on this and plan based on these guidelines."
- Citation:
  - Felt that a lot needed to be cited and was not, could be due to talking to Mr. Chiu, however, need to reference everything.
- Meeting Minutes:
  - Need to do better, not enough info.

Action items	Person responsible	Deadline
----	-	-

Meeting Minutes

Date: February 14, 2023

Time: 10:30am

Teams Meeting

Meeting called by:	Group S	Type of meeting:	TA Check-In Meeting

Attendees: Amanda Fawley, Megan Grosso, Adrianne Matacot, Julianna Moore, Natalie Bot.

Minutes

Discussion:

- Team updated Amanda on progress. Team split up the parts by creating a table of contents.
- Final Recommendations:
  - State final recommendations instead of saying future recommendations.
  - Should be written addressed to our client.
  - Move final recommendations as a subsection of final design, or we can make it our own section.
  - Final recommendations tie into the final decisions.
  - It can be a summary of recommendations at the end.
  - The final design is detailed recommendations. Include cost in this section.
  - Detailed recommendations section doesn't have to be long, it can be repetitive, but it will provide a concise summary.
- Operation and maintenance section can go in final design.

Action items	Person responsible	Deadline
Cancel Reading Week Meeting	Adrianne	-

Meeting Minutes

Date: February 21, 2023

Time: 10:30am

Teams Meeting

Meeting called by:	Group S	Type of meeting:	TA Check-In Meeting

Attendees: Amanda Fawley, Megan Grosso, Adrianne Matacot, Julianna Moore, Natalie Bot.

Minutes

Discussion:

- Updated Amanda on progress: brainstorming ideas for final report and updating our individual parts.
- Updated report based on meeting notes from February 14.

Action items	Person responsible	Deadline
----	Team	-

Meeting Minutes

Date: February 28, 2023

Time: 10:30am

Teams Meeting

Meeting called by:	Group S	Type of meeting:	TA Check-In Meeting

Attendees: Amanda Fawley, Megan Grosso, Adrianne Matacot, Julianna Moore, Natalie Bot.

Minutes

Discussion:

- Updated Amanda on progress: brainstorming ideas for final report and updating our individual parts. No unique progress worth mentioning since last meeting.

Action items	Person responsible	Deadline
----	Team	-

Meeting Minutes

Date: March 7, 2023

Time: 10:30am

Teams Meeting

Meeting called by:	Group S	Type of meeting:	TA Check-In Meeting

Attendees: Amanda Fawley, Megan Grosso, Adrianne Matacot, Julianna Moore, Natalie Bot.

Minutes

Discussion:

- Updated Amanda on progress: brainstorming ideas for final report and updating our individual parts. No unique progress worth mentioning since last meeting.

Action items	Person responsible	Deadline
----	Team	-

Meeting Minutes

Date: March 14, 2023

Time: 10:30am

Teams Meeting

Meeting called by:	Group S	Type of meeting:	TA Check-In Meeting

Attendees: Amanda Fawley, Megan Grosso, Adrianne Matacot, Julianna Moore, Natalie Bot.

Minutes

Discussion:

- Updated Amanda on progress: brainstorming ideas for final report and updating our individual parts.
- RS Means:
  - We can use it and it might not be applicable, but we can check it out and see if it applies.
- We will send the draft report to Amanda on before Monday next week (March 13th).
- Contacting our client:
  - Emphasize that we have a report deadline in two weeks and that he has made the commitment for us to help.
  - Its okay to push for a response.

Action items	Person responsible	Deadline
----	Team	-

Meeting Minutes

Date: March 21, 2023

Time: 10:30am

Teams Meeting

Meeting called by:	Group S	Type of meeting:	TA Check-In Meeting

Attendees: Amanda Fawley, Megan Grosso, Adrianne Matacot, Julianna Moore, Natalie Bot.

Minutes

Discussion:

- Updated Amanda on progress – involved looking through Amanda's comments for draft final report and updating report.
- For citing websites with no date, use the current year if there is no date, because the website is stating the numbers must be up to date as of this year.
- Section 9.1.2 reword?
  - Rephrase" maximum count".
  - Use scoring ranges that will help identify what the maximum or minimum for the criterion are.
  - E.g., 94 cyclists per hour was the highest count of cyclists, and that number was divided by 4.
- Tenses: Write everything as if we have already done it?
  - Yes, everything that we've done should be past tense.
- Future tense is:
  - Recommendations or next steps.
  - Anything to be done in the future.
- EA Act/Process section:
  - It was written in present tense, or partially written in present tense.
  - When describing the process, it can be described as present tense.
- Page margins:
  - Make sure tables fit within the margins, use AutoFit where possible.
- Page 46, "By Who?" comment - would we have to repeat that it was taken from TAC every time? Answer: insert reference after section again.
- Double check our time slot for our final presentation.
- 10 mins presenting (similar to progress report presentation).
- We must ask a question for the other group and its mandatory.

Action items	Person responsible	Deadline
Cancel next week's TA Mtg as this was the last necessary scheduled meeting	Team	-

Appendix I: Team's Hour Logs

CIVL 460 Engineering Design and Practice
Queen's University

Name: NATALIE BOT **Project:** M4

Hours per Week	Hours
Week 1	3.00
Week 2	2.00
Week 3	9.70
Week 4	9.75
Week 5	1.00
Reading Week	2.50
Week 6	4.00
Week 7	9.00
Week 8	12.50
Week 9	12.00
Week 10	15.50
Week 11	9.50
Week 12	0.00
Exam Week 1	3.00
Exam Week 2	0.00
Exam Week 3	0.00
Break Week 1	0.00
Break Week 2	0.00
Week 1	6.00
Week 2	3.00
Week 3	0.50
Week 4	4.50
Week 5	10.75
Week 6	2.00
Reading Week	1.00
Week 7	6.75
Week 8	12.50
Week 9	2.50
Week 10	19.00
Week 11	0.00
Week 12	0.00
Exam Week 1	0.00
Exam Week 2	0.00
Exam Week 3	0.00

Hours per Task

Activity	Hour Tally
Background Research	20
Project Data Review & Interpretation	2.5
Meeting Attendance and Preparation - TAs/Clients	10.45
Meeting Attendance and Preparation - Group	32
Work Plan - Preperation	4.75
Work Plan - Review/Editing	6.5
Work Plan - Peer Review	2.5
Progress Report - Preperation	20.5
Progress Report - Review/Editing	5.5
Progress Report - Peer Review	3
Final Report - Preperation	28.75
Final Report Review/Editing	10
Technical Design Calculations/Work	0
Modelling	0
Budgeting - time and cost, Gantt Charts	3
SOQ - Preperation & Presentation	3
Poster Presentation - Preperation & Presentation	8.5
Final Presentation - Preperation & Presentation	0
Other	1

My hours: 161.95

Hours left in contract: -1.95

Hours per Week

Task Breakdown (general)

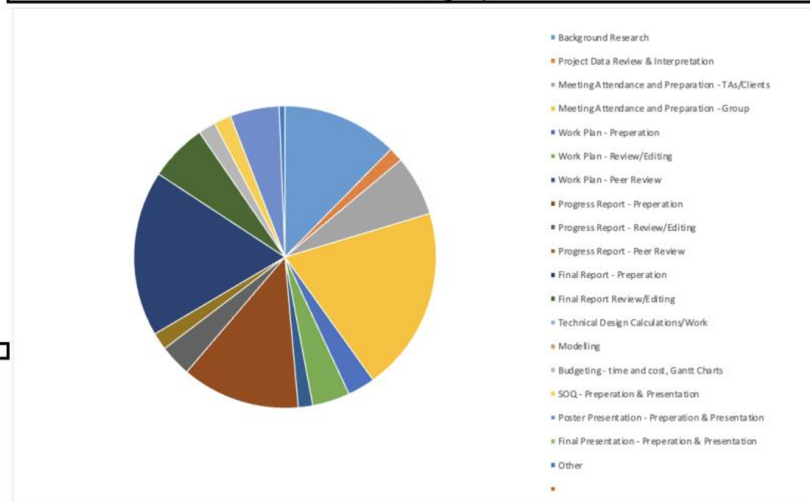


Figure 51: Natalie Bot Hour Log

CIVL 460 Engineering Design and Practice
Queen's University

Name: NAME **Project:** PROJECT

Hours per Week	Hours
Week 1	3.50
Week 2	2.50
Week 3	3.50
Week 4	8.25
Week 5	0.50
Reading Week	0.00
Week 6	0.50
Week 7	5.25
Week 8	9.25
Week 9	5.75
Week 10	14.50
Week 11	39.50
Week 12	0.00
Exam Week 1	0.00
Exam Week 2	0.00
Exam Week 3	0.00
Break Week 1	0.00
Break Week 2	0.00
Week 1	3.50
Week 2	3.00
Week 3	0.50
Week 4	4.50
Week 5	9.25
Week 6	0.50
Reading Week	6.00
Week 7	3.50
Week 8	12.50
Week 9	2.50
Week 10	22.50
Week 11	0.00
Week 12	0.00
Exam Week 1	0.00
Exam Week 2	0.00
Exam Week 3	0.00

Hours per Task

Activity	Hour Tally
Background Research	20
Project Data Review & Interpretation	0
Meeting Attendance and Preparation - TAs/Clients	12
Meeting Attendance and Preparation - Group	25.25
Work Plan - Preperation	10
Work Plan - Review/Editing	0
Work Plan - Peer Review	0
Progress Report - Preperation	48.5
Progress Report - Review/Editing	0
Progress Report - Peer Review	0
Final Report - Preperation	35.5
Final Report Review/Editing	0
Technical Design Calculations/Work	0
Modelling	0
Budgeting - time and cost, Gantt Charts	0
SOQ - Preperation & Presentation	3.5
Poster Presentation - Preperation & Presentation	4.5
Final Presentation - Preperation & Presentation	1
Other	1

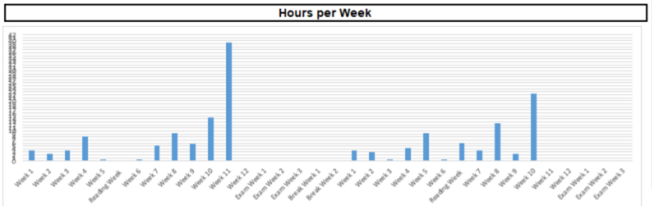
My hours:

161.25

Hours left in contract:

-1.25

Hours per Week



Task Breakdown (general)

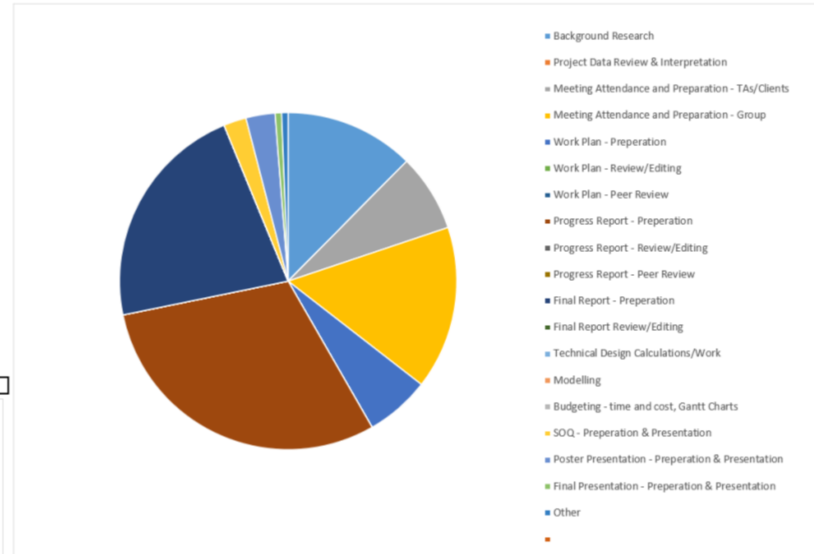


Figure 52: Megan Grosso Hour Log

CIVL 460 Engineering Design and Practice
Queen's University

Name: NAME Project: PROJECT

Hours per Week

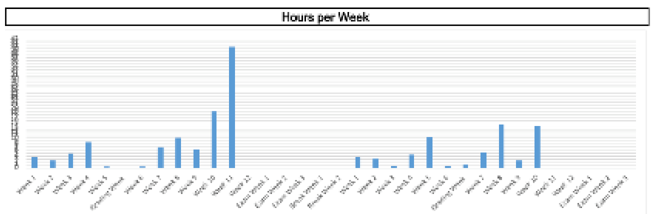
	Hours
Week 1	3.50
Week 2	2.50
Week 3	4.85
Week 4	8.68
Week 5	0.25
Reading Week	0.00
Week 6	0.25
Week 7	6.75
Week 8	10.00
Week 9	6.25
Week 10	19.00
Week 11	40.50
Week 12	0.00
Exam Week 1	0.00
Exam Week 2	0.00
Exam Week 3	0.00
Break Week 1	0.00
Break Week 2	0.00
Week 1	3.50
Week 2	3.00
Week 3	0.50
Week 4	4.50
Week 5	10.25
Week 6	0.50
Reading Week	1.00
Week 7	5.00
Week 8	14.50
Week 9	2.50
Week 10	14.00
Week 11	0.00
Week 12	0.00
Exam Week 1	0.00
Exam Week 2	0.00
Exam Week 3	0.00

Hours per Task

Activity	Hour Tally
Background Research	15
Project Data Review & Interpretation	0
Meeting Attendance and Preparation - TAs/Clients	11.78
Meeting Attendance and Preparation - Group	27.5
Work Plan - Preperation	8.75
Work Plan - Review/Editing	12.5
Work Plan - Peer Review	0
Progress Report - Preperation	31.25
Progress Report - Review/Editing	19.5
Progress Report - Peer Review	0
Final Report - Preperation	24.5
Final Report Review/Editing	0
Technical Design Calculations/Work	0
Modelling	0
Budgeting - time and cost, Gantt Charts	0
SOQ - Preperation & Presentation	3.5
Poster Presentation - Preperation & Presentation	6.5
Final Presentation - Preperation & Presentation	0
Other	1

My hours: 161.78

Hours left in contract: -1.78



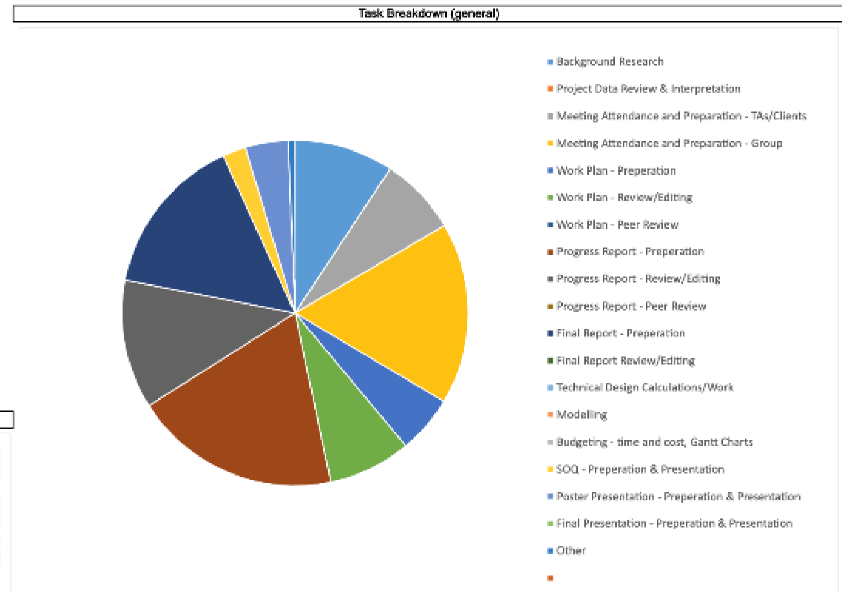


Figure 53: Adrianne Matacot Hour Log

CIVL 460 Engineering Design and Practice
Queen's University

Name: NAME Project: PROJECT

Hours per Week	Hours
Week 1	3.50
Week 2	2.50
Week 3	4.95
Week 4	8.08
Week 5	0.25
Reading Week	0.00
Week 6	0.25
Week 7	6.75
Week 8	10.50
Week 9	5.25
Week 10	19.00
Week 11	40.50
Week 12	0.00
Exam Week 1	0.00
Exam Week 2	0.00
Exam Week 3	0.00
Break Week 1	0.00
Break Week 2	0.00
Week 1	3.50
Week 2	3.00
Week 3	0.50
Week 4	4.50
Week 5	10.25
Week 6	0.50
Reading Week	1.00
Week 7	5.00
Week 8	14.00
Week 9	4.50
Week 10	13.00
Week 11	0.00
Week 12	0.00
Exam Week 1	0.00
Exam Week 2	0.00
Exam Week 3	0.00

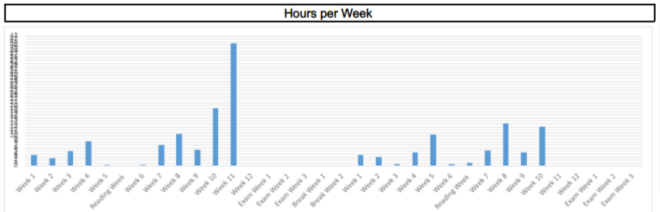
Hours per Task

Activity	Hour Tally
Background Research	15
Project Data Review & Interpretation	0
Meeting Attendance and Preparation - TAs/Clients	12.53
Meeting Attendance and Preparation - Group	15
Work Plan - Preperation	8.25
Work Plan - Review/Editing	13.25
Work Plan - Peer Review	0
Progress Report - Preperation	28.25
Progress Report - Review/Editing	18.5
Progress Report - Peer Review	0
Final Report - Preperation	22
Final Report Review/Editing	16.5
Technical Design Calculations/Work	0
Modelling	0
Budgeting - time and cost, Gantt Charts	0
SOQ - Preperation & Presentation	3.5
Poster Presentation - Preperation & Presentation	6.5
Final Presentation - Preperation & Presentation	1
Other	1

My hours: 161.28

Hours left in contract: -1.28

Hours per Week



Task Breakdown (general)

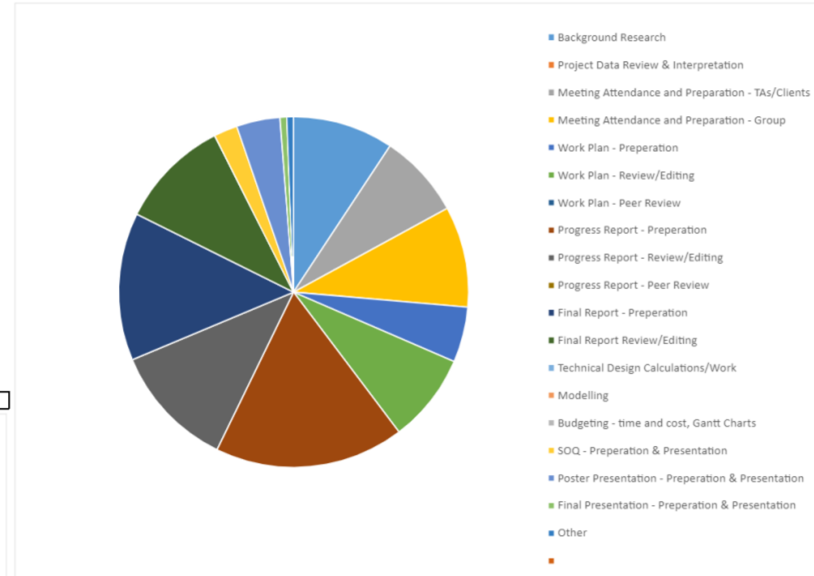


Figure 54: Julianna Moore Hour Log