Carleton University
Transportation Strategy

FINAL DRAFT

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January 24, 2019

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1. INTRODUCTION

1.1. STUDY PURPOSE AND OBJECTIVES

Carleton University has retained Parsons to develop a Transportation Strategy that will address the numerous transportation challenges and opportunities expected to impact the University environment over the next five years. The key factors driving the need for this strategy include:

- **Hog's Back Swing Bridge Closure (anticipated August 2019)** – The National Capital Commission is planning to close the Hog's Back Swing Bridge for rehabilitation. It is our understanding that this project will begin in August 2019 and end in May 2020 (prior to the O-Train Line 2 closure). As Colonel By Dr is the only alternative access point to campus besides Bronson Ave, and currently processes 40% of traffic entering/exiting the campus, This closure is expected to significantly increase traffic entering and exiting via Bronson Ave.
- **O-Train Line 2 (Trillium Line Extension) Closure for Construction (2020-2021)** – The City of Ottawa is planning to shutdown the existing O-Train Line 2 for approximately 18 months as part of the Trillium Line South project. During this time, the R2 detour bus service (previously Route 107) will operate between Bayview Station and Greenboro Station at 5-minute frequencies during peak periods. The R2 detour service will significantly increase bus and transit passenger traffic within campus. OC Transpo is expected to have completed the Ravens Road Bus Access on campus, which will help accommodate the R2 service route.
- **O-Train Line 2 (Trillium Line South) Operation (2021+)** – The opening of Trillium Line South is expected to result in reductions in passenger vehicle traffic and parking demand on campus, in addition to reduced bus volumes. In addition, there is an opportunity for the University to collaborate with the City of Ottawa in defining the Carleton LRT Station design requirements, in addition to capitalizing on City active travel investments connecting to the LRT station.
- **Loss of 900 parking spaces** – With decommissioning of Parking Garage P9 and loss of other parking lots within the campus core area as a result of new building construction, there is a need to assess future parking supply and demand needs.
- **Congestion on campus roads –** High delays and long queus at campus accesses, particularly at the Campus/University and Bronson/University/Sunnyside intersections during the afternoon peak hour.
- **Pedestrian and cyclist conflict** – Expressed need for new cycling facilities and improvements for both pedestrians and cyclists.

Overall, the main goal of the Transportation Strategy, as identified in the study Terms of Reference, is to provide recommendations that enhance:

1. **Choice** (i.e. enhancements to walking, biking and transit);
2. **Safety** (i.e. each mode is allocated space relative to its vulnerability); and
3. **Infrastructure** (existing infrastructure should be optimized to accommodate all modes).

1.2. STUDY SCOPE

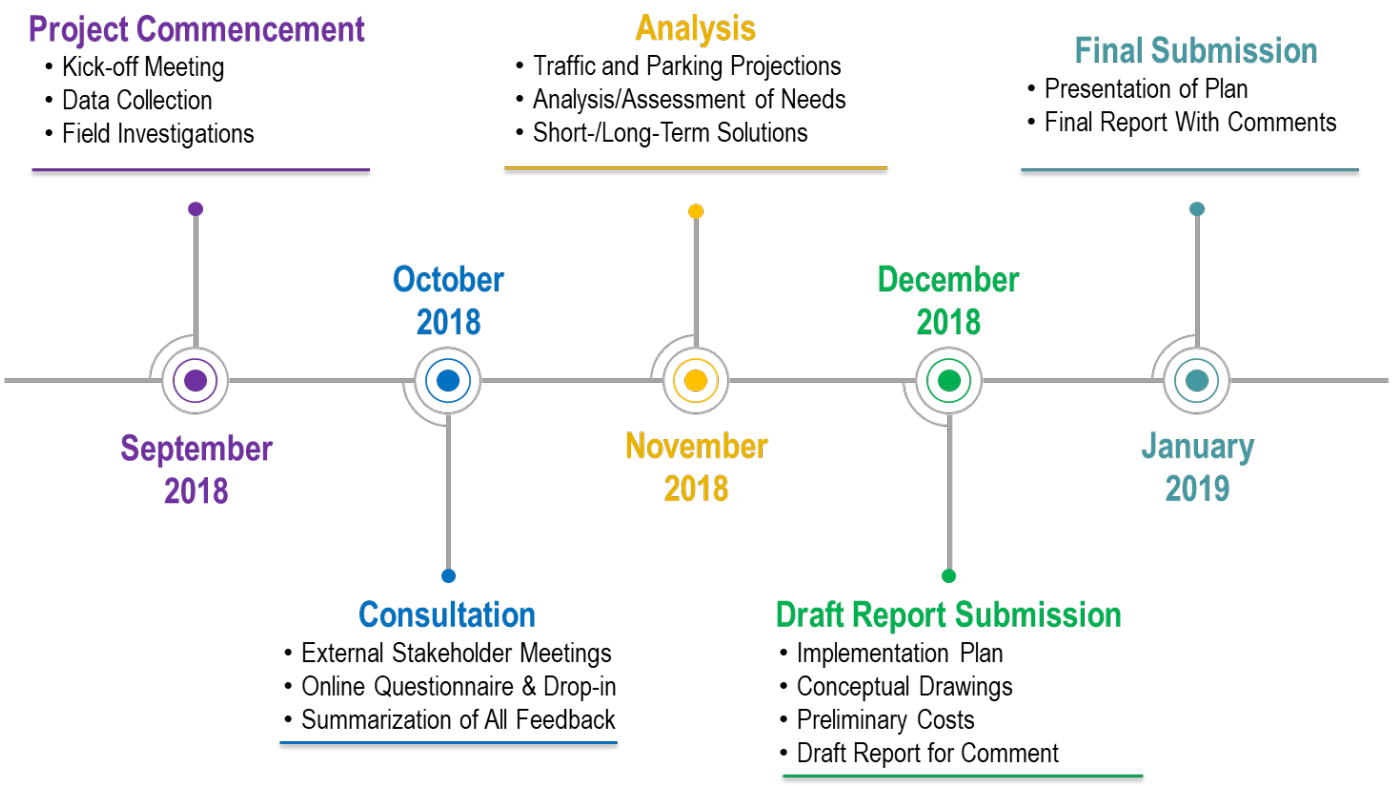
This assignment was completed over an accelerated 4-month schedule and included the following scope of work:

- Start-up meeting with university staff; review of all background information, and site visits.
- Data collection, including traffic, cycling and pedestrian counts.
- Consultation external stakeholders, including the City of Ottawa and the National Capital Commission.

- Consultation with the campus population via an on-line survey (over 660 participants) and drop-in session.
- Projection of future traffic and parking demand.
- Analysis and assessment of future infrastructure needs.
- Identification of short- and long-term solutions for the following key transportation elements: Pedestrians/Cycling; Transit; Roads; Parking; Pick-ups/Drop-offs; Service and Emergency Vehicle; and Accessibility.
- Preparation of conceptual drawings for recommended improvements.
- Transportation demand management and parking pricing recommendations to reduce reliance on single occupancy cars.
- Identification of implementation plan and cost estimates.
- Presentation of study findings and documentation.

An overview of the project process is illustrated in **Figure 1** below.

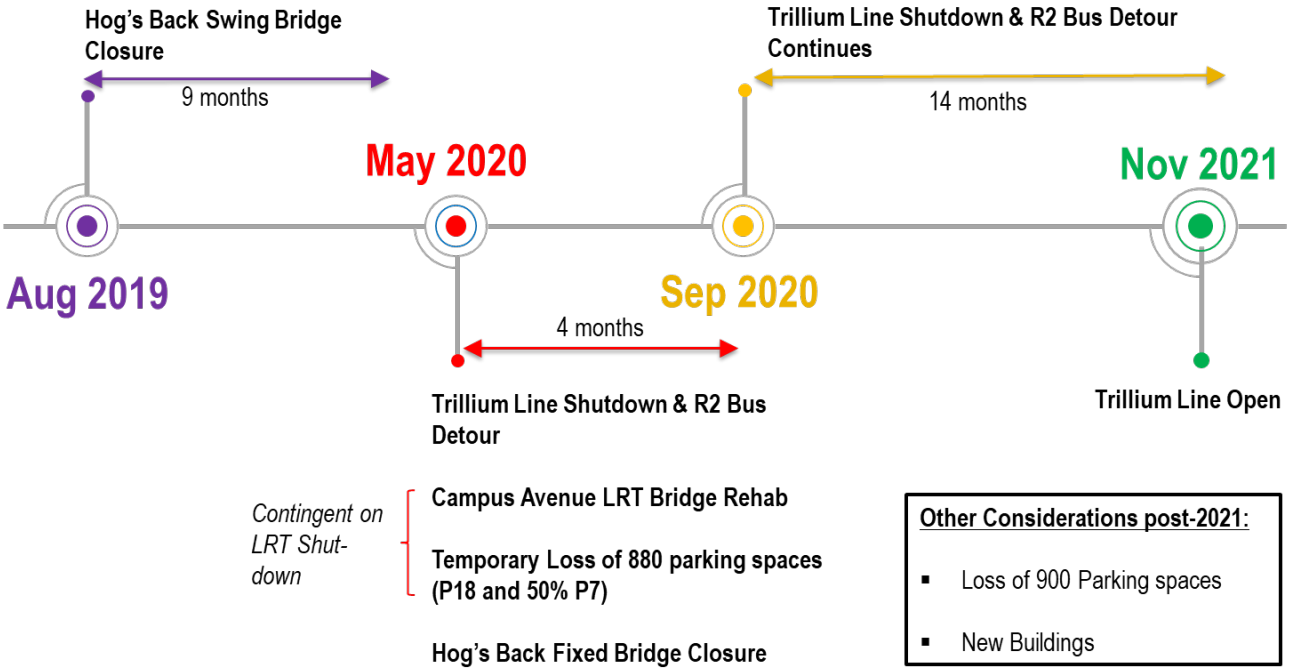
Figure 1 Study process



1.3. CHRONOLOGY OF EVENTS

In discussions with Carleton University and key stakeholders, it was revealed that a number of events will occur within the short-term horizon that will significantly affect Carleton University traffic patterns/ behaviour. An overview of the chronology of events is provided in **Figure 2** below.

Figure 2 Chronology of Events



1.4. CONSULTATION ACTIVITIES

An extensive level of consultation was adopted to ensure that the recommendations resulting from the transportation strategy are embraced and supported. At the outset of the study, a working group meeting was held with key stakeholders from the City of Ottawa, National Capital Commission (NCC), Carleton University and community representatives. The purpose of this meeting was to establish an understanding of nearby City and NCC projects, facilitate collaboration, and ensure integration with future initiatives within the study area.

Following, and more importantly, consultation with students, faculty, and staff was conducted via an on-line survey and drop-in session at the University Centre Galleria. The online survey was made available between October 24th, 2018 and November 6th, 2018 on the Carleton University Transportation Strategy project website. A total of 667 participants took part in the survey, including students, faculty and staff. This survey provided valuable insight from the campus population regarding their transportation needs and challenges as they move on, off and around campus.

The drop-in session was held on October 31st, 2018 and was attended by approximately 35-40 students, faculty and staff. Display boards introducing the study were made available and attendees were invited to complete the on-line survey and provide their input directly on multiple "Idea Boards". The following three themes/questions were presented to guide feedback:

- **Livability**: How do we need to think about transportation in relation to our built environment on campus?
- **Accessibility**: How do we ensure openness to our campus and that the experience of getting around Carleton's campus is empathetic to all users' requirements?

- **Sustainability**: How can we contribute to Carleton reducing the numbers of car journeys on our network, promote appropriate sustainable transport alternatives and reduce the university's carbon footprint?

The top 5 issues identified by the campus community are summarized follows:

1. Congestion at Campus/University Intersection
2. Poor Transit Service
3. Lack of Cycling Facilities and Amenities
4. Loss of Accessible Parking within Campus Core
5. Poor Pedestrian Crossing Safety

A project website was also maintained to introduce the project, communicate upcoming events and encourage feedback from the campus population (https://carleton.ca/fmp/transportation-strategy/).

A detailed Consultation Report presenting the results of the on-line survey and drop-in session is provided in **Appendix A,** while the external working group meeting minutes are provided in **Appendix B**."

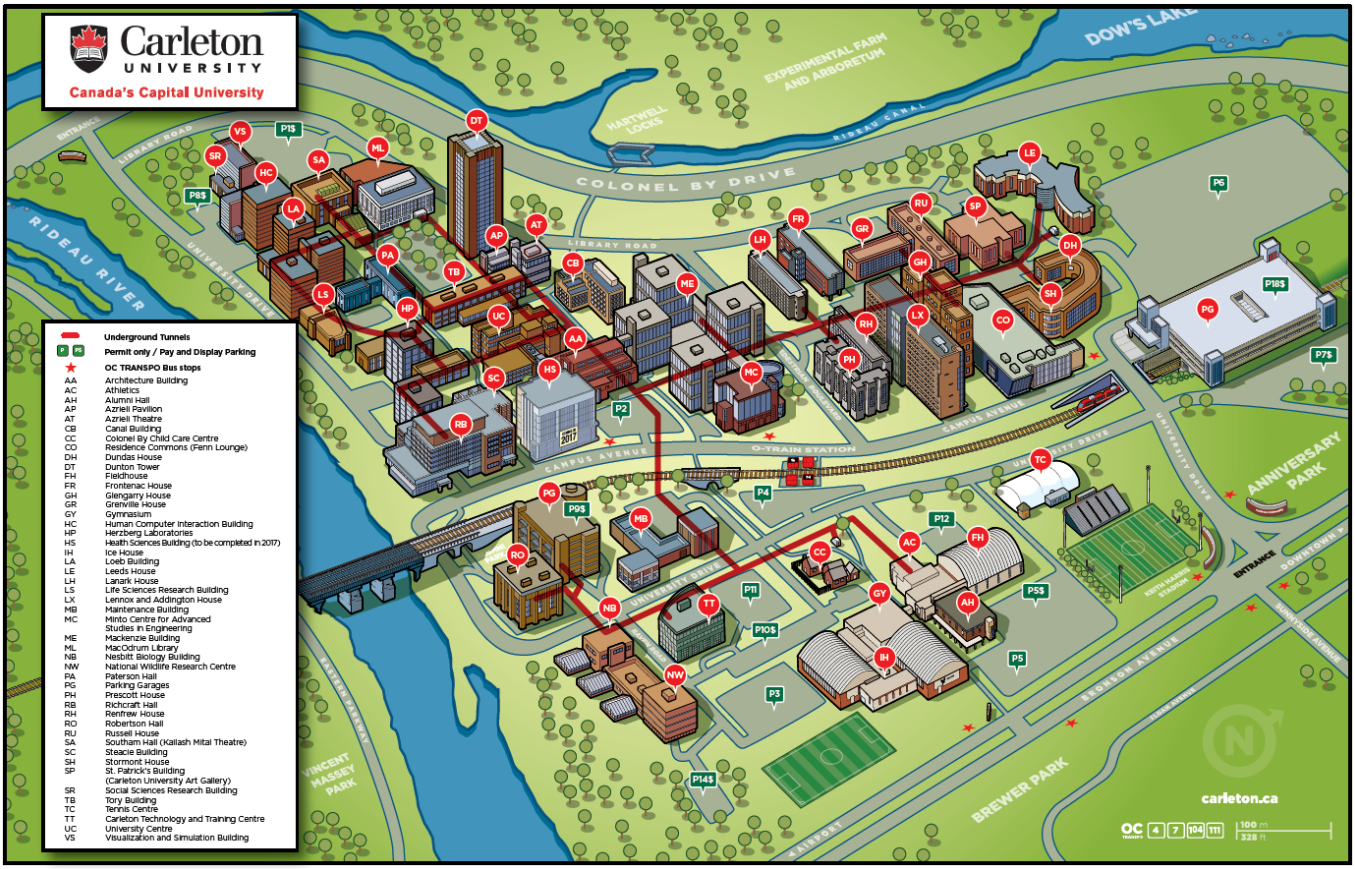
2. STUDY CONTEXT

2.1. CAMPUS OVERVIEW

Carleton University has evolved significantly in recent years. Over the past 10 years, undergraduate and graduate enrollment has grown by 18% to over 28,000 students, and continued growth is expected. There are also over 3,600 students living on campus and over 4,500 faculty and staff present on a daily basis. A brief overview of the road network, adjacent land uses, and the general campus layout is provided below.

- **External Road Network**: The campus is bordered by Bronson Ave to the east, Colonel By Dr to the north and west, and the Rideau River to the south. Access to the University is provided via two main access located at the Bronson/Sunnyside/University Dr and Colonel By Dr/University Dr intersections. Both accesses are under signalized control.
- **Adjacent Land Uses**: Land uses adjacent to the University include the Old Ottawa South Community and Brewer Park directly to the East, Dow's Lake and the Glebe Community directly to the North, the Experimental Farm to the West, and the Rideau River and Vincent Massey Park directly to the South.
- **Campus Layout**: The campus is laid out in a north-south direction with the majority of academic buildings concentrated on the south side of campus near the Colonel By/University Dr accesses, while majority of parking is provided on the north part of campus. The campus layout is illustrated in Error! Not a valid bookmark self-reference. below.

Figure 3 Carleton University Campus Layout



To accommodate future growth on campus, development plans within the 5-year horizon include the construction of several new buildings, as well as several modifications to the campus transportation network, including:

- ARISE Building – Constructed and fully occupied
- Health and Sciences Building - Constructed and currently at 50% occupancy
- Nicol Building - Under construction
- Engineering Building – Planned for Construction (assumed after 2021)
- New Field House on P12 (assumed after 2021)
- Residential Building on part of P6 – Planned for Construction (assumed after 2021)
- New Bus Only Access off Bronson at Raven Rd
- New Right-in/Right-out access off Bronson at P5
- Conversion of the Northern section of Library Road to a pedestrian promenade

2.2. 2016 CAMPUS MASTER PLAN AND GUIDING PRINCIPLES

Carleton University has established a strong commitment to creating a more sustainable campus environment and has implemented several sustainable transportation initiatives over the years.

Figure 4 Campus Master Plan

The University's latest five-year Campus Master Plan (CMP), approved by the board of directors in June 2016, embraces the following key directions:

- A stronger North Campus framework
- More developed standards for landscape
- A cohesive approach to outdoor spaces
- Built form standards that support high quality development

The CMP also identifies several core principles to promote sustainable transportation including: focusing on creating streets and walkways for people (movement); reinforcing connections to surrounding communities; and matching parking demand and supply. The CMP also included the following specific recommendations related to the transportation strategy:

- Prioritize transportation modes in the following order: pedestrians, bicycles, transit, cars, and trucks.
- Focus on creating streets and walkways for people
- Reinforce connections to surroundings
- Match Parking Demand and Supply
- Move parking to periphery of campus
- Expansion of tunnel system
- Improvements to sidewalks and pathways for accessibility
- Quad and green space in front of the University Centre that is more welcoming
- Develop cycling route
- Special services for people with disabilities

The above core principles and priorities were recognized and incorporated in this Transportation Strategy.

2.3. TRAVEL ORIGINS AND MODES OF TRAVEL

Origins and Destinations

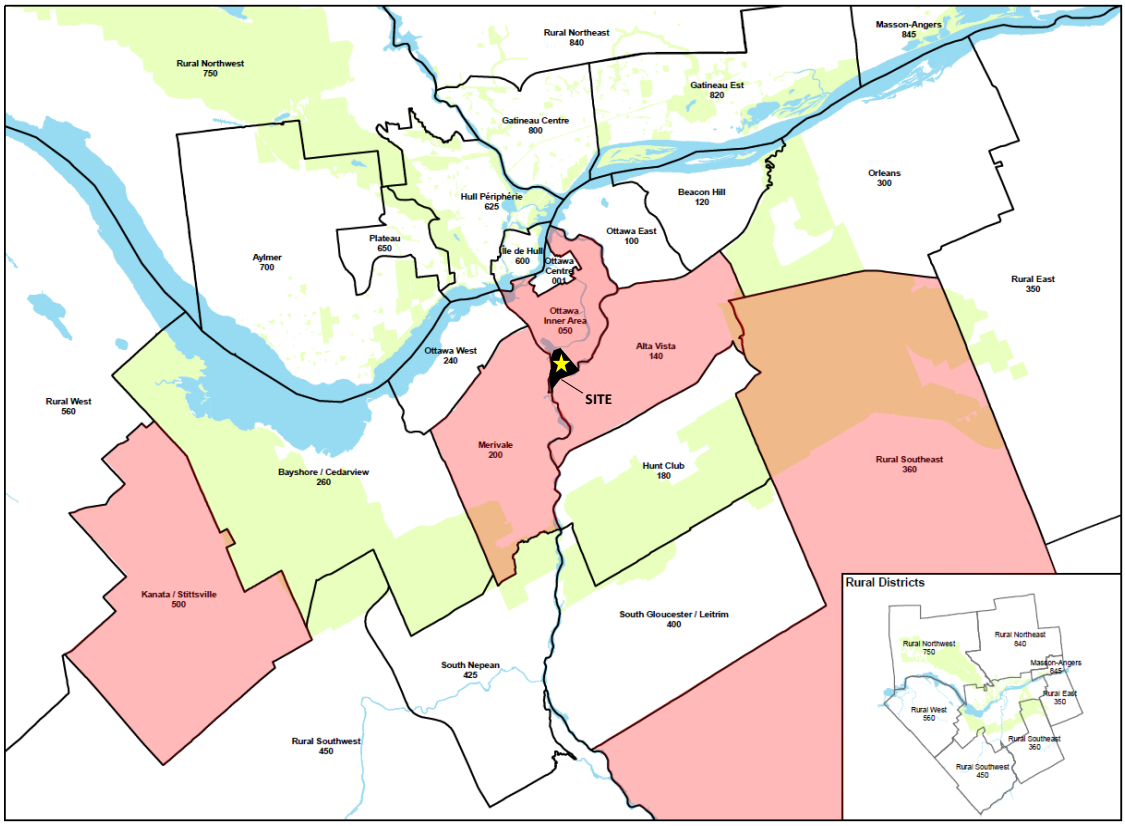
Through the TRANS Committee, the National Capital Region (NCR) Household Origin-Destination (OD) Survey was most recently updated in 2011. It provides a detailed assessment of the trip patterns and travel choices in the National Capital Region. Staff at the City of Ottawa extracted the following information specific to Carleton University during the commuter morning peak:

- Although there are many contributing districts for travel to/from the Campus, the biggest are the Ottawa Inner Area, Alta Vista, Merivale, and Kanata/Stittsville (see Error! Not a valid bookmark self-reference.).

- The OD data suggest that approximately 75% of vehicle trips most likely use the north access at Bronson Ave compared to the 25% that are likely to use the south access at Colonel By Dr.

- According to the OD survey, approximately 50% of trips are made to/from districts that require drivers to use Bronson Ave as their main route. Trips will either remain on Bronson Ave to reach the Ottawa Inner Area district or use Highway 417 to travel east (e.g. Ottawa East, Orleans) or west (e.g. Ottawa West, Kanata/Stittsville). The remaining 25% will use either Sunnyside Avenue, Riverside Drive, or Airport Parkway to head either east (e.g. Alta Vista) or south (e.g. Hunt Club, Rural Southeast).

Figure 5 2011 TRANS Districts



Travel Mode Share

The City of Ottawa conducted a Special Generators Survey in the 2013/2014 school year regarding travel mode share at colleges and universities in the National Capital Region (**Table 1**). Overall, the results indicate that the University is doing well on the transit front, but may benefit from improvements to facilitate reduced reliance on vehicles.

Table 1 Mode Share Comparison

INSTITUTION	STUDENT POPULATION	MODE SPLIT				
		TRANSIT	CARS DRIVER	CAR PASSENGER	CYCLE	WALK
Algonquin College	20,000	51%	32%	5%	0%	12%
University of Ottawa	40,000	56%	17%	5%	2%	19%
Carleton University	**28,000**	**61%**	**22%**	**7%**	**2%**	**8%**
La Cité collégiale	5,000	35%	46%	7%	2%	9%
Université du Québec en Outaouais	6,000	29%	54%	9%	0%	9%
Cégep de l'Outaouais	5,000	34%	43%	13%	1%	8%
Average	17,000	53%	26%	6%	1%	13%
NCR General Population (2011)	3,110,200	13%	55%	15%	2%	10%

The Special Generators Survey revealed the following:

- Carleton University has the highest transit mode share of all colleges and universities within the National Capital Region (61% transit mode share) and this is expected to increase with implementation of the City's Light Rail Transit (LRT). This stresses the importance of providing strong pedestrian and cycling connections between all buildings and transit stops and maximizing the efficiency of internal transit circulation.
- Approximately 29% of students arrive to campus by car, compared to 22% of students that arrive by car at the University of Ottawa. This indicates that there is some potential to reduce reliance on private vehicles and highlights the importance of making alternative travel modes more attractive options through transportation demand management strategies and improvements to active travel facilities.
- Approximately 13% of students live on campus, which is about double the percentage of students living on campus at the University of Ottawa and Algonquin College. Thus, improvements to both tunnel and surface connections between the residences and the remainder of the campus are considered critical.
- Although the travel mode share for cycling is only 2%, approximately 50% of all students have access to a bike, which drops to 18% for students living on campus. This highlights the need to promote cycling as a viable mode of transportation through improvements such as new cycling facilities and end-of-trip facilities (e.g. storage), particularly for students living on campus.

Considering the on-line survey results, the travel mode share for respondents was skewed more heavily towards personal vehicles when compared to the Special Generation Survey, with a car mode share of approximately 50% (versus 30%), and a transit mode share of only 30% (versus 60%). On the other hand, the mode share for pedestrians and cyclists was approximately 15%, which is higher than the 10% mode share identified in the Special Generators Survey.

It is noteworthy that the Ottawa Cycling Plan indicates that over two thirds of all cycling trips in the City are 4.0 kilometres or less in distance, and that over 90% of all cycling trips are within 8.0 kilometres distance. Interestingly, the results from the on-line survey showed that approximately 60% of on-line survey respondents live within this buffer area, which indicates a high potential to transfer vehicle trips to cycling trips.

With regards to future mode share after Stage 2 LRT is operational, the City's 2011 Transportation Demand Forecasting Model indicates that the Carleton University node has a transit mode share of 69% and an auto mode share of 31%. Once LRT service is expanded in 2023, the public transit mode share is expected to become even more dominant and reach 80% (i.e. 16% increase in transit riders) and the auto mode share (both drivers and passengers) is expected to drop to 20% (i.e. 20% drop in auto mode share). Further details regarding projected mode share shifts after Stage 2 LRT is operational are included in **Appendix E**.

3. ACTIVE TRAVEL

3.1. EXISTING CONDITIONS

3.1.1. PEDESTRIAN AND CYCLING VOLUMES

The existing pedestrian and cycling volumes are illustrate in **Figure 6** and **Figure 7** below.

Figure 6 Existing AM & PM Peak Hour Pedestrian Volumes

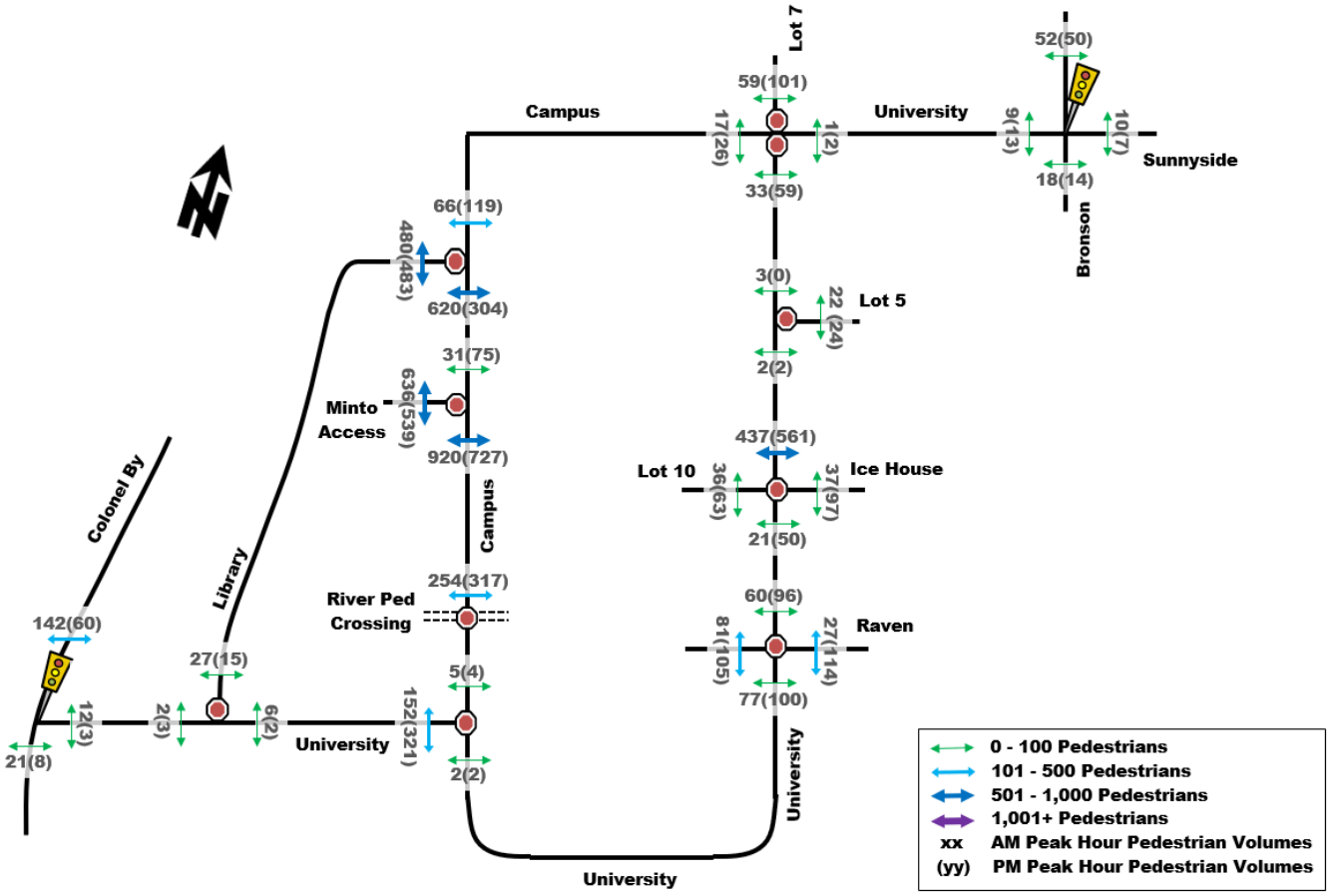
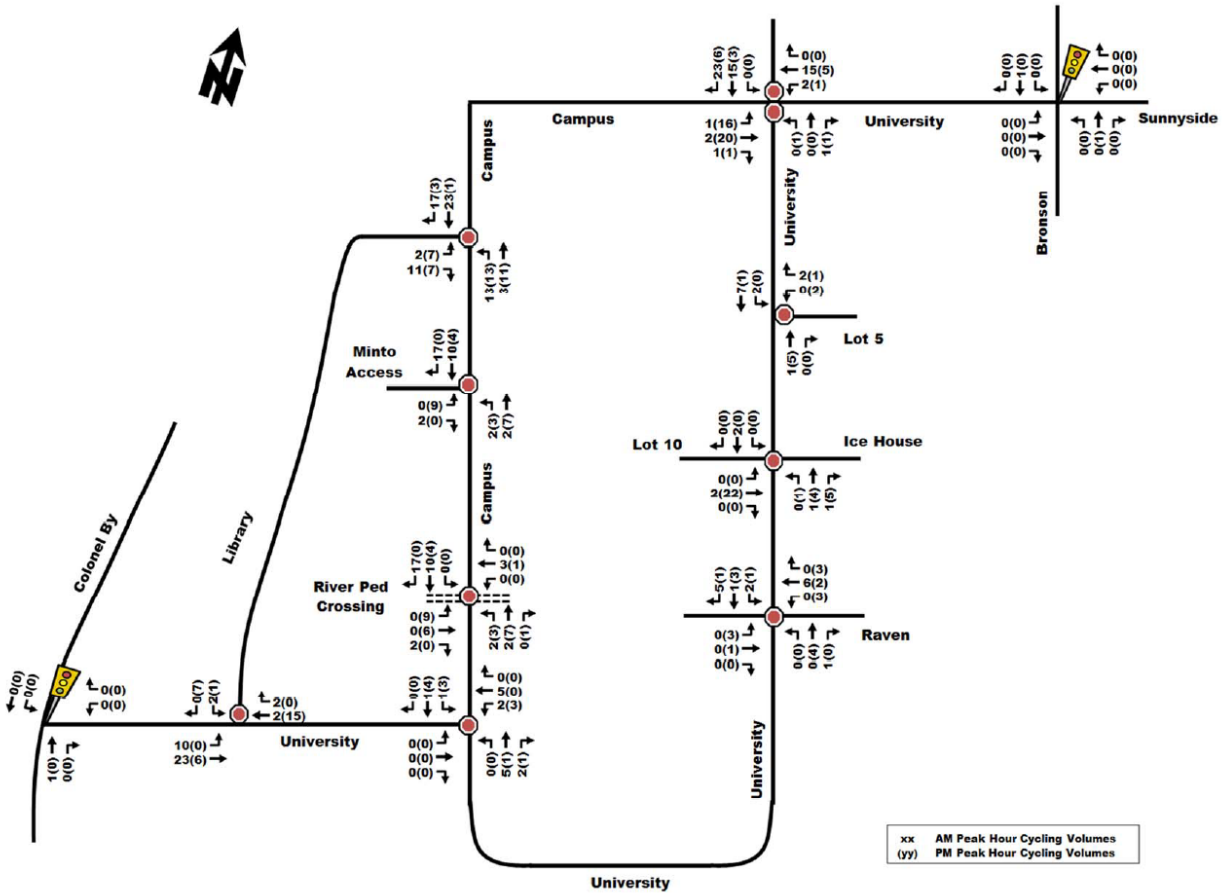


Figure 7 Existing AM & PM Peak Hour Cycling Volumes



3.1.2. PEDESTRIAN FACILITIES

The current pedestrian network is comprised of numerous sidewalks, mixed-use pathways and pedestrian paths of varying widths, materials and stages of maintenance. Based on the pedestrian counts undertaken (**Figure 6**), the following five locations were identified as having the highest number of pedestrians crossing roadways, thus creating the highest potential for conflicts between pedestrians and vehicles:

Figure 8 Multi-Use Pathway Facility

1. Campus Ave crossing at Library Road (~620 pedestrians in AM; ~300 in PM)
2. Campus Ave crossing just south of Minto C.A.S.E. Building (~920 pedestrians in AM; ~730 in PM)
3. Campus Ave crossing in front of Richcraft Building (~250 pedestrians in AM; ~300 in PM)
4. Library Road crossing 90m west of intersection with Campus Ave (~480 pedestrians in AM; ~480 in PM)
5. Minto C.A.S.E. Building access crossing off Campus Ave (~640 pedestrian in AM; ~540 in PM)

In addition, there are three main points for pedestrians to cross the LRT tracks as follows:

1. The Campus Ave N bridge at the north of campus (directly south of Lot P18);
2. A pedestrian O-Train underpass near the Minto C.A.S.E Building to the west and Lot P4 to the east (approximately 80m south of the LRT Station); and

3. The pedestrian O-Train underpass near the Richcraft Hall to the west and Roberson Hall to the east.

A common theme throughout the consultation process was that the "University is very car focused and not pedestrian friendly." This is evident in the online questionnaire where nearly 20% of online respondents disagreed or strongly disagreed with the statement "I feel comfortable and safe from traffic" while over 30% were neutral on this statement. These concerns generally stemmed from perceived poor or unsafe intersection/ mid-block crossings, particularly in front of the LRT station, and a lack of pedestrian connectivity to key nodes and facilities on campus, such as the LRT platforms.

3.1.3. CYCLING FACILITIES

Figure 9 Campus Bike Racks

Cycling is an important means of transportation for many in the university community. Overflowing bicycle racks speak to the popularity of this convenient and inexpensive means of travel. However, although cycling is currently a reasonable means of travel to/from the campus, there is currently no designated bicycle network within the campus.

Based on the cycling counts undertaken (**Figure 7**), the following intersections / road segments were identified as having the highest number of cyclists:

1. Campus Ave LRT Bridge (from Bronson and north Multi-Use Pathway)
2. Campus Ave between University Dr and Minto Access
3. Northern section of Library Road
4. University Dr between Campus Ave N and Ice House

In addition, there is a heavily used off-road multi-use pathway running east-west between University Dr and Brewer Park. This multi-use pathway provides connectivity to the Bronson Ave bike lanes and Sunnyside Avenue suggested cycling route. The on-line survey indicated a high level of pedestrian and cyclist conflict within this multi-use pathway due to the narrow corridor, particularly at LRT underpass.

Another heavily used off-road multi-use pathway is located at the north end of campus and connects the Campus /University intersection to Bronson Ave, just south of the Bronson Ave/Colonel By ramp. The online survey indicated that cyclists experience a high level of difficulty while traversing the Campus/University intersection.

In terms of cycling amenities, the consultation feedback identified the lack of sufficient bike storage facilities, including the lack of secure indoor storage, as a key challenge to cycling to/from campus.

It should be noted that the Campus Master Plan includes the recommendation of providing primary cycling routes on Campus Ave and University Dr. In addition, the City of Ottawa Cycling Plan identifies Campus Ave, Library Road and most of University Dr as suggested cycling routes within campus.

3.1.4. FUTURE LRT CONNECTIVITY

The Stage 2 LRT Connectivity Study identifies the following potential active travel initiatives within the vicinity of the Carleton LRT station:

1. A new pathway on west side of the LRT connecting Carleton Station to Heron Road, including a Pedestrian/Cycling bridge over the Rideau River
2. Widening of underpass near the LRT station from 3.0m to 9.0m (conflict point between pedestrians and cyclists). Underpass to be accessible with ramps.

3. 20 bike racks at LRT station

At the time of writing this report, the above measures have not yet been approved by Council.

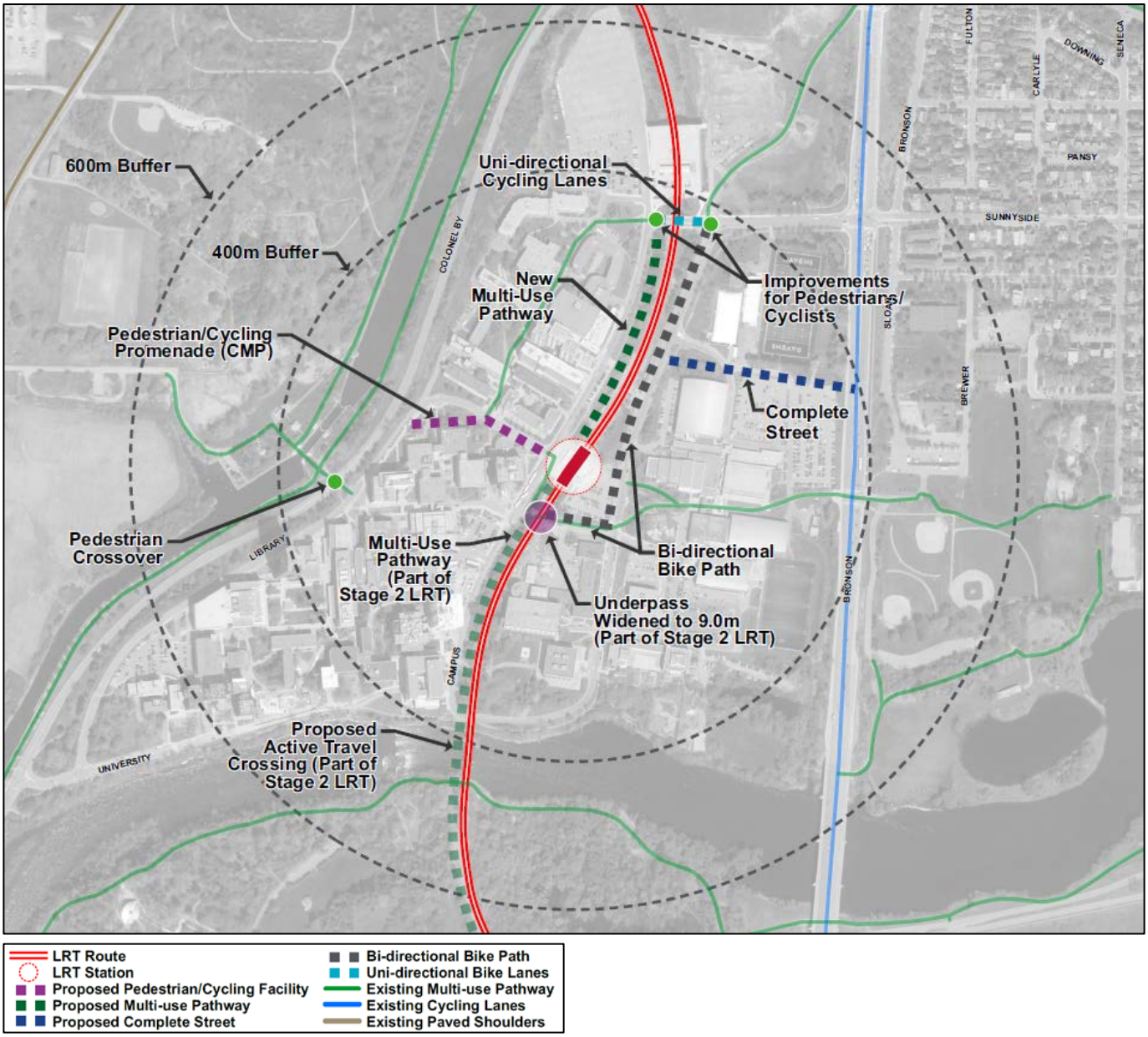
3.2. SHORT TERM (0 TO 5 YEAR) RECOMMENDATIONS

Based on direction from the Campus Master Plan, University project team, and consultation feedback, the following key directions were identified:

- Provide dedicated cycling facilities
- Improve pedestrian crossings, particularly in front of LRT station
- Connect to surrounding active travel facilities
- Address accessibility standards (AODA and COADS)

A summary of the short-term pedestrian and cycling recommendations is presented in the sections below. The key pedestrian and cycling infrastructure recommendations are illustrated in **Figure 10.**

Figure 10 Recommended Short-Term Pedestrian and Cycling Plan



3.2.1. NORTH-SOUTH MULTI-USE PATHWAY EAST OF CAMPUS AVE

It is recommended that the potential Multi-Use Pathway (MUP) between the Rideau River crossing and Carleton LRT Station (to be constructed as part of Stage 2 LRT) be extended further north to the Campus Ave O-Train Bridge. This improvement will provide a cycling connection to/from the north end of Campus, the Bronson Spine Route and the northern Multi-Use Pathway. A conceptual plan illustrating this measure is provided in **Figure 37**.

3.2.2. DEDICATED CYCLING FACILITIES CAMPUS AVE NORTH

It is recommended that dedicated uni-directional bike lanes be provided along the section of Campus Ave between Campus Ave and University Dr (including the LRT Bridge). This can be accommodated within the current bridge width without need for any bridge widening. A conceptual plan illustrating this measure is provided in **Figure 37**.

3.2.3. DEDICATED CYCLING FACILITIES ALONG UNIVERSITY DR

It is recommended that bi-directional bike lanes be provided along the west side of University Dr, between Campus Ave and the pathway connecting to the LRT underpass. The dedicated bi-directional cycling lanes could potentially be implemented in conjunction with modifications at the Campus/University within reclaimed space. Although this improvement can generally be provided within the available curb-to-curb space, this measure will result in the loss of 19 parking spaces along the northern section of University Dr. A conceptual plan illustrating this measure is provided in **Figure 37**.

3.2.4. CROSSWALK AND SIGNAGE IMPROVEMENTS

In general, the site inventory revealed inconsistent signage and treatments at pedestrian crossing locations. In April 2015, AECOM completed a Campus Traffic Study for the University. Part of the study included an evaluation of existing pedestrian crosswalk locations within campus according to the Ontario Traffic Manual (OTM) Book 15 – Pedestrian Crossing Treatment standards, which specify appropriate pedestrian crossover (PXO) treatments. Site surveys indicate that current PXO pavement markings and signage remain non-compliant with OTM standards.

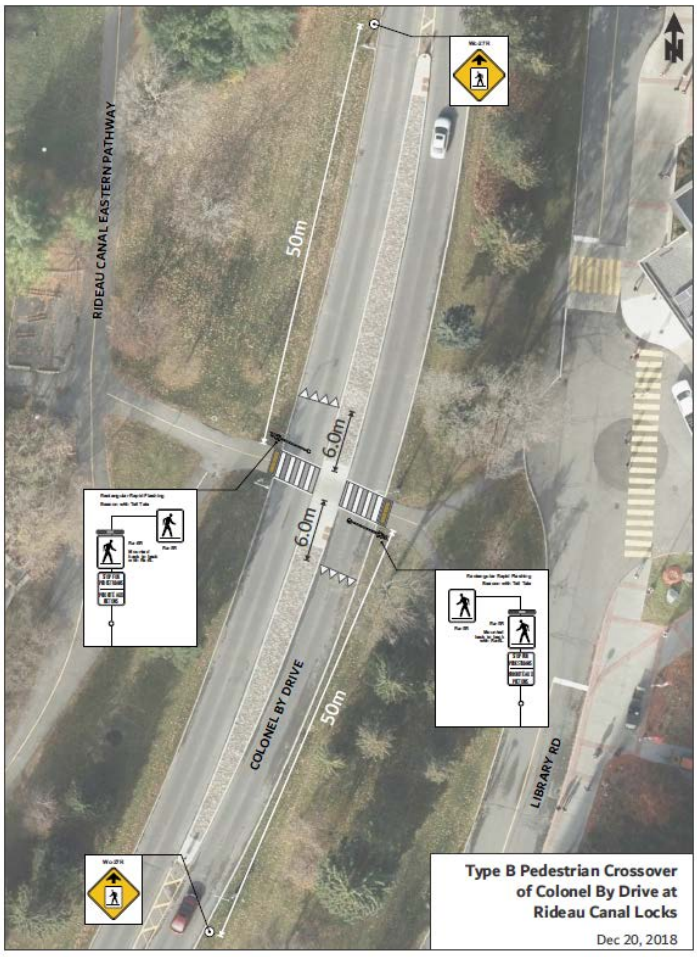
The implementation of the pedestrian crossover evaluation results recommended in **Section 4.6** of the AECOM Study is recommended. These modifications are relatively low-cost changes and it is recommended that they be implemented to help improve pedestrian crossing safety and signage consistency.

3.2.5. COLONEL BY PEDESTRIAN CROSSOVER AT HARTWELL LOCKS

The Hartwell crossing is a popular way for students at Carleton to get to the canal. The NCC implemented a pedestrian refuge at the crossing location in 2013, however the Multi-Use pathway crossing of Colonel By Dr at the Rideau Canal Hartwell Locks is an uncontrolled crossing where pedestrians and cyclists cross without the aid of traffic control measures and a dedicated right of way. Drivers are not required to yield the right-of-way. At this location, pedestrians and cyclists need to wait for safe gaps in traffic before attempting to cross on the roadway. At an uncontrolled location, the pedestrians and cyclists must not enter the roadway if vehicles are not able to stop and drivers must make every effort to avoid a collision.

Parsons completed a high-level review of the subject crossing, including completion of a Pedestrian Crossover (PXO) warrant, to determine if the current conditions warrant improvements to a controlled crossing. The details of this review are provided in **Appendix C**. PXOs are typically implemented to provide pedestrians with added protection, as drivers are required to yield the right of-way to pedestrians. Based on the PXO warrant, a Type B PXO, which includes pavement markings, signage and flashing lights, was found to be warranted. A conceptual design of the proposed Hartwell PXO is provided in **Figure 11** and **Appendix C**.

Figure 11 Hartwell/ Colonel By PXO Design



3.2.6. CONNECTIONS TO LRT STATION AND BUS STOPS

The spine of any active transportation plan is providing safe and accessible connections between major active mode facilities, i.e. pedestrian/cycling/transit. The recommendations up to this point were designed to help augment pedestrian/cycling connectivity and safety on campus. How these connections integrate with existing and future transit facilities is integral to prevent bottlenecks and user dissatisfaction in the overall active transportation system, which is crucial to reducing auto usage on campus long-term.

The following recommendations are designed to improve connections to and from major transit facilities on campus:

- Provide raised crosswalk in front of LRT west platform (as described in **Section 5.0**)
- Improve pedestrian/cycling connection from the east side of the LRT station through Parking Lot P4 to the pedestrian underpass via the implementation of widened sidewalks and landscaping (as described in **Section 6.0**).
- Improve pedestrian/cycling connectivity between the Physical Recreational Centre transit stop on University Dr to the O-Train pedestrian underpass (as described in **Section 6.0**). It is recommended that this connection include a separated bi-directional cycling lane.

3.2.7. RE-PURPOSE LIBRARY ROAD FOR PEDESTRIANS/CYCLISTS

Library Road is currently a local campus road for general traffic between Campus Ave and University Dr S. This road bisects the west side of campus with residence facilities to the north and academic facilities to the south and currently serves a high volume of pedestrians coming to/from residences. In addition, the LRT Station is located just across from the Library Road and Campus Ave intersection, which combined, forms a multi-modal hub. As a result, this is a heavily travelled road for pedestrians and cyclists. It is recommended that the section of Library Road, be re-purposed to serve pedestrians and cyclists, and prohibit general vehicle travel. Emergency vehicles and cyclists would still be able to pass through.

The reclaimed roadway space can be fully utilized to enhance the pedestrian and cyclist realm near the Campus Ave multi-modal hub. It is recommended that any treatments for this section provide proper separation and designation of pedestrian and cycling facilities to reduce potential conflicts.

In terms of implementation timeline, it is recommended that this measure be implemented after re-opening of the O-Train in late 2021 / early 2022, and when construction of the engineering building extension is complete.

3.2.8. COLLABORATION WITH STAGE 2 LRT OFFICE

It is recommended that the University ensure O-Train pedestrian underpass is widened from 3.0 m to 9.0 m as part of Stage 2 LRT. It is recommended that the design of the future underpass properly designates pedestrian and cycling facilities to ensure separation between them and prevent pedestrian/cyclist conflicts.

It is also recommended that the University provide input into the design of the Multi-Use Pathway (MUP) proposed on the west side of the LRT tracks from the potential pedestrian/cycling river crossing northwards to the LRT station. Ideally, the design of the pathway provide separation between pedestrians and cyclists to help reduce the risk of pedestrian/cycling conflicts, which is a common concern cited during the consultation process.

3.2.9. CYCLING AMENITIES

An important consideration in promoting cycling is the provision of end-of-use facilities, including sheltered bicycle racks, secure bicycle lockers and shower facilities. The University has approximately 2,000 bicycle racks on campus. However, the actual capacity is influenced by many factors including the physical location of the rack, placement of bicycles and the perceived availability of space.

In addition, the University has 100 fully monitored indoor secure bicycle storage spaces in the Athletics buildings and 60 fully monitored indoor bicycle storage spaces in the Residence Commons. In addition, there are shower facilities that can be used by cyclists in the Athletics Building.

In terms of the adequacy of the number of bicycle racks provided on campus, the total existing student, faculty and staff population is 32,500 and an approximate cycling mode share of 5%. This would require a total of 1,625 bicycle racks which is well below the number provided. Within the next 5-year horizon, assuming a 10% growth in the campus population would translate into 1,790 bicycle racks required, which is still below the current number of bike racks provided. The provided number of bicycle racks also exceeds the City of Ottawa's Zoning By-Law Section 111 requirements for bicycle parking.

Although there is no identified shortage in overall campus bicycle parking supply, the results of the on-line survey and site observations clearly indicate a limited available bicycle parking within the campus core. This is not unreasonable as the demand for bike parking will vary based on location, with bicycle racks further away from the campus core having lower demand.

In addition, a key area of improvement identified through the consultation process is the provision of indoor / sheltered bicycle racks and secure bicycle lockers, as concern for bicycle theft is a considerable deterrent to many cyclists. Many universities and colleges have made upgrading end-of-use cycling facilities a priority. In Camosun College (Victoria, BC) and Dalhousie University (Halifax, NS), 20% of the bicycle racks are either sheltered or secured. In a recent transportation survey, Humber College in Toronto discovered that the biggest barrier students had for cycling to campus was the lack of secure bicycle storage facilities.

Based on the above, the following upgrades in cycling amenities are recommended.

- **Secure indoor bike storage with surveillance cameras –** It is recommended that **250** additional indoor parking spaces be provided within the campus core, and that permit prices be increased from the current annual fee of $10 to $15 per term or $45 per year.

  Indoor bike storage areas would also include access to basic maintenance and air pump tools at the parking stations, as well as vending machines for other small accessories. It is recommended that the 250 additional indoor permit bike spaces be allocated as follows:

  - River Building Parking Garage **– 100 spaces**
  - Library Building or Dunton Tower**– 75 spaces**
  - Dunton Tower **– 75 spaces**

- **Increase outdoor bike parking spaces** – Site observations and results of the on-line survey indicate that bicycle parking is in short supply within the campus core and should be expanded in high demand areas. It is recommended that **100** additional outdoor bike parking spaces be provided and distributed among the following key buildings:

  - River / Steacie Buildings**– 50 spaces**
  - Dunton Tower**– 50 spaces**

  Placement and type of bike racks should consider optimal efficiency of bike space usage.

  Figure 12 Covered Bike Storage

  In addition, usage of both indoor and outdoor bike racks should be monitored on an annual basis to identify additional future areas of need.

- **Shower facilities** – Incorporate new shower facilities in all new campus buildings.
- **Marketing of Current Bike Services:**

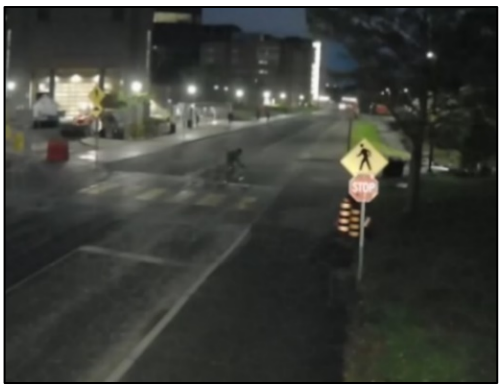
- Bike Hub – Although a Bike Hub currently exists on campus, the on-line survey indicates that this service might not be well advertised, as many respondents indicated the need for such a service. Thus, more marketing of the bike hub is recommended.

- Bike sharing (Right Bike Share) - More marketing of the current bicycle sharing on campus in collaboration with City TDM staff.

3.2.10. LIGHTING

A site visit was undertaken during evening hours to observe night time lighting conditions on campus. Poor lighting conditions were identified at all pedestrian crossing locations across campus, an example is shown in **Figure 13**. Therefore, it is recommended than an illumination study be completed and lighting on campus be upgraded to meet City of Ottawa's Right-of-Way Lighting Policy and the Crime Prevention through Environmental Design Principles.

Figure 13 Cyclist Crossing PXO in Poor Lighting



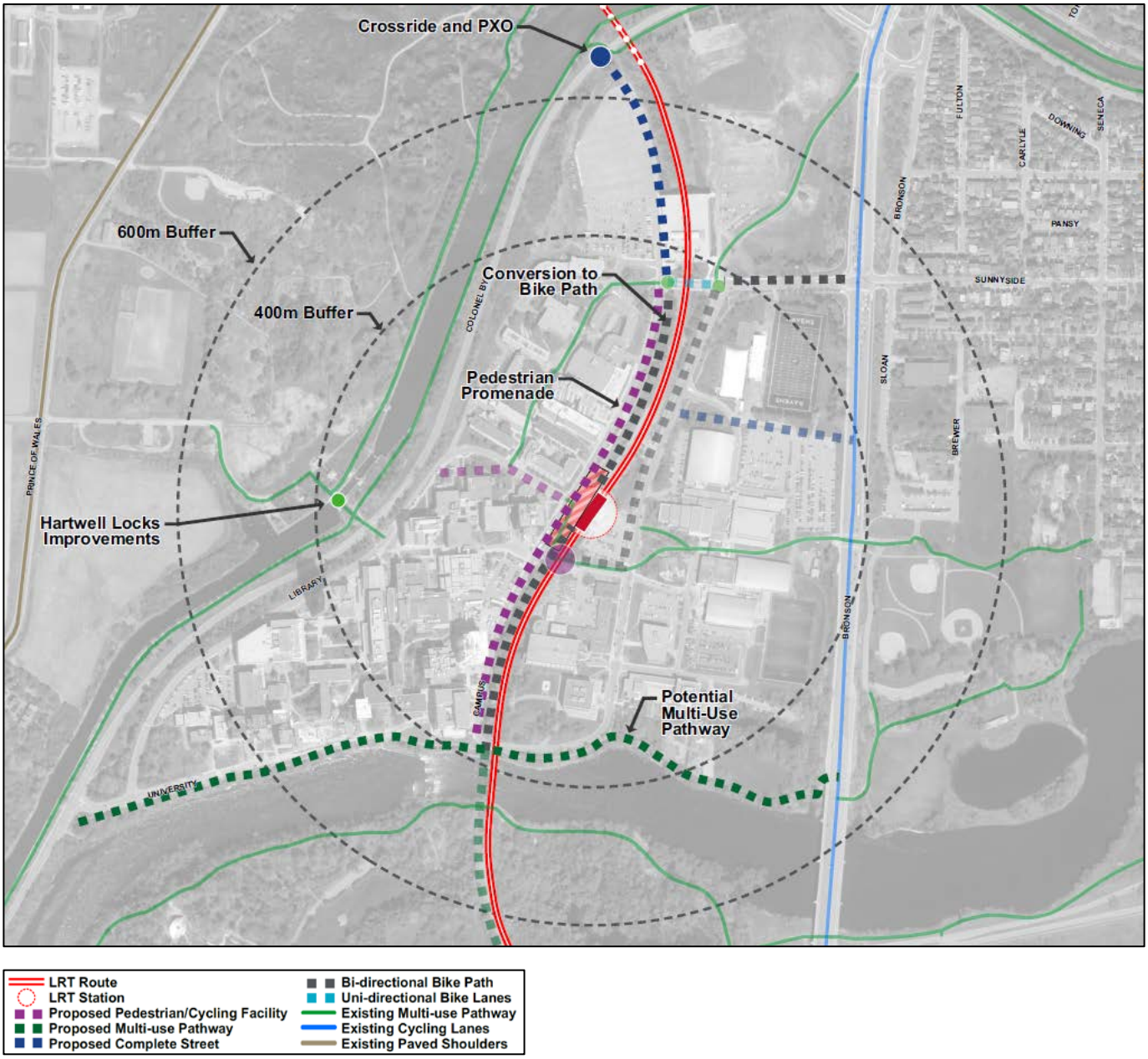
3.3. LONG TERM (5+ YEAR) RECOMMENDATIONS

Based on direction from the Campus Master Plan, University project team, and consultation feedback, the following key directions were identified:

- Provide dedicated cycling facilities
- Improve pedestrian crossings, particularly in front of LRT station
- Connect to surrounding active travel facilities
- Address accessibility standards (AODA and COADS)

A summary of the long-term pedestrian and cycling recommendations is presented in the sections below. The key pedestrian and cycling infrastructure recommendations are illustrated in **Figure 14.**

Figure 14 Recommended Long-Term Pedestrian and Cycling Plan



3.3.1. PEDESTRIAN TUNNEL EXTENSIONS

The Campus Master Plan identifies recommended locations for improved connectivity of the tunnel system, including improved connections from the Robertson Building to the River Building and northwards to the parking facilities and future residential buildings. Accessibility requirements for future pedestrian tunnel extensions are provided in **Appendix D**.

It is recommended that the following tunnel projects be constructed as a priority:

- Tunnel connection from Residences to P18 as part of P18 construction
- Tunnel connection to the LRT station
- Tunnel connection to the potential bus transit hub

3.3.2. HARTWELL LOCKS IMPROVEMENTS

The NCC Capital Pathways Strategic Plan, which is currently underway, identifies the following vision for NCC parkways:

- Low volume
- Don't pose barrier to canal
- More pedestrian and cyclist friendly

As part of the consultation process for the NCC Capital Pathways Strategic Plan, the City of Ottawa has highlighted several areas with need for improvement, including the Hartwell Locks crossing.

Figure 15 Hartwell Locks

3.3.3. CAMPUS AVE PEDESTRIAN/CYCLING PROMENADE

Campus Ave is a heavily travelled road for pedestrians and cyclists, particularly pedestrians travelling to/from the LRT Station. It is recommended that Campus Ave be re-purposed to a pedestrian/cycling promenade that is limited to use by pedestrians, bicycles, and shuttle/service/emergency vehicles only. This would result in a strong pedestrian/cycling focus within the campus and meet the Campus Master Plan key principle of prioritizing pedestrians and cyclists. This is considered a long-term 10+ year horizon recommendation and would ideally be implemented after construction of the northern access to Colonel By Dr.

3.3.4. CROSSRIDES AT CAMPUS ACCESSES

Figure 16 Existing Crossride at Bronson Ave and Colonel By Dr Offramp intersection

Crossrides at intersections with crosswalks allow cyclists to continue through the intersection without being not required to dismount their bicycles when using the crosswalks. A crossride can be a separate facility beside the crosswalk, or can be integrated into the crosswalk itself. An added benefit is that bicycle signals are not required at crossride facilities. An example of a crossride facility located on Bronson Ave, further north of University Dr is illustrated in the **Figure 16** below.

With a renewed focus on cycling, the City of Ottawa is considering the implementation of crossride facilities throughout the City. The two site accesses at Bronson/Sunnyside/University Dr and Colonel By/ University Dr intersections are potential locations for crossrides, particularly since Bronson Ave has dedicated cycling lanes on both sides of the road and the Colonel By/ University Dr provides acceses to the NCC pathway. Crossrides at these two intersections would provide students, faculty and staff with safer and more convenient cycling crossings at the campus accesses and further encourage bicycle use to and from campus. The University may wish to work with the City and the NCC to integrate the installation of crossrides at these intersections.

3.3.5. EAST-WEST MULTI-USE PATHWAY NORTH OF RIVER

The East-West pathway north of the Rideau River is currently included in the City of Ottawa Ultimate Cycling Master Plan. Based on discussions with City staff, there is a desire to advance the construction of the pathway as part of the new pedestrian/cycling bridge over the Rideau River, however this is currently no budget allocated for this improvement. It is recommended that the University work with the City to reach an agreement to advance the implementation of the pathway.

Existing field observations noted worn pathways along the future route between University Dr and Bronson Ave. The proposed pathway would formalize this route, providing a direct link to the City cycling network between Colonel By Dr and Bronson Ave without having to navigate through campus or cross Bronson Ave. This serves to benefit any cyclist currently

travelling north on Colonel By Dr and seeking to cross campus to continue east, in addition to providing an alternative to crossing at Brewer park and enhancing connections to the surrounding communities. Although this is identified as a long-term recommendation, the University may wish to initiate contact with the City to discuss potential cost-sharing opportunities and potential advancement as part of the proposed Rideau River pedestrian/cycling crossing.

4. ACCESSIBILITY

The Accessibility for Ontarians with Disabilities Act (AODA) requires obligated organizations to comply with a number of accessibility standards. These are specified in O. Reg. 191/11, which can be viewed online at the following URL: https://www.ontario.ca/laws/regulation/110191

The standards that are applicable to outdoor public spaces are contained in *Part IV.1 Design of Public Spaces Standards (Accessibility Standards for The Built Environment)*. These include the standards that apply to transportation facilities such as roads and sidewalks, and as such are relevant to the Master Transportation Plan.

A high-level desktop review of the Carleton University exterior environment was completed to highlight some of the existing non-AODA compliant facilities and to provide recommendations on the timing for addressing these non-compliances. The details of this review are further described below. The review was completed using the City of Ottawa's 1:2000 mapping, aerial mapping and Google Street View and focused on the facilities on or adjacent to the main corridors (University Dr, Campus Ave and Library Avenue). The campus minor networks were not included in this review.

4.1. EXTERIOR PATHS OF TRAVEL

The following table identifies specific non-compliances associated with curb ramps and sidewalks/pathways slopes.

Table 2 Exterior Paths Non-Compliance

ELEMENT	LOCATION	NON-COMPLIANCE	RECOMMENDATIONS
Curb ramp	NW corner of Intersection of University Dr and Campus Ave	There is a trip hazard created by the full height curb continuing midway into the crosswalk. Accessible curb ramp should be provided.	Non-compliance could be addressed with intersection reconstruction.
Curb ramp	SW and SE corner of Intersection of Campus Ave and Campus Ave	There is a trip hazard created by the full height curb at crosswalk preventing someone in a wheelchair from accessing the sidewalk.	**Curb ramp non-compliance should be addressed proactively given safety concern for wheel chairs being trapped in live traffic**
Pathway slope	University Dr east of parking P4 - Tunnel entrance	Pathway slope exceeds the 5% maximum.	**Non-compliance should be addressed proactively given that this is the only exterior tunnel entrance in the vicinity.**
Pathway slope	University Dr at Robertson Hall	Pathway slope at intersection with Raven Rd exceeds the 5% maximum.	Non-compliance could be addressed when other improvements are completed in the vicinity given other accessible routes to Robertson Hall are currently available.

4.2. RAMPS

Ramp elements associated with buildings have not been reviewed given the limited information available from street or aerial imaging. Further investigation such as a site review is recommended to physically confirm that the requirements are met.

4.3. STAIRS

The following table identifies specific non-compliances associated with stairs within accessible routes. It should be noted that limited information was obtained as part of our desktop review. Further investigation such as a site review is recommended to physically confirm that other requirements are met.

Table 3 Stairs Non-Compliance

ELEMENT	LOCATION	NON-COMPLIANCE	RECOMMENDATIONS
Stairs	University Dr - Carleton Technology and Training Centre	There are no TWSI at the top of the flight of stairs There are no high tonal contrast markings along the full width of the leading edge of every step	Non-compliance could be addressed when other improvements are required to the stairs or surrounding area
	University Dr - Robertson Hall		
	University Dr - Herzberg Laboratories		
	University Dr - Loeb Building		
	Campus Ave - Minto Case		
	Campus Ave - MUP O-Train Underpass		
	Library Road - Azrieli Theatre		
	Library Road - Azrieli Pavilion		
	Library Road - Dunton Tower		

4.4. TACTILE WALKING SURFACE INDICATORS (TWSIS)

The following table identifies typical and specific non-compliances associated with tactile walking surface indicators (TWSI) that are not present throughout the campus.

Table 4 TWSIs Non-Compliance

ELEMENT	LOCATION	NON-COMPLIANCE	RECOMMENDATIONS
TWSI at signalized and unsignalized Intersections (Road – Road)	Typical throughout campus	There are no TWSI at the base of the curb ramps on all quadrants of the intersection	Non-compliance could be addressed over time as facilities are being upgraded.
TWSI at intersections (Road – Entrance)	Typical Throughout campus	There are no TWSI at the base of the curb ramps of parking lot entrance crossing and commercial entrance	Non-compliance could be addressed over time as facilities are being upgraded.
TWSI at Pedestrian Cross-Overs (PXO)	Typical Throughout campus	There are no TWSI behind the curb of the pedestrian cross-overs	Non-compliance could be addressed over time as facilities are being upgraded.
TWSI	Library Road PXO at Colonel By crossing at locks	There are no TWSI behind the curb of the PXO	**Non-compliance should be addressed proactively given that this is the primary link to the Rideau Canal pathway network.**

4.5. ACCESSIBLE PARKING

The following table identifies specific non-compliances associated with accessible parking spaces. Best practices suggest that accessible ramps should be provided at each access aisle and include an exterior path of travel to the associated facility. Providing this link would enhance safety of accessibility space users by limiting their travels in driving aisles behind parked cars.

Table 5 Accessible Parking Non-Compliance

ELEMENT	LOCATION	NON-COMPLIANCE	RECOMMENDATIONS
Accessible parking	University Dr - Physical Recreation Centre parking	-Accessible spaces are not sized in accordance with type A van accessible or B regular sizes. -There are no access aisles -Accessible parking space signs are not compliant with the latest requirements. -Number of accessible spaces is insufficient	**Non-compliance should be addressed proactively given low cost and complexity of task required.**
	University Dr - Carleton Technology and Training Centre parking	-Accessible spaces are not sized in accordance with type A van accessible or B regular sizes. -There are no access aisles -Accessible parking space signs are not compliant with the latest requirements.	**Non-compliance should be addressed proactively given low cost and complexity of task required.**
	Raven Rd - Arena parking	-Accessible spaces are not provided at this location	**Non-compliance should be addressed proactively given low cost and complexity of task required.**
	Raven Rd - parking P14, K.H.J Nesbitt biology Building	-Accessible spaces are not provided at this location	**Non-compliance should be addressed proactively given low cost and complexity of task required.**
	University Dr - Loeb Building parking	-Accessible spaces are not sized in accordance with type A van accessible or B regular sizes. -There are no access aisles -Accessible parking space signs are not compliant with the latest requirements.	**Non-compliance should be addressed proactively given low cost and complexity of task required.**
	Campus Ave - parking in front of Lennox and Addington House	-Accessible parking space signs are not compliant with the latest requirements. -There are no TWSI on accessible aisles curb ramp.	**Non-compliance for signs should be addressed proactively given low cost and complexity of task**
	Library Road - parking in front Canal Building	-On street accessible parking space is non-compliant with the latest best practices. Parking spaces should be relocated to provide users with a safe access aisle for entering and exiting vehicles.	Non-compliance could be addressed over time as facilities are being upgraded.
	Library Road - parking in front of Azrieli Pavilion	-On street accessible parking space is non-compliant with the latest best practices. Parking spaces should be relocated to provide users with a safe access aisle for entering and exiting vehicles.	Non-compliance could be addressed over time as facilities are being upgraded.

	Library Road - Dunton Tower	-Existing accessible parking space west and south of building do not comply with the access aisle requirement -Accessible parking space signs are not compliant with the latest requirements.	**Non-compliance should be addressed proactively given low cost and complexity of task**
	Library Road - Parking P1 VSIM Building	-Accessible parking space signs are not compliant with the latest requirements.	**Non-compliance should be addressed proactively given low cost and complexity of task**

4.6. PASSENGER LOADING ZONES

The following table identifies specific non-compliances associated with Passenger Loading Zones.

Table 6 Passenger Loading Zones Non-Compliance

ELEMENT	LOCATION	NON-COMPLIANCE	RECOMMENDATIONS
Passenger Loading Zones	University Dr - Physical Recreation Centre	- There are no access aisle markings - There is no accessible curb ramp - There is no signage	Non-compliance for pavement marking and signage should be addressed proactively given low cost and complexity of task required.
	University Dr - Arena	- The existing access aisle is not recessed into surrounding concrete -There are no access aisle markings - There is no accessible curb ramp - There is no signage	Non-compliance for signage should be addressed proactively given low cost and complexity of task required.
	University Dr - Carleton Technology and training Center	-There are no access aisle markings -There is no accessible curb ramp - Existing signage is not compliant with the latest requirements	Non-compliance for pavement marking and signage should be addressed proactively given low cost and complexity of task required.
	Raven Rd - National Wildlife Research Centre	-Depth of access aisled is insufficient - There are no access aisle markings - There is no accessible curb ramp - There is no signage	Non-compliance for pavement marking and signage should be addressed proactively given low cost and complexity of task required.
	Campus Ave - Richcraft Hall	- Size of access aisle is insufficient - There are no access aisle markings - There is no accessible curb ramp - There is no signage	Non-compliance for pavement marking and signage should be addressed proactively given low cost and complexity of task required.
	Campus Ave - Architecture Building	- The existing access aisle is not recessed into surrounding concrete -There are no access aisle markings - There is no accessible curb ramp - There is no signage	Non-compliance for pavement marking and signage should be addressed proactively given low cost and complexity of task required.

	Stormont Dundas and Leeds House	- There are no access aisle markings - There is no accessible curb ramp - There is no signage	Non-compliance for pavement marking and signage should be addressed proactively given low cost and complexity of task required.

4.7. TRANSIT STOPS

The following table identifies non-compliance associated with Transit Stops.

Table 7 Transit Stop Non-Compliance

ELEMENT	LOCATION	NON-COMPLIANCE	RECOMMENDATIONS
Transit Stop	University Dr North Bound in front of Physical Recreation Centre	- Bench, garbage receptacle and accessible seating place are not provided. Benches and accessible seating places are particularly important for those with mobility disabilities.	Bus stops should be proactively upgraded to be made COADS compliant based on consultation with OC Transpo.
	Campus Ave South Bound - Residence Commons		
	Campus Ave South Bound in front of Minto Building		

4.8. BUS SHELTERS

Our review of the bus shelters determined that the shelters are in general conformance with the requirements as per the latest version of street and aerial mapping. Further investigation such as a site review is recommended to physically confirm that the requirements are met.

5. PARKING

5.1. ASSESSMENT OF PARKING SUPPLY / DEMAND

This section evaluates the suitability of the existing parking supply in meeting parking demand requirements, in addition to the impacts of proposed development plans and losses in campus parking supply.

There is currently a total of approximately 4,400 parking spaces on campus. As previously mentioned, a new Residence and Field House building are planned for development on existing parking lots within the next 5-year horizon, in addition to the planned decommissioning of Parking Lot P9. Upon completion, these developments will result in the loss of 900[1] parking spaces as follows:

Loss of P9 Structure	-651
• 5-year de-commissioning schedule	
Loss of 20% of P6 (for new Residences)	-197
Loss of P-12 (for Field House Building)	-52
Total	-900

Figure 17 Existing P9 Structure

As such, there is a need to develop a strategy to mitigate the impact of this significant loss in parking. The following key principles were identified through consultation with the University project team and direction provided in the Campus Master Plan:

- Balance future parking supply and demand.
- Update parking rates to be consistent with market rates.
- Move parking out of the campus core to create a more pedestrian and bike friendly environment, while accommodating those with accessibility needs, loading/service and emergency services.

Existing parking supply and demand data was obtained from the University and used to calculate parking occupancy rates at various times during typical weekdays. This information was used to understand how campus parking facilities are currently being utilized. Based on the parking counts, the overall campus parking occupancy rate during a typical weekday is approximately **91%**. Based on industry standards, a parking occupancy of 85% is considered an ideal target and is often referred to as the "functional capacity" of parking facilities. However, occupancies of up to 90% may be acceptable in off-street parking lots that are in use by employees who would generally be familiar with the parking lot/garage. It is also noteworthy that the City of Ottawa Municipal Parking Strategy targets a parking occupancy of 85% for municipal parking lots, and parking rates in lots with occupancies that exceed 85% are increased to maintain the target 85% occupancy.

Based on the above, the campus parking facilities as a total are currently considered to be operating above "functional capacity". However, the survey also indicates that the P18 and P7 parking lots located in the northern campus area are operating at a 75% and 84% occupancy rates, respectively, which indicates some surplus parking capacity in the northern end of campus.

Preliminary 5-year projections for student and new development growth were estimated based on information provided by the University project team. Future parking demand projections were estimated based on growth projections and expected shifts in travel mode after implementation of Stage 2 LRT. Future parking demand projections are provided in **Appendix E**.

[1] Reserved parking spaces will also be lost as part of the Engineering Building Extension. The relocation of these parking spaces should be addressed as part of the Engineering Building extension design.

Based on future losses in parking supply, average weekday parking occupancies before and after Stage 2 LRT are as projected to be as follows:

- Just before opening of the Trillium Line (2021) assuming no loss in parking: **99% Occupancy**
- After full implementation of Stage 2 LRT (2023) and loss of P9: **115% Occupancy**

5.2. SHORT TERM (0 TO 5 YEAR) RECOMMENDATIONS

5.2.1. PARKING PRICING

Although parking pricing can potentially be a contentious issue, raising parking prices has been demonstrated to reduce parking demand in many universities, and is one of the main approaches used for balancing parking demand with supply.

Currently, parking is relatively inexpensive when compared to peer educational institutions in Ottawa. Inevitably, with the loss of parking due to campus projects, reduction in parking space per capita and the current campus parking demand levels that exceed "functional capacity", there will be a need to increase parking pricing in the very near-term. Monthly parking permit prices on campus vary widely from **$36/month to $118/month** depending on proximity to the campus core. A comparison of parking permit prices with nearby parking structures and surface lots, in addition to peer educational institutions in the City of Ottawa (namely the University of Ottawa and Algonquin College) is provided in **Table 8**. The geographic area investigated for nearby parking facilities was generally bounded by Carling Avenue to the north, Hog's Back/Brookfield to the south, Bank Street to the east, and Fisher Avenue to the west.

As shown in **Table 8**, current parking rates at Carleton University are particularly low and unmatched at any peer institution. Key findings are summarized below:

- This comparison indicates that the cost of student monthly passes in peer institutions varies from a **$100 to $172**, while student monthly passes at Carleton University range from **$38-$51**.

- Similar to Carleton University, permit prices at both the University of Ottawa and Algonquin College vary based on parking lot/garage location. However, it is noteworthy that walking distances from parking facilities at the University of Ottawa and Algonquin College campuses are generally shorter, with the exception of the University of Ottawa Lees parking lot, which is approximately 1.2km from the Ottawa University Centre and has a monthly permit rate of $100/month. Comparatively, P7 at Carleton University is approximately 800 m from the Carleton University Centre and has a monthly permit rate of $38.5/month.

- The highest monthly parking permit (staff) at Carleton University is approximately **45%** lower than the highest University of Ottawa parking permit, and approximately **35%** lower than the highest Algonquin College parking permit. The highest monthly parking permit (staff) at Carleton is also approximately **22%** lower than the average of University of Ottawa and Algonquin College parking permits.

- The lowest monthly parking permit at Carleton University (students) is approximately **185%** lower than the average of the lowest parking permits at the University of Ottawa and Algonquin College.

- The average monthly staff parking permit at Carleton University is approximately **40%** lower than the average of monthly permits in nearby parking facilities.

- Daily parking rates at Carleton range from $8 to $14. The high end of the daily rate is an average of **20%** lower than the average daily rate at the University of Ottawa and Algonquin College, which charge $16-18.

- Hourly parking rates for short term parkers is presently set at $3.50. This is approximately **15%** lower than the average hourly rate at the University of Ottawa and Algonquin College.

Table 8 Parking Price Comparison

LOCATION	PARKING RATES ($)						
	Parking Administered By	Student Monthly Permit Rate	Student Residence Monthly Permit Rate	Staff Monthly Permit Rate	Hourly Rate	Daily Maximum	Weekend
Carleton University	Carleton University	$38-$51 $27.5 evening	$51	$41-$118	$3.50/hr	$8-$14	$5 Flat Rate
University of Ottawa	University of Ottawa	$100-$172 $62.5 evening/weekend	$100-$172	$100-$172	$4.50/hr	$16	$9 Max. or $4.5/hr
Algonquin College	Algonquin College	$115-$162 $24.5 evening/weekend	$162	$91	$4.00/hr	$18	$9 Max., Some Lots Free
The Ottawa Hospital	The Ottawa Hospital	$92 for all visitors			$3.5/30min	$13	Same rates apply
The Glebe Garage (170 Second Street)	City of Ottawa	$130			$2.50/hr	$14	-
Booth Street Complex (580 Booth Street)	Impark	$125			-	-	-
518 Rochester (No longer available)	Impark	$132 $70 after 3pm			$4/hr	$9	-
Carling Square (560 Rochester / 785 Carling)	Gilad Parking	$115 Monthly parking $150 Garage parking			-	-	-
Preston &Beech (75 Beech Street)	Gilad Parking	$135			$3.00/30min	$12	$4.00 Flat Rate

The above findings are consistent with the current campus-wide parking occupancy rate of 91%, which is considered above "functional capacity". Generally, parking occupancy rates of 90% or higher indicate that parking is too cheap.

Based on the above, an increase of in monthly permit and daily parking rates appears to be appropriate. An increase in parking rates will help achieve the following key objectives:

1. Achieving consistency with market rates; and
2. Balancing parking supply and demand by maintaining a parking occupancy of close to 85%.

The Victoria Research Institute's "Understanding Transport Demand and Elasticities" study states that the elasticity of parking demand in relation to parking prices for employees is generally in the order of –0.1 to –0.30. In forecasting the impact of parking price increases on parking demand, the parking price elasticity was estimated to be -0.1 for faculty and staff based on previous surveys conducted by Carleton University suggesting very low parking price elasticities. A price elasticity of -0.1 means that a 10% increase in parking prices would result in a 1% decrease in parking demand. Students were assumed to have a parking price elasticity of -0.2 based on the assumption that students are generally more sensitive to changes in price. In general, price elasticities that are lower than -1.0 are considered "inelastic".

Future parking demand assumptions:

- **During LRT Shut-down (May 2020 to November 2021)**: 10% increase in parking demand due to increase in student enrollment (+5%) and increase in automobile mode split due to less convenient transit service (+5%).

- **Five-year Horizon, after Stage 2 LRT in operation**: No net increase in parking demand as projected increase in staff population (+10%) balances with projected decrease in parking demand as a result of Stage 2 LRT (-13%).

- **Transportation Demand Management (TDM)**: 5% reduction in parking demand to reflect implementation of TDM measures identified in **Section 5.2.6**.

Future parking supply assumptions:

- **During LRT Shut-down (May 2020 to November 2021)**: No change in parking supply, with the exception of the temporary loss of 900 parking spaces during the summer of 2020 (4-month period).

- **Five-year Horizon, after Stage 2 LRT in operation**: Completion of P18 expansion, de-commissioning of P9, and permanent loss of approximately 250 parking spaces (P12 and 20% P6).

Based on the comparison of peer institutions and predominant market rates, the following price scenarios were identified and assessed:

1. **Do Nothing**: Parking occupancy rate reaches **100%** capacity.

2. **Scenario 1:** Monthly permit prices range from **$45 to 147 per month**, and daily rates increase to **$16 per day**. This is projected to result in the following impacts:

    - Reduced parking demand in the order of approximately **140** parking spaces.
    - 2021 Parking occupancy (during LRT Shut-down): **91%**
    - 2023 Parking Occupancy (after Stage 2 LRT open): **89%**

3. **Scenario 2:** Monthly permit prices from **$54 to 177 per month**, and daily rates increase to **$16 per day**.. This is projected to result in the following impacts:

- Reduced parking demand in the order of approximately **250** parking spaces.
- 2021 Parking occupancy (during LRT Shut-down): **88%**
- 2023 Parking Occupancy (after Stage 2 LRT open): **87%**

4. **Scenario 3:** Monthly permit prices from **$73 to 177 per month**, and daily rates increase to **$16 per day**. This is projected to result in the following impacts:

   - Reduced parking demand in the order of approximately **450** parking spaces.
   - 2021 Parking occupancy (during LRT Shut-down): **84%**
   - 2023 Parking Occupancy (after Stage 2 LRT open): **82%**

The analysis results indicate that **Scenario 3** provides an ideal parking utilization level. **Scenario 3** permit prices at each parking lot are included in **Appendix E**.

In terms of implementation timing, it is recommended that the new permit prices would be implemented in **May 2019** in order to maintain parking occupancy levels of less than 90% during the LRT Shut-down. In addition to serving as a parking demand management tool, this increase in parking pricing can be used to fund future parking structures, as well as active travel and transportation demand management initiatives.

It is also recommended that the University implement an ongoing parking utilization monitoring program to inform future price adjustments. The University may also wish to conduct a detailed parking management and pricing study to further refine campus parking prices.

Details of the parking supply versus demand analysis for different parking price scenarios is provided in **Appendix E**.

5.2.2. ADDITIONAL PARKING SUPPLY

As the campus parking supply is currently at "functional capacity", a new structured parking garage will be needed before the de-commissioning of P9 in 2022/2023, even with a 100% increase in parking pricing and reductions in vehicle activity as a result of Stage 2 LRT. Based on the Campus Master Plan, there are two options for locating the parking garage. The first option involves a vertical expansion of P18 by three levels to provide 615 additional parking spaces, while the second option involves construction of a new parking structure on the existing P3 parking lot that would add approximately 650 parking spaces.

Although either option would provide comparable benefits in terms of addressing the loss in parking supply, P18 meets the key principle of moving parking to the periphery of campus in order to reduce vehicle traffic within the campus core. In addition, the shut-down of the Trillium Line in 2020 provides an exceptional opportunity for construction of the P18 expansion. As such, the **expansion of P18** is recommended for to address future parking demands within the 5-year horizon.

5.2.3. TEMPORARY OFF-SITE PARKING

In order to construct the expansion of P18, the P18 parking garage would need to be closed for a 4-month period during the Summer of 2020. Off-site parking was considered as a potential option to support the University's parking demand during this 4-month closure. However, as providing off-site parking will include running a shuttle service to and from campus and leasing an off-site parking area, these costs can become a financial burden on the University if not necessary. Thus, it is recommended, that a campus parking survey be completed in the Summer of 2019 to determine whether there is enough surplus capacity on campus to cover the loss of P18 during the summer months between May to August. Assuming re-opening of P18 before the start of the Fall 2020 Semester and completion of the P18 extension before de-commissioning of P9, the parking survey may show that temporary off-site parking may not be needed. A contingency plan for a temporary off-site parking lot should also be put in place in the cast that parking issues arise or re-opening of the existing P18 is delayed.

5.2.4. ACCESSIBLE PARKING AND SHUTTLE SERVICE

New building construction has resulted in the loss of accessible parking spaces within the campus core, making it more difficult for students and staff with disabilities to access parking within the campus core. In addition, with the planned demolition of Parking Lot P9, a significant portion of centrally located parking spaces will be lost, including xxx accessible parking spaces.

Although these changes are consistent with the Campus Master Plan direction to pedestrianize the campus, it is important that requirements for those with accessibility needs are met. As such, it is recommended that the University transfer some reserved and/or permit parking spaces within the campus core to accessible parking. For example, it is our understanding that the University currently plans to transfer the 22 parking spaces in parking lot R-1 located just west of Southam hall and adjacent to the Library parking garage to new accessible and visitor parking spaces.

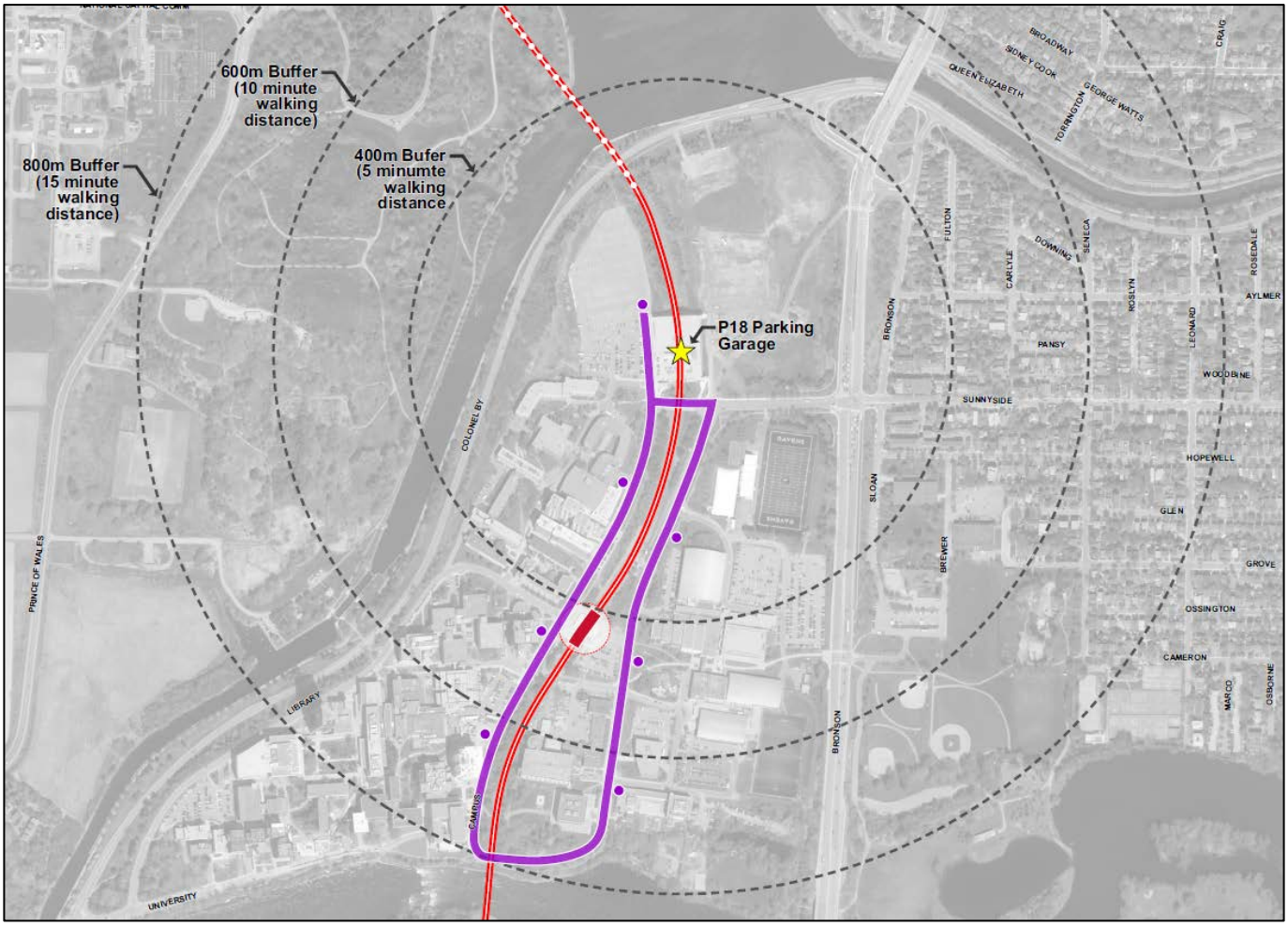
It is also recommended that the accessible parking spaces lost in P9 be added to P18 as part of the proposed P18 expansion.

To further address the loss of parking within the campus core for those with accessibility needs, it is proposed that a shuttle van service be provided to students with accessibility needs between P18 and key campus destinations, in addition to service at the LRT station and bus stops. It is proposed that small shuttles run along the campus loop and that service be provided either at 10-minute frequencies during peak periods and 20-minute frequencies during off-peaks, or on an on-demand basis. Hours of operation may run between 7:00am and 7:00pm. The shuttle service may also be available to special guests/ visitors with passes printed in advance.

A potential shuttle service plan including shuttle route and potential stops is illustrated in **Figure 18**. The precise location of pick-ups/drop-offs should ensure that direct walking routes to/from building entrances are available. In the long-term horizon, it is envisioned that this on-campus shuttle system utilize an autonomous or driverless system as the technology evolves.

Finally, it is recommended that a tunnel extension from Residences to P18 be implemented as part of P18 construction. Studies have indicated that a 15-minute walking distances to/from parking that is weather protected is considered a “LOS C”, while an outdoor walking distance of only 5-minutes would equally be ranked a “LOS C”. As shown in **Figure 18**, the majority of the campus is within a 15-minute walking distance of P18.

Figure 18 Recommended Shuttle Service Plan



5.2.5. SMART TECHNOLOGIES

In order to incentivize parkers to seek spaces in other facilities, the University should provide real-time information on the available parking capacity around the campus at all times through a website and mobile application. This technology would also provide the ability to use a lot search engine to filter the list of all parking facilities by permit type, day and time of visit to campus. A system could also be put into place to allow the pre-registration of parking for visitors.

In addition, parking enforcement and permit management could be substantially streamlined if a license plate reader (LPR) system or other suitable system were installed on-campus. For example, rather than having an enforcement officer constantly circling lots for violations, a LPR system would automatically notify a central dispatch area if there was a violator in a certain parking lot.

5.2.6. TRANSPORTATION DEMAND MANAGEMENT

Transportation Demand Management (TDM) programs aim to encourage the adoption of alternative travel behavior. TDM programs also provide an opportunity to reduce campus parking demand requirements.

Currently, the University has a number of Transportation Demand Management (TDM) strategies in effect, which are managed by Parking Services. These TDM programs include the following, among others:

- **U-Pass program (CUSA/OC Transpo)**
- **City's Rideshare Carpool Program and Ottawa Ride Match**
- **Carsharing (ZipCar and VRTUCar)** – Several car sharing programs are provided with designated parking throughout campus including the Residence Commons Building, P9, and P4.
- **Bike sharing (Right Bike Share)** – Located at the Residences Commons building, this program allows members of the Carleton community to borrow a bike at Carleton, travel within the City and return the bike either on campus or at 17 designated locations within the City.
- **Bike Repair Station** – A bike repair station is currently located between the Architecture Building and University Centre, including all the tools necessary to perform basic repairs and maintenance.
- **EV Charing** - Two electric vehicle charging stations provided at Parking Garage P9.

Each of these programs helps make it more convenient and affordable for students and faculty/staff to use alternative modes of transportation, which helps limit the campus parking demand. Thus, it is key that the University continue to maintain and promote each of these programs. Additional TDM initiatives that the University may implement include:

Parking Pricing Adjustments

Implement parking pricing adjustments to reflect market value, as described in **Section 5.2.1**.

Employee Transit Pass Program

Consider implementing an Employee Transit Pass Program offering reduced transit passes for permanent full-time faculty and staff.

A recent example implemented in January 2019 is at Université de Sherbrooke, where employees now receive $50 off a bus pass if they leave their vehicles at home, thus paying $16 for the pass, instead of the usual $66. This initiative aimed to address current over-capacity conditions at Université de Sherbrooke parking lots. Other Canadian universities that implement a reduced transit program include Dalhousie University (25% off regular transit pass), University of Waterloo (15% off regular transit pass), and University of British Coloumbia (15% off regular transit pass).

It is recommended that the University offer a 15% subsidized transit pass to faculty and staff, in addition to a certain number of transit passes at 55-75% reduction for faculty and staff who exchange their parking permits.

Suggested implementation: May 2019 (prior to Hog's Back closures and one year prior to LRT shut-down).

Telecommuting and Flextime Program

Consider implementing a Telecommuting and Flextime Program. Telecommuting allows employees to perform some, or even most, of their work at home, thus reducing their need to commute. In general, this option is most applicable for university staff members who are able to work independently without the need for daily direct contact with students and other university personnel. Flextime grants employees a certain amount of flexibility in scheduling their work hours, thus reducing peak traffic volumes and peak parking demand.

Suggested implementation: May 2019 (prior to Hog's Back closures and one year prior to LRT shut-down).

Carpool and Guaranteed Ride Home Program

Consider implementing carpool permits, offered at lower price or preferred parking locations to encourage the use of carpooling. Price discounts could range from 25% to 50% depending on the number of people registered in the car pool. This program could also include a guaranteed ride home program for car poolers that offers a free ride home in an emergency situation for car poolers that live within a certain distance of campus (e.g. 20 km). In this case, car poolers would receive a free ride home from a designated company in case of emergencies.

Suggested implementation: May 2019 (prior to Hog's Back closures and one year prior to LRT shut-down)

Electric Vehicle Charging

As previously mentioned, the University currently provides two electric vehicle charging stations provided at Parking Garage P9. Based on input from University staff, these charging stations often remain unused. With the planned demolition of P9, it is recommended that two charging stations be implemented in P18 as part of the extension project. It is recommended that the University continue to monitor use of these charging stations and provide additional stations if demand warrants.

Marketing

Liaise with the City of Ottawa to improve marketing and promotion of TDM initiatives, particularly the rideshare program. This is particularly important as the results of the on-line survey indicated generally poor awareness of the University's TDM initiatives.

New Cycling Facilities

Implement new cycling facilities on campus and improvements to bicycle storage and amenities, as later described in **Section 6.0**.

On-going Monitoring

Conduct on-going monitoring of parking demand to ensure campus parking utilization targets are met.

5.3. LONG TERM (5+ YEARS) RECOMMENDATIONS

5.3.1. SATELLITE PARKING OPPORTUNITIES

Carleton University is currently used as a satellite parking site for events at Lansdowne. Le Breton Flats, which is a major future development project in the general area of Carleton University, provides the opportunity to further optimize the utilization of parking on campus and generate an additional source of revenue for the University.

The opportunity to provide satellite parking for events at other facilities (e.g. the Future LeBreton Flats) was communicated to City of Ottawa staff during the November 6th, 2018 Working Group meeting. City staff responded that they are currently in the process of updating the Park & Ride Strategy in 2019 and will include policy direction in the new document to accommodate establishment of such facilities at Carleton University and potentially other locations in the City.

5.3.2. AUTONMOUS SHUTTLE SERVICE

In the long-term horizon, it is envisioned that the proposed on-campus shuttle system may utilize an autonomous or driverless system as the technology evolves.

Figure 19 Example Autonomous Shuttle Vehicle

6. ROAD NETWORK

6.1. EXISTING CONDITIONS

6.1.1. EXISTING ROAD NETWORK

Carleton University campus is bound by the Rideau River to the south and two major roadways, Bronson Ave to the east and Colonel By Dr to the west and north. Vehicular access to and from campus is only possible via these two roadways.

Colonel By Dr is a north-south scenic parkway that is managed by the National Capital Commission (NCC). The NCC maintains the scenic features of the parkway by limiting signage, prohibiting commercial vehicles, restricting access, and landscaping. At the Carleton University access, Colonel By Dr is a two-lane, undivided roadway with a posted speed limit of 60 km/h. The Colonel By Dr and University Dr intersection is currently unsignalized with a southbound left-turn lane and a northbound right-turn lane to permit entry into campus from Colonel By Dr. To exit campus, there is a westbound channelized right-turn lane on University Dr.

Bronson Ave is a north-south arterial road under City of Ottawa jurisdiction. At the Carleton University access, Bronson Ave is a six-lane, divided roadway with a posted speed limit of 70 km/h. The Bronson Ave and University Dr intersection is currently signalized with a southbound channelized right-turn lane and a northbound left-turn lane to permit entry to campus. To exit campus, there is an eastbound left-turn lane and right-turn lane on University Dr.

Within campus, there are four existing roads: University Dr, Campus Ave, Library Road and Raven Rd. All campus roads are two-lane, except for the section of University Dr approaching Bronson Ave where it widens to four lanes and near Colonel By Dr, where it widens to three lanes. The speed limit on any campus road is 40 km/h unless otherwise posted. All campus intersections are unsignalized.

6.1.2. EXISTING TRAFFIC VOLUMES

The traffic data collection program consisted of weekday peak period turning movement counts at various intersection on campus. These counts were either provided by the City of Ottawa or collected by Parsons. The data was stratified by cars, heavy vehicles, pedestrians and cyclists.

The City of Ottawa provided standard eight-hour peak period counts (7am to 10am; 11:30am to 1:30pm; 3pm to 6pm) at the following intersections:

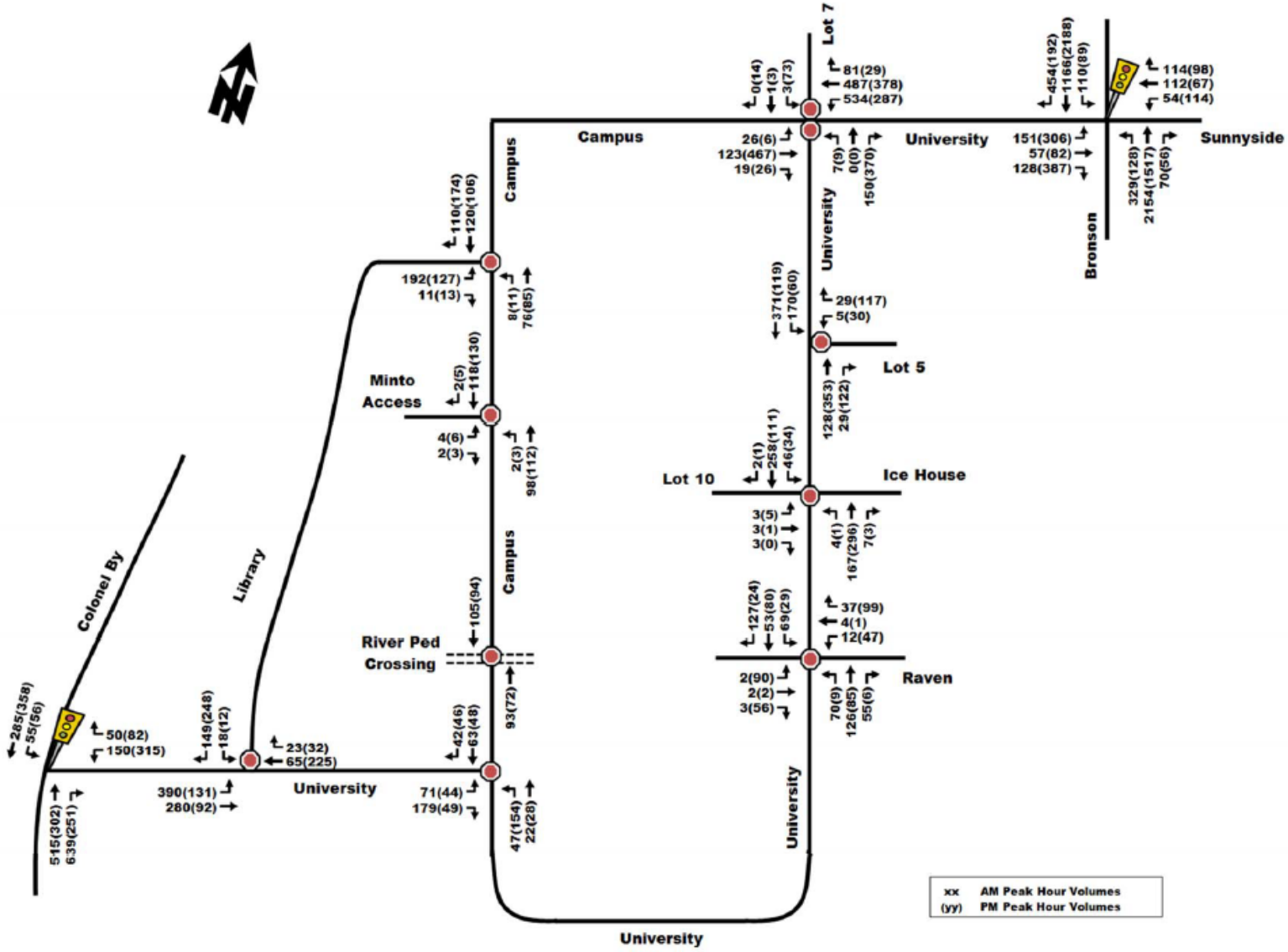
- Bronson Ave and University Dr/ Sunnyside Avenue (Wednesday January 15, 2015)
- Colonel By Dr and University Dr (Tuesday December 1, 2015)

For intersections located within campus, Parsons collected the required turning movement counts for the four-hour peak period (7am to 9am; 3pm to 5pm) at the following locations:

- University Dr and Campus Ave (Wednesday October 3, 2018)
- University Dr and Lot P5 Access (Wednesday October 3, 2018)
- University Dr and Lot P10 Access (Wednesday October 3, 2018)
- University Dr and Raven Rd (Thursday October 4, 2018)
- University Dr S and Campus Ave (Thursday October 4, 2018)
- Campus Ave and Richcraft Hall Pedestrian Crossing (Thursday October 4, 2018)
- Campus Ave and Minto C.A.S.E Building Access (Wednesday October 3, 2018)
- Campus Ave and Library Road (Wednesday October 10, 2018)
- University Dr S and Library Road (Wednesday October 3, 2018)

The existing traffic volumes are illustrated in **Figure 20**. The raw count data has been provided in **Appendix F**.

Figure 20 Existing Traffic Volumes



6.2. AREAS OF CONCERN

The areas of concerns related to traffic and road network conditions were stratified based on results of the online questionnaire and the site review process. Locations that were identified as "hot-spots" or poor operation conditions were evaluated further during the intersection capacity analysis. A summary of the key themes has been provided below.

6.2.1. EXISTING ISSUES

All respondents were asked to rank existing roadway/ traffic conditions in the order of importance. The top three issues were:

1. *Congestion at the Campus Ave and University Dr intersection*
2. *Vehicular and pedestrian conflicts, particularly across Campus Ave at the LRT crossing at Library Road, and the "main" bus stop crossing by the Minto C.A.S.E. Building*
3. *Traffic congestion exiting parking lots*

The overriding theme among respondents was the concern with on-campus congestion, particularly along the University Dr corridor between Bronson Ave and Campus Ave, which provides access to the largest parking lots on campus, P6, P18 and P7. The next most noted concern was the Campus Ave LRT node, where passengers outlet from the west platform and try to cross Campus Ave by Library Road. This is a particularly congested node because of the highly utilized bus stop by the Minto C.A.S.E. Building, causing buses to queue along this block that may contribute to sightline issues and blockages of pedestrian crossings.

Field investigations were conducted during peak periods to document notable traffic behaviour, such as illegal maneouvers, queue spillback, intersection blockages etc. The details of these investigations have been described below.

1. *University Dr Corridor (Bronson Ave to Campus Ave) – Field observation confirmed queue spillback in both directions from Bronson Ave to Campus Ave, and vice versa.*
2. *Campus Ave and University Dr intersection – There were numerous issues noticed at this location including severe congestion during the morning and afternoon peak periods. Additionally, some drivers, notably northbound on University Dr or southbound from Lot P7, became impatient waiting in the queue and would circumvent, forcing themselves into traffic. Others in the northbound direction would U-turn and proceed elsewhere. Near collisions were also noticed.*

   The congestion combined with erratic driver behaviour caused many east/westbound drivers to stop or pause when reaching University Dr/ Lot P7 despite being a free flow movement.

   The lack of appropriate signage, lighting, pavement markings and medians for an intersection of this size leads to confusion in low light conditions. For example, some drivers making the westbound left-turn were observed nearly turning into the northbound lane.
3. *Library Road and University Dr S – the westbound queue in the afternoon peak hour extended back from Colonel By Dr, which created sightline issues with the eastbound left-turn at Library Road. Two nNear misses with cyclists were noted.*

Field investigations corroborated the responses from the online questionnaire. The University Dr corridor is operating poorly, creating unsafe conditions for drivers and alternate modes. Additionally, the traffic activity near Colonel By Dr appears to lead to potentially unsafe conditions.

Addressing these concerns was a primary objective of the Traffic Strategy, since the short-term horizon includes some significant events that will add additional strain the campus road network, specifically the Hog's Back Swing Bridge Closure and the O-Train Line 2 shutdown.

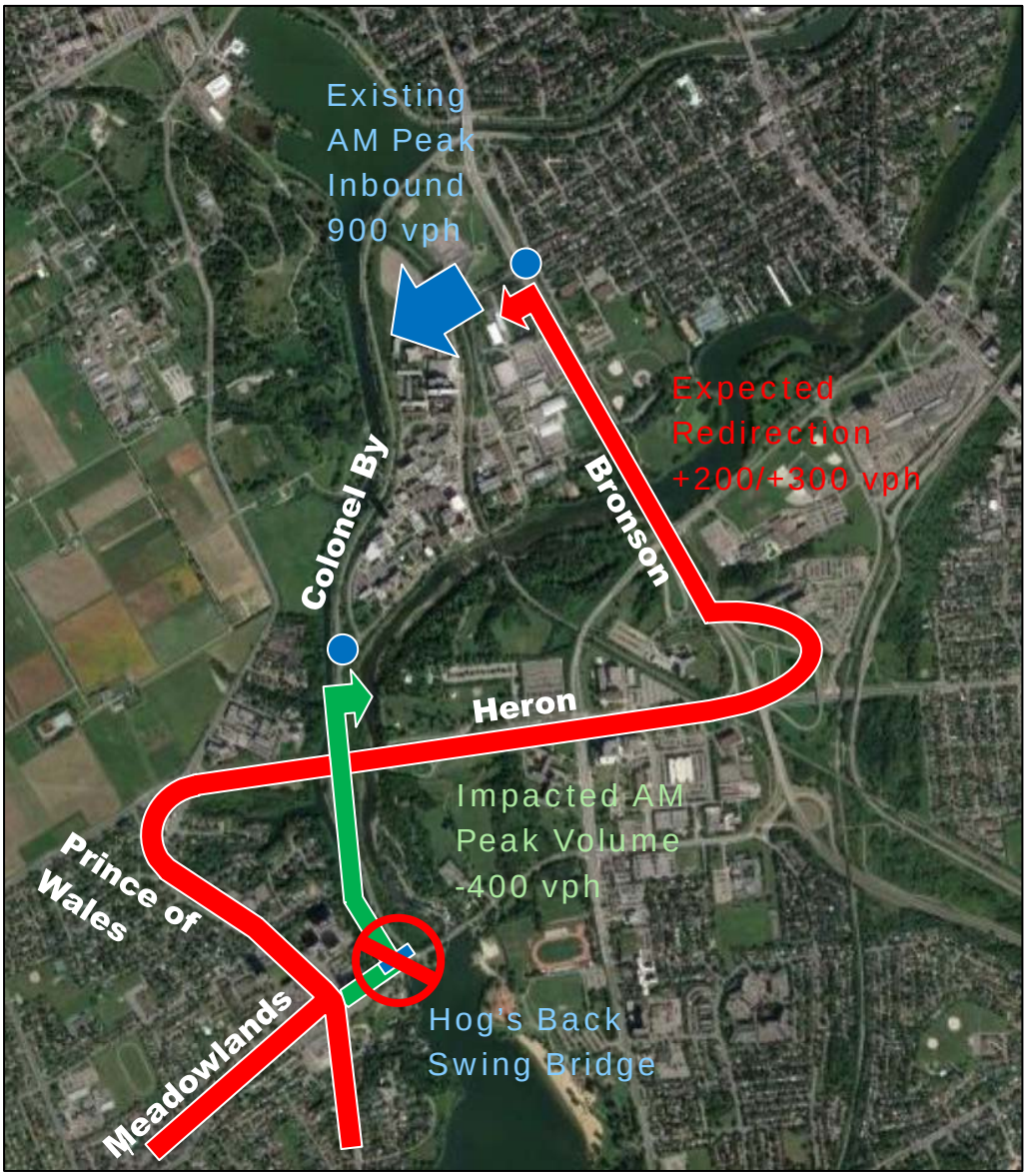
6.2.2. FUTURE ISSUES

Hog's Back Swing Bridge

The Hog's Back Swing Bridge is located approximately 1-km south of the Colonel By Dr/University Dr intersection. This bridge crosses over the Rideau Canal and provides access to Colonel By Dr from the west. As previously noted, the NCC is planning to close this bridge for rehabilitation in August 2019 for a 9-month period. The Hog's Back Swing Bridge is an important connection for Carleton University, since it provides a direct route to campus for travelers originating southwest of the Rideau River. It was estimated approximately 400 of these inbound vehicles in the morning peak hour would be forced to redirect when the Hog's Back Bridge is shut down for rehabilitation.

Figure 21 illustrates the likely impacts of this redirection. The expected alternative route to campus would be via the University Dr/Bronson Ave intersection. It was estimated between 200 and 300 vehicles in the morning peak hour would divert, which represents approximately 20% to 35% of existing inbound traffic at University Dr/ Bronson Ave intersection in the morning peak hour. The campus survey highlighted the public concern with congestion along the University Dr – Campus Ave corridor; the Hog's Back Swing Bridge closure would clearly exacerbate the current congestion if no interventions are considered.

Figure 21 Hog's Back Swing Bridge Closure AM Peak Hour Traffic Impacts



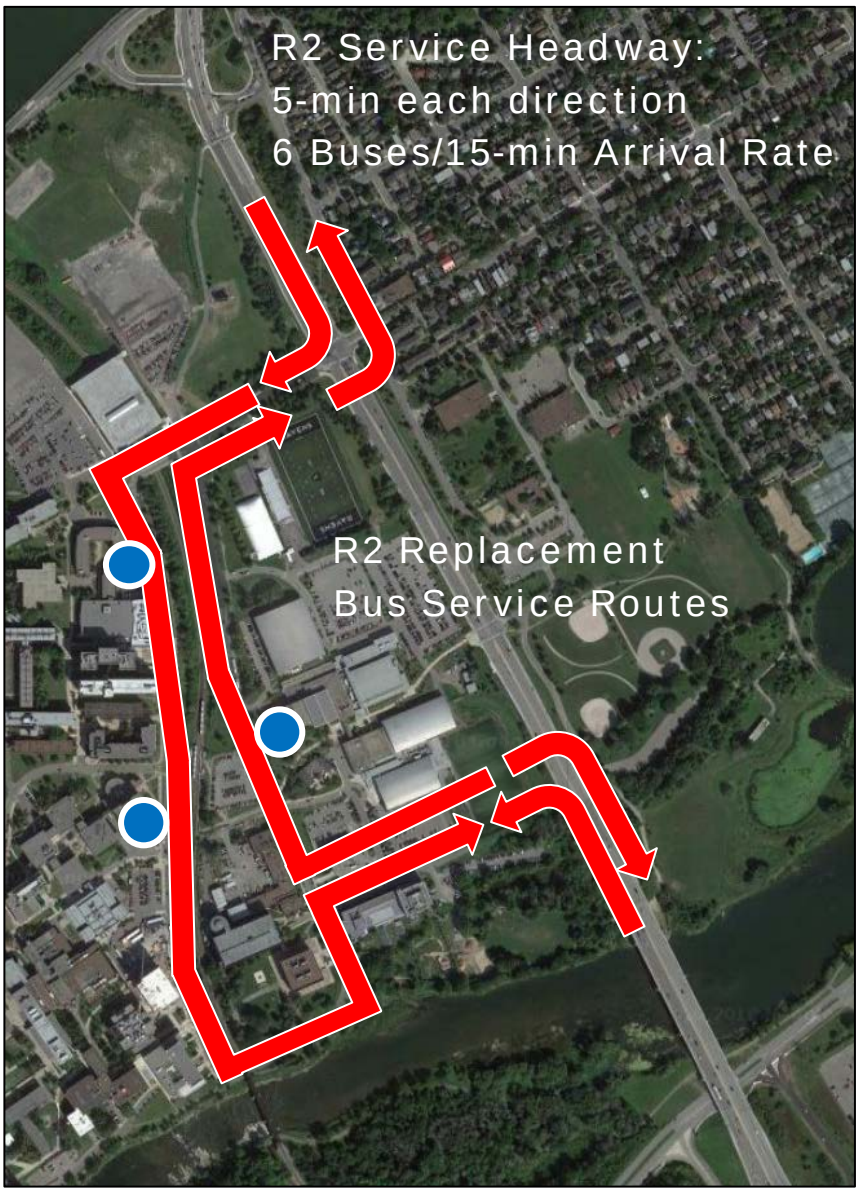
Trillium Line Shutdown

The City of Ottawa is planning to extend the current Trillium Line as part of the Stage 2 upgrades to the LRT system. The extension will require the existing Trillium Line (O-Train Line 2) be shut down for an 18-month period beginning May 2020 (according to the current plan).

As previously discussed, the City of Ottawa plans to implement a replacement bus service (R2) to offset the loss of LRT. They have also tentatively committed to constructing a new bus-only access off Bronson Ave at Raven Rd on campus. The proposed routing of the R2 Replacement Bus Service is shown in **Figure 22**.

The anticipated traffic impacts during the O-Train Line 2 shut down is the increase in the number of buses on campus. OC Transpo confirmed the current plan is to run the R2 service on 5-minute headways in both directions. This means an increase in bus arrival rates by 6 buses every 15-minutes, which represents a 150% increase in the bus arrival rate to campus compared to existing conditions. Buses are large, slow to manoeuvre and require more road space than general traffic. Adding more buses to the already congested University Dr – Campus Ave corridor will increase risks of congestion on University Dr, and risks to safety along Campus Ave at pedestrian crossing points and with conflicting vehicular movements.

Figure 22 O-Train Line 2 Shutdown Peak Period Traffic Impacts



Trillium Line South Open

The opening of Trillium Line South will trigger the discontinuation of the R2 Bus Replacement Service and existing Route #104. Bus traffic will decrease on campus as a result. Therefore, no road network concerns were identified in this scenario.

6.3. INTERSECTION CAPACITY ANALYSIS

The critical locations identified in the online questionnaire and general site review were assessed in more detailed using an intersection capacity analysis software in order to provide quantitative support of the noted traffic conditions. From this, traffic specific mitigation measures can be developed and evaluated to estimate their overall effectiveness.

The following intersections were cited during site investigations and in the online questionnaire as the most congested in the campus network:

- Bronson Ave and University Dr
- University Dr and Campus Ave N
- Campus Ave and Campus Ave N
- Colonel By Dr and University Dr

These locations were modeled in Synchro to assess the existing intersection capacity and corroborate campus feedback and field observations noted. The results of this analysis have been summarized in **Table 9**. The corresponding intersection capacity analysis reports have been provided in **Appendix G**.

Table 9 Intersection Capacity Analysis Results - Existing Traffic

INTERSECTION	INTERSECTION CONTROL	PEAK HOUR	OPERATIONAL RESULTS*			
			V/C RATIO	DELAY (S)	LOS	CRITICAL MOVEMENTS
Bronson Ave and University Dr N	Traffic Signal	AM	1.06	160	F	SBL, SBT and NBT\R
		PM	1.10	90	F	SBT and EBL
University Dr and Campus Ave N	NB / SB Stop	AM	0.42	185	F	NB and SB Approach
		PM	9.47	>500	F	
Campus Ave and Campus Ave N	All-Way Stop	AM	0.64	15	B	All movements show acceptable LOS
		PM	0.63	17	C	
Colonel By Dr and University Dr S	Traffic Signal	AM	0.68	21	B	All movements show acceptable LOS
		PM	0.66	23	B	

* - The operational results were shown for the worst movement only. Other movements may also experience poor conditions.

The results from the intersection capacity analysis indicate the University Dr intersections with Bronson Ave and University Dr/ Lot P7 Access are operating near or above capacity. This congestion was most apparent on Bronson Ave; however, the eastbound left-turn was shown to be over-capacity in the afternoon peak hour. The Colonel By Dr and University Dr S intersection was shown to operate well in both peak periods.

An unexpected result was how well the section of University Dr between Campus Ave and the Lot P7 Access functioned. The unsignalized intersections were shown to have sufficient capacity to accommodate existing traffic. This is contrary to field observations and public feedback via the online questionnaire, which suggest congestion triggers queue spillback on University Dr between Campus Ave and Bronson Ave.

SimTraffic analysis was completed to augment the capacity analysis to show queue behaviour along this corridor. The results of the queuing analysis have been provided in **Table 10**. The corresponding queueing reports have been provided in **Appendix G**.

Two queue measures were provided: the 95th percentile queue and the maximum queue. These values were compared with the available storage length or link capacity. The 95th percentile queue represents a theoretical length based the standard deviation of the average. The maximum queue is simply the maximum back of queue observed for the analysis interval.

Table 10 Queuing Analysis

ROAD SECTION	PEAK HOUR	95TH PERCENTILE QUEUE (M)	MAXIMUM QUEUE (M)	LINK CAPACITY (M)
University Dr N				
EBL at Bronson Ave	AM	55	65	85
	PM	90	100	85
EBT or EBR at Bronson Ave	AM	30	35	170
	PM	75	80	170
WBL at University Dr/ Lot P7	AM	40	55	60
	PM	45	60	60
WBT\R at University Dr/ Lot P7	AM	100	190	170
	PM	10	20	170
Campus Ave N				
WBT\L\R at Campus Ave/ Lot P6/ Lot P18	AM	50	60	55
	PM	45	55	55
University Dr				
NBR at University Dr N/ Campus Ave N	AM	30	40	70
	PM	165	125*	70
NBT\L at University Dr N/ Campus Ave N	AM	10	15	135
	PM	200	135*	135
University Dr S				
WBL at Colonel By Dr	AM	45	55	60
	PM	55	65	60

* - Upstream metering/ congestion causes Max queue to be shorter than 95th queue. In this situation, the 95th queue is the worst-case scenario.

The queuing analysis results corroborate field observations and online questionnaire respondents' commentary on local traffic conditions. Queues along the University Dr corridor between Bronson Ave and Campus Ave were shown to exceed available link capacity in both the morning and afternoon peak periods. They were also found to exceed available link capacity on the westbound approach to Colonel By Dr along University Dr S.

Through this analysis, it was confirmed that the main triggers for the existing congestion along the University Dr - Campus Ave corridor were:

- Heavy traffic volumes on the back-to-back left-turns on University Dr - Campus Ave between Bronson Ave and University Dr with limited storage length that overflows and blocks the adjacent travel lane and the upstream intersection
- Heavy WB traffic on Campus Ave N with limited capacity at the Campus/Campus all-way stop, and limited storage between Campus Ave and University Dr, which queues block the upstream intersections

The congestion exhibited on the westbound approach to the Colonel By Dr and University Dr S intersection were triggered by unoptimized signal timings at the Colonel By Dr and University Dr S intersection.

Contributing to the triggers along the University Dr – Campus Ave corridor is the fact there are significant spacing constraints. The intersection spacing between Bronson Ave and University Dr is only 200m, of which 170m is effective storage to share between the back-to-back left-turn lanes. The effective spacing between University Dr and Campus Ave is approximately 50m, which only accommodates 7 to 8 vehicles, and is fixed with respect to lane arrangements due to the O-Train bridge structure.

Mitigating these triggers was considered a high priority since the impacts extend beyond vehicular congestion, but to transit operations and increases risks to pedestrians and cyclists. There is also added urgency to address these issues due to the upcoming closures to the Hog's Back Swing Bridge and the O-Train Line 2, which will add even more traffic pressure to the University Dr – Campus Ave corridor.

Secondary concerns noted in the traffic analysis included traffic interactions along Campus Ave near the LRT Station, and along University Dr S between Colonel By Dr and Library Road.

6.4. POTENTIAL MITIGATION MEASURES

There were two general approaches to address the various issues noted:

1. Increase vehicular capacity along the University Dr/ Campus Ave corridor; and,
2. Reduce vehicular demand along the corridor.

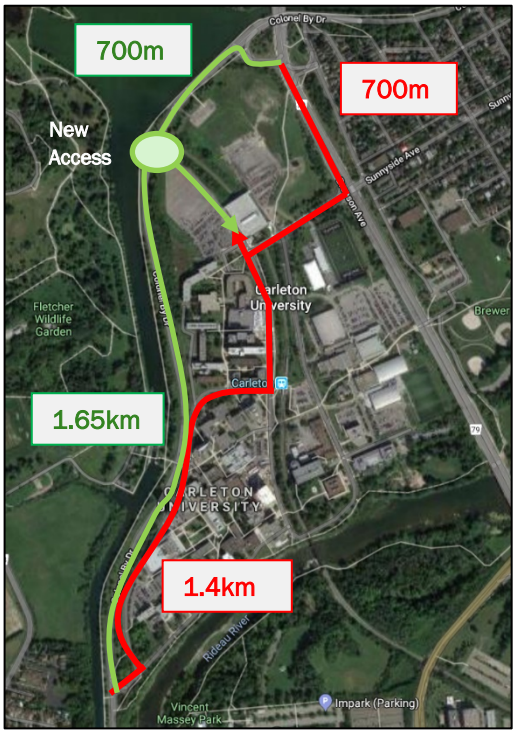
Increasing corridor capacity is the more direct approach to improving traffic operations. This can be done in a myriad of ways, such as changing or optimizing the intersection control (stop signs or signals), adding lane capacity, increasing storage lengths, restricting conflicting movements, redirecting crosswalks, reconfiguring lane arrangements etc. The various were considered, but a key consideration was to ensure any measure did not adversely affect pedestrians, cyclists and/or transit service.

Reducing corridor traffic demand is an indirect way to improve traffic operations. In situations where right-of-way or roadway space is limited, managing demand may be a more feasible and effective measure. Options for reducing demand include, constructing alternative access points to provide routes that avoid the congested links or encouraging alternate modes of travel. Due to the short-term horizons outlined in this study, the mitigation measures considered were restricted to the former.

A list of potential traffic mitigation measures has been provided that can help improve road network operations on campus. A summary of these mitigation measures, with a brief discussion of the expected benefits(s), has been provided below.

6.4.1. NEW COLONEL BY DR ACCESS INTERSECTION

Figure 23 Colonel By Access Route Comparison



Carleton University is currently seeking approval from the NCC to implement a second multi-modal access (not including transit) from Colonel By Dr to service the emerging north campus expansion. This additional link would be highly effective in reducing traffic demand along the University Dr corridor. If an all-turns signalized access is constructed in addition to the existing Colonel By Dr access, it would provide ideal redundancy to the campus road network.

Currently, campus traffic is limited to two access points, one from Bronson Ave and the other from Colonel By Dr. As a result, any event or deficiency that affects one, will put enormous pressure on the other (e.g. the Hog's Back Swing Bridge Closure). **Figure 23** illustrates the alternate routes possible with the new access located by Lot P18 to the north end of campus, as outlined in the CMP. The highest traffic volumes entering the site are the southbound right-turn at Bronson Ave and University Dr N, and the northbound right-turn at Colonel By Dr and University Dr S. A common destination on campus today is the Lot P6 and P18 area. The new access would be an attractive alternative, with comparable travel distances and likely improved travel times since Colonel By Dr is a well-controlled parkway.

How this measure would address noted areas of concern:

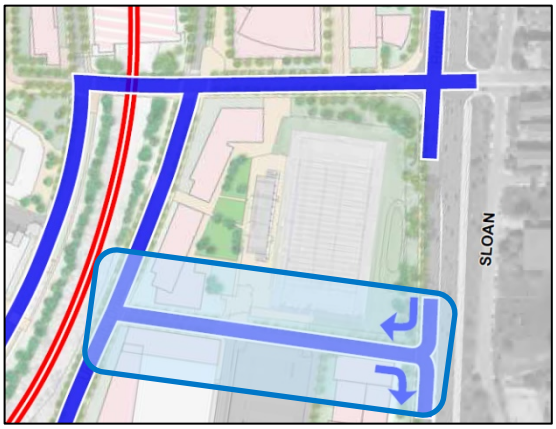
- Provides essential redundancy to the campus road network if either existing access intersection is closed or affected by an event (e.g. Hog's Back Swing Bridge Closure)
- Reduces traffic demand and thereby, existing congestion along the critical University Dr corridor.
- Indirectly improves transit operations and pedestrian/cycling safety along the critical University Dr corridor.
- Helps accommodate future north campus expansion

Potential challenges:

- Requires NCC approval.

6.4.2. STADIUM WAY CONNECTION AND RIGHT-IN RIGHT-OUT BRONSON AVE ACCESS

Figure 24 Proposed Stadium Way



One of the main congestion triggers on the University Dr corridor identified in the traffic analysis was the heavy westbound left-turn from University Dr to University Dr. Based on the inbound traffic distribution, nearly 60% of this westbound left-turn traffic originates from the north, making the southbound right-turn at Bronson Ave in both peak hour periods. Therefore, an effective way of reducing the westbound left-turn traffic volume is to redirect the southbound right-turn to an alternative location.

It is our understanding that Carleton University is planning to implement a right-in/right-out (RIRO) vehicle connection to Bronson Ave as identified in the Campus Master Plan Update (2016). This connection was validated in a Transportation Assessment completed by Parsons in 2017. In this analysis, its anticipated up to 50% of the southbound right-turn would redirect from Bronson Ave to the new RIRO, which helps improve traffic flow along the University Dr – Campus Ave corridor.

An added benefit to this measure is that a new E/W street (Stadium Way) can be designed as a complete street, with pedestrian and cycling facilities to accommodate travel between the sport facilities, parking and Bronson Ave, avoiding University Dr N. The current one-way loop within Lot P5 can be maintained, but the alignment should be fixed/ straightened to provide optimal safety and traffic flow through the corridor.

How this measure would address noted areas of concern:

- Provides essential redundancy to the campus road network if either existing access intersection is closed or affected by an event (e.g. Hog's Back Swing Bridge Closure).
- Reduces traffic demand and thereby, existing congestion along the critical University Dr corridor.
- Indirectly improves transit operations and pedestrian/cycling safety along the critical University Dr corridor.
- Helps accommodate future north campus expansion.
- Reduces pedestrian traffic along University Dr N.
- Provides an additional access in case of emergency evacuation.

Potential challenges:

- May increase northbound left-turn U-turns at the Bronson Ave and University Dr intersection. Note, the northbound left-turn is a fully protected phase in the signal timing plan, which removes the potential conflicts with pedestrians and oncoming vehicles, and there are three southbound travel lanes, which provides sufficient space for vehicles to safely complete the maneuver.
- Increases vehicular traffic within Lot P5 area between sports facilities and parking. The implementation of traffic calming measures will likely address this concern.
- The design will likely require a southbound deceleration lane for the right-in, which has to be functionally reviewed and approved by City staff.

6.4.3. ONE-WAY ROAD CONVERSION

The University Dr and Campus Ave loop is currently bi-directional, with one travel lane in each direction. While this configuration provides greater mobility and accessibility within campus, it creates increases turning movement conflicts at intersections and crossing points. The most problematic locations noted in the online questionnaire and during site investigations were:

- The University Dr and University Dr intersection; and
- The Campus Ave section between the LRT Station and the "main" bus stop by the Minto C.A.S.E. building.

In the former case, bi-directional flow creates significant vehicular conflicts between left-turns and other movements. In the latter case, bi-directional flow creates significant pedestrian conflicts and sightline concerns at crossing points, due to the mix between cars and buses along the corridor.

Reconfiguring the flow from bi-directional to one-way would eliminate many of these conflicts. Three main one-way conversion scenarios were considered:

1. One-way conversion of the entire campus loop, clockwise, starting and ending at the University Dr and University Dr intersection;
2. One-way conversion of the entire campus loop, counter-clockwise, starting and ending at the University Dr and University Dr intersection; and,
3. Partial one-way conversion of the campus loop: northbound only along the section of University Dr between the Lot P5 Access and University Dr N; and southbound only along the section of Campus Ave between Campus Ave N and University Dr S.

Scenarios 1 and 2 were removed from consideration based on the following:

- Scenarios 1 and 2 force a large portion of campus traffic to travel along the entire loop to reach their destination, which greatly hinders mobility and accessibility on campus (particularly to and from Lots P6 and P18).
- Scenario 2 does not address the WBL queue spillback issue at the University Dr and University Dr intersection. In addition, Scenario 2 would require significant changes to transit passenger stops and loading areas.

Scenario 3 is a hybrid approach that takes advantage of the one-way conversion benefits at the most critical areas, while maintaining adequate mobility and accessibility on campus. The primary benefit of the one-way conversion is reducing in vehicular conflicts at the two noted locations. This reduces congestion and indirectly benefits all active transportation modes. An additional benefit of this measure is that it reclaims roadway space that can be used for alternative uses, ideally to support sustainable transportation modes (i.e. transit, pedestrians and cyclists).

Careful consideration was made when planning for this measure to ensure long-term plans for the campus are not adversely affected. However, the one-way conversions will require up and downstream modifications (at additional cost) to ensure prohibited movements are enforced.

At the University Dr and Campus Ave N/ Lot P7 intersection, appropriate signage and medians would be needed to prevent the westbound left-turn. This synergizes well with the westbound left-turn restriction mitigation measure. This allows the northbound right-turn lane to be extended the entire block and channelized, which helps reduce congestion along this section of University Dr. At the Campus Ave and University Dr S intersection, the northbound lane on Campus Ave would have to be blocked/ gated and appropriately signed to enforce the one-way conversion.

How this measure would address noted areas of concern:

- Reduces queue spillback and congestion in both directions along the University Dr corridor.
- Reduces queue spillback and congestion in the northbound direction on University Dr.
- Indirectly improves bus operations and reliability with less congestion.
- Safer pedestrian crossings on Campus Ave due to vehicles only travelling in one direction.
- Reclaimed lane space may be converted for alternative mode uses, e.g. transit platform width, pedestrian/cycling facilities.
- Second lane may be used as a dedicated transit lane.
- Synergizes with other traffic mitigation measures along University Dr corridor.

Potential challenges:

- Non-compliance – One-way travel must be properly signed and will likely require monitoring during early stages of deployment.
- Slight loss of mobility and accessibility – People traveling from the south on Bronson, destined for the southeast quadrant of campus will be required to travel the campus loop. However, the Lot P5 access previously noted provides an alternate option via U-Turn.

It is critical that one-way conversion be preceded by an extensive information campaign, followed by an enforcement campaign, including speeding and running stop signs.

6.4.4. BRONSON AVE / CAMPUS AVE INTERSECTION DOUBLE EBL

One of the main congestion triggers on the University Dr corridor identified in the traffic analysis was the heavy eastbound left-turn (EBL) from University Dr to Bronson Ave. The EBL storage length is insufficient to accommodate the traffic demand, leading to queue spillback in the afternoon peak hour. This result is caused by over 300 vehicles making this turn. The City of Ottawa typically requires a double left-turn lane when left-turn volumes exceed 300 vehicles per hour. Therefore, a double left-turn lane option was considered. A SimTraffic analysis confirmed that a double left-turn lane was effective in eliminating the potential queue spillback (**Table 11**).

Table 11 Bronson/University/Sunnyside Intersection EBL SimTraffic Results

ROAD SECTION	PEAK HOUR	95TH PERCENTILE QUEUE (M)	MAXIMUM QUEUE (M)	LINK CAPACITY (M)
University Dr N				
Single EBL at Bronson Ave	PM	90	100	85
Double EBL at Bronson Ave	PM	55	60	85

A double left-turn can be accommodated by re-assigning the lane arrangements on the EB approach to replace the EBL, EBT and EBR with an EBL, EBL and EBT\R, as shown in **Figure 25**.

Figure 25 Potential Bronson/University/Sunnyside Reconfiguration

How this measure would address noted areas of concern:

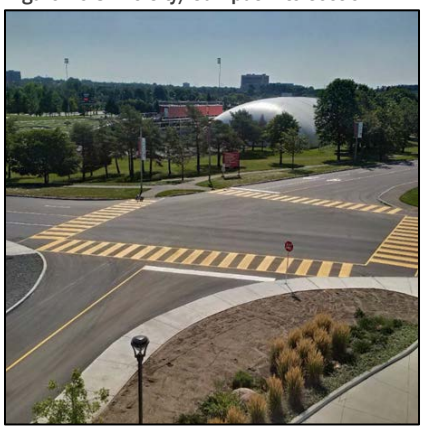
- Effectively reduces risk of queue spillback from EBL that affects upstream intersections.
- Improves traffic flow along University Dr corridor.

Potential challenges:

- Requires City of Ottawa approval.
- New timing plan required that may adversely impact Bronson Ave operations.

6.4.5. UNIVERSITY DR / CAMPUS AVE N / LOT P7 INTERSECTION MODIFICATIONS

Figure 26 University/Campus Intersection



Similar to the previous mitigation measure, the WBL from University Dr to University Dr was found to be one of the triggers of congestion along the corridor. There are over 500 vehicles making this left-turn onto University Dr heading south in the morning peak hour, which even exceeds the other two movements combined.

Left-turn traffic of this magnitude has few options to mitigate it. As previously noted, there are significant constraints along this corridor. Storage space is at a premium due to the bridge constraint and the requirement for EBL storage at Bronson Ave.

The following measures were considered, but ultimately were not considered viable:

- All-way stop control – was not warranted based on City of Ottawa standards.
- Traffic Control signal – not warranted based on City of Ottawa standards and also exacerbates queues and congestion along the corridor.

Based on this analysis, it was clear that maintaining free-flow movements along University Dr was essential to reduce queue spillback. There were only two options considered viable that would be effective both Short-Term and Long-Term to address this corridor congestion:

- WBL restriction – re-design the intersection to prohibit the WBL, which removes the WBL storage lane requirement and increases available storage capacity for the EBL at Bronson Ave.
- Roundabout – implementing a roundabout would permit the WBL movement without a storage lane, which also increases available storage capacity for the EBL at Bronson Ave. This option is discussed in more detail in the next section.

Focusing on the WBL restriction, enforcement will be critical. Further to this, the intersection today has a large footprint with no medians and slight sightline limitations at the bridge, which contributes to some confusion and hesitation amongst drivers when approaching to make the WBL. Removing this movement and adding appropriate medians to enforce the restriction will improve traffic flow.

How this measure would address noted areas of concern:

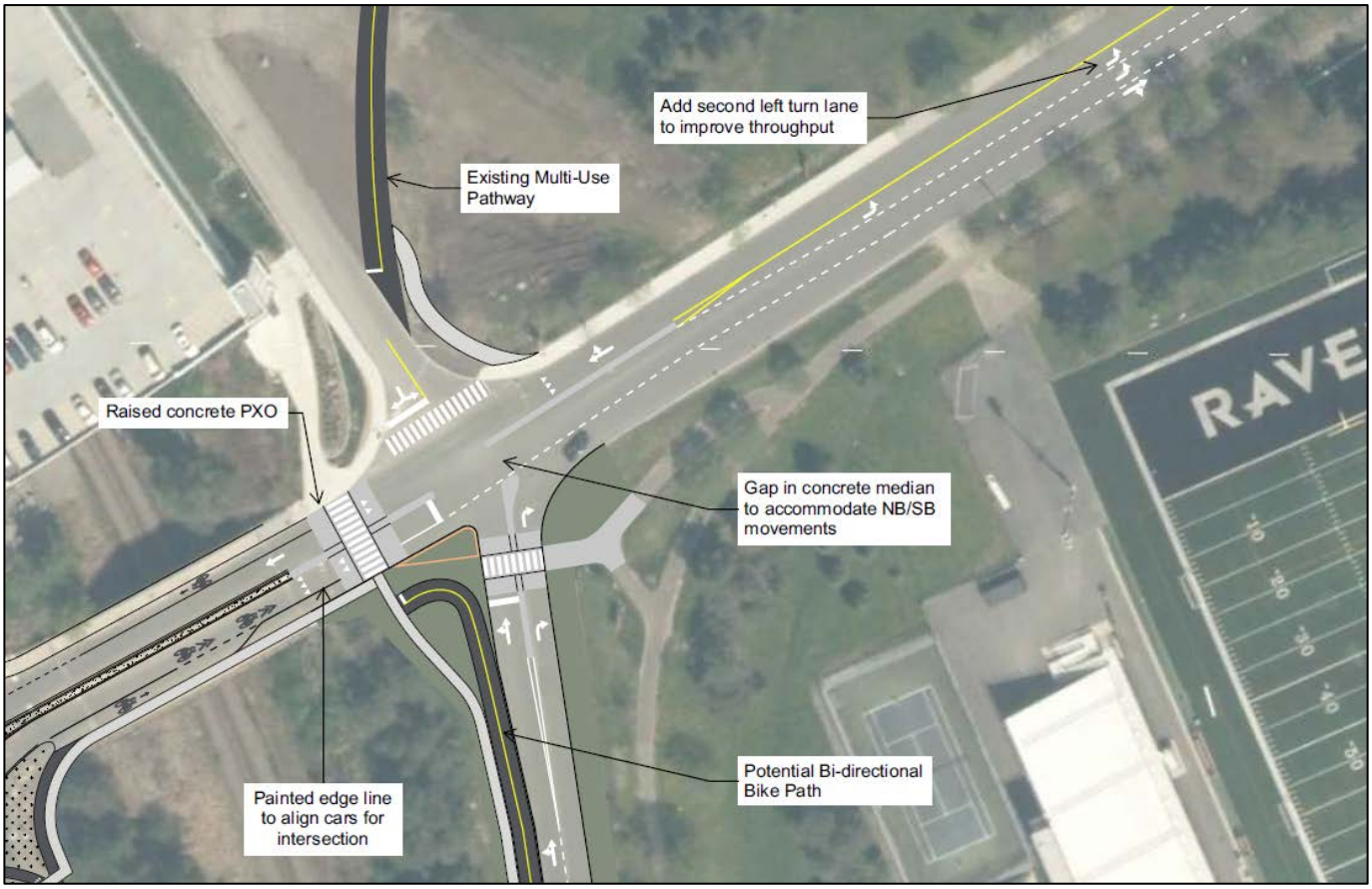
- Removes queue spillback concerns in WB direction at University Dr.
- Indirectly improves safety with fewer left-turn conflicting movements.
- Synergizes well with One-Way Conversion measure on University Dr northbound – which removes the enforcement concern.

Potential challenges:

- On campus accessibility – this forces people coming from Bronson Ave destined for facilities on the east side of the LRT tracks to travel the loop to reach destination.
- In addition to proper design (e.g. medians and signage), enforcement may be required to prevent this movement during early stages of implementation.
- Moves traffic bottleneck to Campus Ave N and Campus Ave intersection.
- Does not improve side-street traffic congestion.
- May impact emergency services; design should accommodate them.

A conceptual design drawing for the potential re-design of University Dr / Campus Ave N for WBL restriction is presented in **Figure 27.**

Figure 27 University/ Campus/ P7 Concept for WBL Restriction

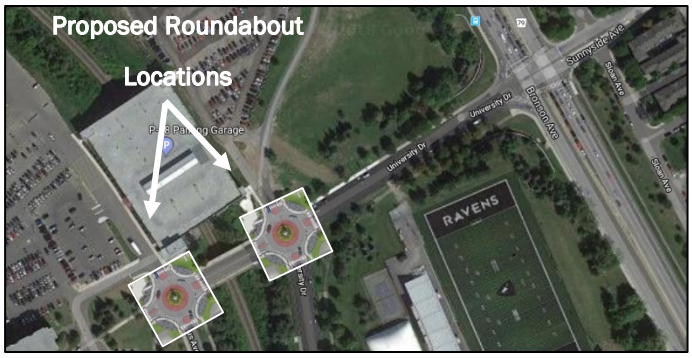


6.4.6. ROUNDABOUTS

Based on the traffic analysis, both short- and long-term congestion along the University Dr corridor between Bronson Ave and Campus Ave would be best mitigated via roundabouts. Roundabouts are very effective in these types of scenarios, where there is a large imbalance in traffic volumes (heavy in one direction and light in all others). An intersection that does not warrant an all-way stop control or traffic signals, this heavy movement, which is typically given free-flow priority, monopolizes the intersection capacity that results in heavy delays and congestion for all other movements.

Roundabouts equalizes priority to first-come first-serve basis. The centre-island forms a natural traffic calming measure, forcing the heavy movement to slow down, but not force a stop, and yield to vehicles already in the roundabout. This equal prioritization creates sufficient gaps in traffic flow for the low volume side-street traffic to enter and complete their movement. Roundabouts also provide aesthetic value. Specialized roadway treatments can be used, and the centre-island can be landscaped to function as a gateway feature.

Figure 28 Proposed Roundabout Locations



How this measure would address noted areas of concern:

- Reduces queue spillback and congestion in both directions along University Dr corridor
- Improves operations of side-street traffic, e.g. traffic exiting parking areas
- Naturally reduces speeds, which improves safety for pedestrians and cyclists
- Allows turnaround maneouvers for all vehicle types (e.g. fire trucks, transit)

- Provides aesthetic benefit, gateway features that coincides with Campus Master Plan

Figure 29 Example Roundabout as a Gateway Feature

Potential challenges:

- Space – requires large footprint and the O-Train bridge presents significant constraint. However, initial design review confirmed there is space to accommodate a roundabout at both locations.
- Driver unfamiliarity – while the number of roundabouts has increased in the City of Ottawa, they are still a small portion of the overall network and drivers may not be familiar on how to navigate it properly.

The roundabout level-of-service analysis have been provided in **Appendix G**. Conceptual drawings of the potential roundabouts are shown in **Figure 30** and **Figure 31**.

Figure 30 Roundabout Concept at Campus/ Campus Intersection

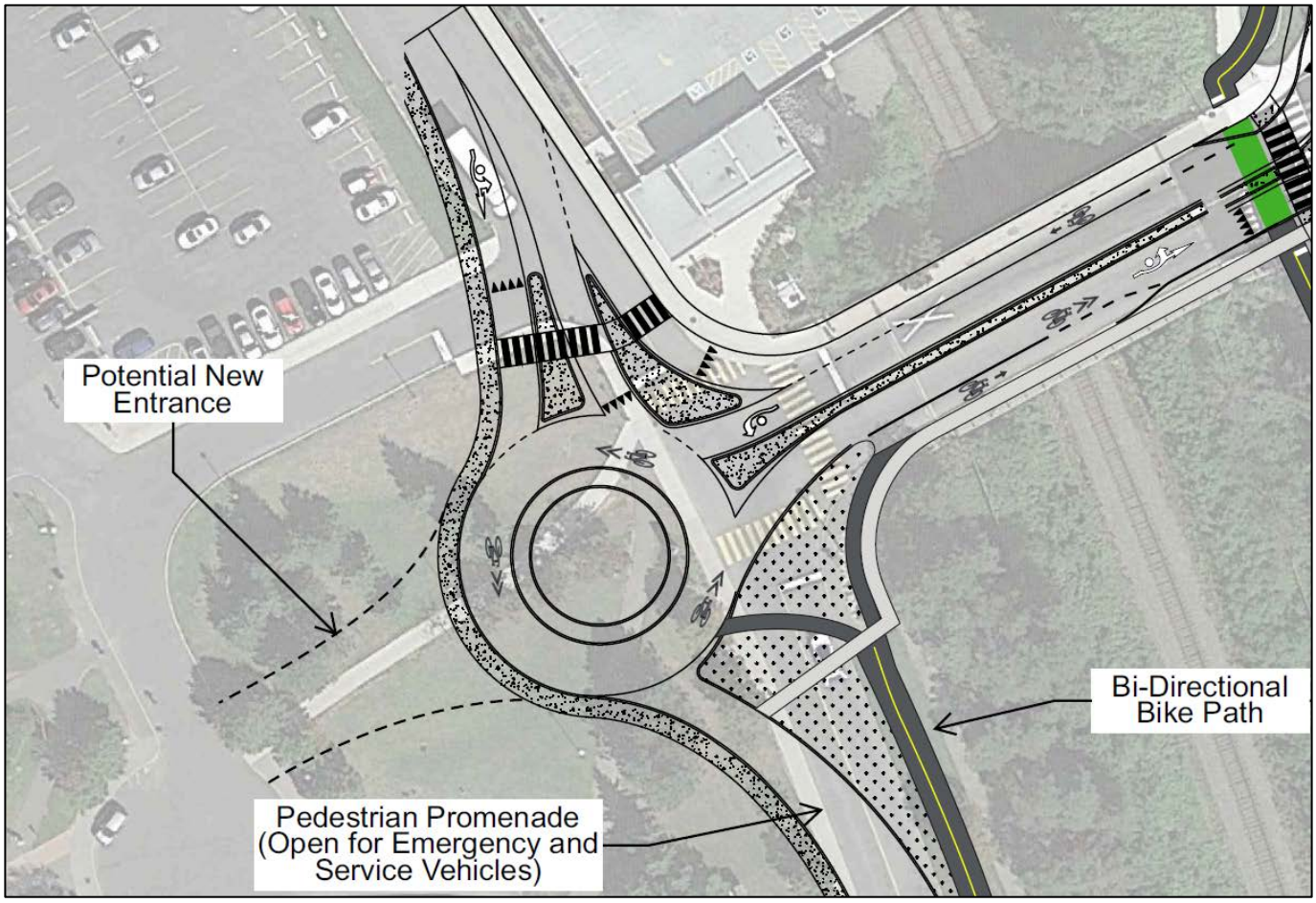
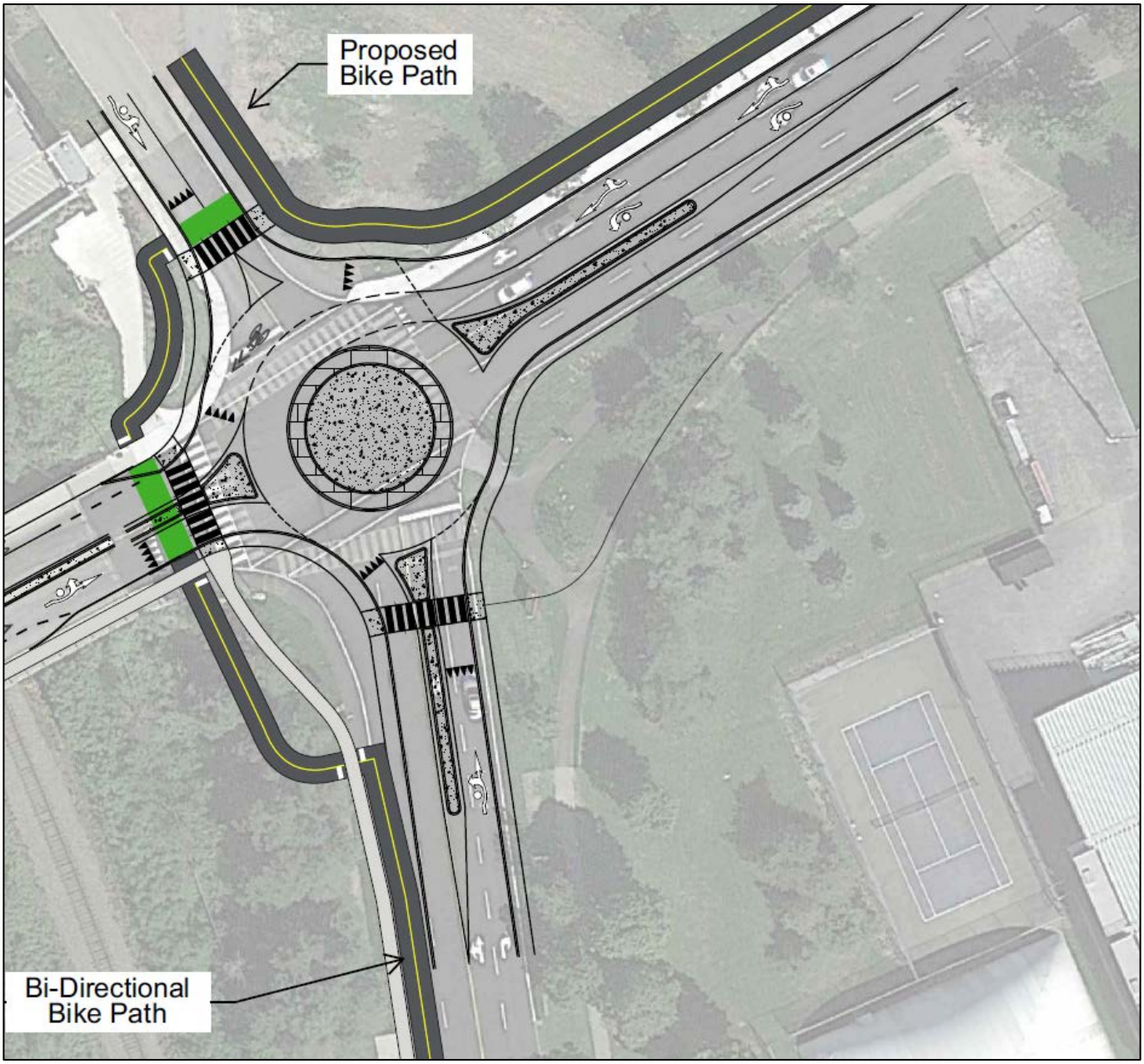


Figure 31 Roundabout Concept at Campus/ University/ P7 Intersection



6.4.7. COLONEL BY DR / UNIVERSITY DR S INTERSECTION MODIFICATIONS

The Colonel By Dr and University Dr S intersection was shown to operate within City of Ottawa standards. However, field observations noted that queues spillback from the intersection (westbound) that creates sightline concerns at the Library Road intersection. The traffic analysis confirmed that by adjusting the signal timing plan at this intersection to increase the WB green time and reducing it on Colonel By Dr, the westbound queue can be reduced to lower the risk of this conflict.

How this measure would address noted areas of concern:

- Reduces queue spillback and congestion on University Dr S near Library Road
- Indirectly improves pedestrian and cycling safety by reducing risk of sightline impacts

Potential challenges:

- Requires City of Ottawa and NCC approval
- Slight reduction in levels-of-service on Colonel By Dr.

6.4.8. PICK-UP/DROP OFF

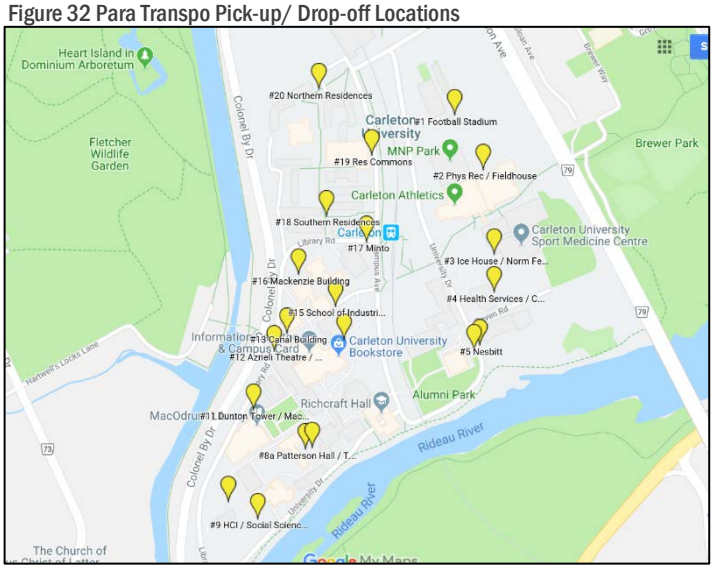
The university generates considerable pick-up/drop-off activity, including rideshare, taxis, school groups and "kiss and ride". As such, the provision of safe and efficient travel routes and pick-up/drop-off facilities is critical in the development of the Transportation Strategy. Currently, there are no formal pick-up/drop-off locations on campus, although significant pick-up/drop-off activity was observed in front of the University Centre and within P1 near the Library building. On the other hand, several designated pick-up/drop-off areas are provided for taxis and Para Transpo vehicles throughout the campus, as described below:

- **ParaTranspo pick-up/drop-off** – 20 designated ParaTranspo pick-up/drop-off points are provided throughout the campus. Designated locations are illustrated in **Figure 32.**

- **BlueLine Taxi pick-up/drop-off** – Designated taxi stand are provided at the Residence Commons Building and University Centre, in addition to designated pick-up points at the following locations:

    1. Athletics Building
    2. Day Care Building
    3. Robertson Hall
    4. Leeds Residence
    5. Campus Ave in front of Minto
    6. Steacie Building
    7. University Dr/Lot 8 in front of Loeb
    8. Lot 1, west of Southam Hall
    9. Dunton Tower/MacOdrum Library loading zone
    10. Library Road at the Azreili Theatre tunnel entrance.

Figure 32 Para Transpo Pick-up/ Drop-off Locations



With regards to pick-up/drop-off areas, the current un-formal drop-off location at University Centre will no longer be available with development of the Entry Quad in the 5-year horizon. Similarly, the Campus Master Plan includes a new development on the current P1 lot near the Library Building and this location will also no longer be available for pick-up/drop-off. Furthermore, with the reduction in parking space per capita as the campus developments, pick-up/drop-off zones are expected to increase in significance.

It is recommended that an 8-space designated pick-up/drop-off zone be created on University Dr by eliminating 8 on-street visitor parking spaces along the east side of University Dr between Raven Rd and P11 access (just across P11). Creating a drop off area on University Road just outside of the campus core may be beneficial in terms of reducing congestion from pick-up/drop-off activity within campus. It is also recommended that an additional 6-7 space designated pick-up/drop-off zone be provided along Library Road in front of Dunton Tower, however this would require the elimination of 6 permit parking spaces. Similar to the current Para Transpo and taxi designated pick-up/drop-off areas, these new areas would signed and posted appropriately and communicated through the University website.

With regards to Para Transpo and taxi pick-up/drop-off areas, it is recommended that the current locations be maintained, and that a new pick-up/drop-off area be provided at the future Entry Quad along Campus Ave. Considering school bus pick-up/drop-off during the summer, the proposed one-way movement along Campus Ave, presented in **Section 6.4.3**, will facilitate school bus drop-offs along Campus Ave without blocking the flow of traffic.

Figure 33 University Dr Bus Stop Pick-up/ Drop-off

6.4.9. EMERGENCY AND HEAVY VEHICLE CIRCULATION

As recommended in the Campus Master Plan, service and emergency vehicles will use the campus street system where possible, and use shared pedestrian service routes where street access is unavailable (e.g. northern section of Library Road). New campus developments will consider the delivery needs of future programs and these needs will be addressed during the detailed design of the new buildings. The University might also consider restricting large deliveries during the critical morning and afternoon peak periods.

Carleton University staff raised concerns with how heavy vehicles and emergency vehicle may be impacted by the different mitigation measures contemplated in this Traffic Assessment. The main concern was the O-Train bridge height restriction located at the south end of campus, as shown in **Figure 34**. This potential conflict was noted and reviewed.

Currently, the City of Ottawa height limit is 4.1m before oversize requirements are triggered. In this case, the majority of standard size vehicles and carriages should be accommodated by the current bridge structure. Any oversized vehicles are expected to provide a contingency plan to accommodate travel.

Figure 34 O-Train Bridge

6.5. SHORT-TERM (0 TO 5 YEARS) RECOMMENDATIONS

The following set of traffic specific recommendations have been staged based on the expected significant events within the Short-Term horizon. It was assumed that any modifications from the prior scenario will be completed for the following scenarios. This approach ensures continuity of the plan throughout.

There are expected to be simultaneous recommendations for other modes, i.e. Transit, Pedestrian, Cycling and Parking Strategies, which will not be revisited in detail here.

6.5.1. IMMEDIATE

It is recommended that Carleton University immediately implement the following measures:

1. Consult City of Ottawa to adjust signal timing plan at Colonel By Dr and University Dr S intersection to reduce queue impacts on the WB approach.
2. Implement Pick-up / Drop-off Area along east side of University Dr between Raven Rd and P11 access (in front of the Carleton Technology and Training Centre).

3. Implement localized traffic recommendations within parking areas and minor streets as outlined in the AECOM Report.

6.5.2. SCENARIO 1: HOG'S BACK SWING BRIDGE CLOSURE (2019)

The Hog's Back Swing Bridge Closure will create a significant change in Carleton University traffic patterns. It effectively closes off the Colonel By Dr from nearly 40% of inbound campus traffic in the morning peak hour. Although a formal Traffic Management Strategy has not yet been confirmed by NCC, the impacts are expected add significant strain to the University Dr - Campus Ave corridor.

To reduce the potential impact of this closure, significant modifications are necessary to reduce peak period traffic load on University Dr by providing alternate access to draw traffic away from this corridor; in addition to improving traffic flow by adjusting lane arrangements and restricting critical movements. Understanding the time and cost constraints of constructing new facilities prior to the closure, only the feasible measures were considered.

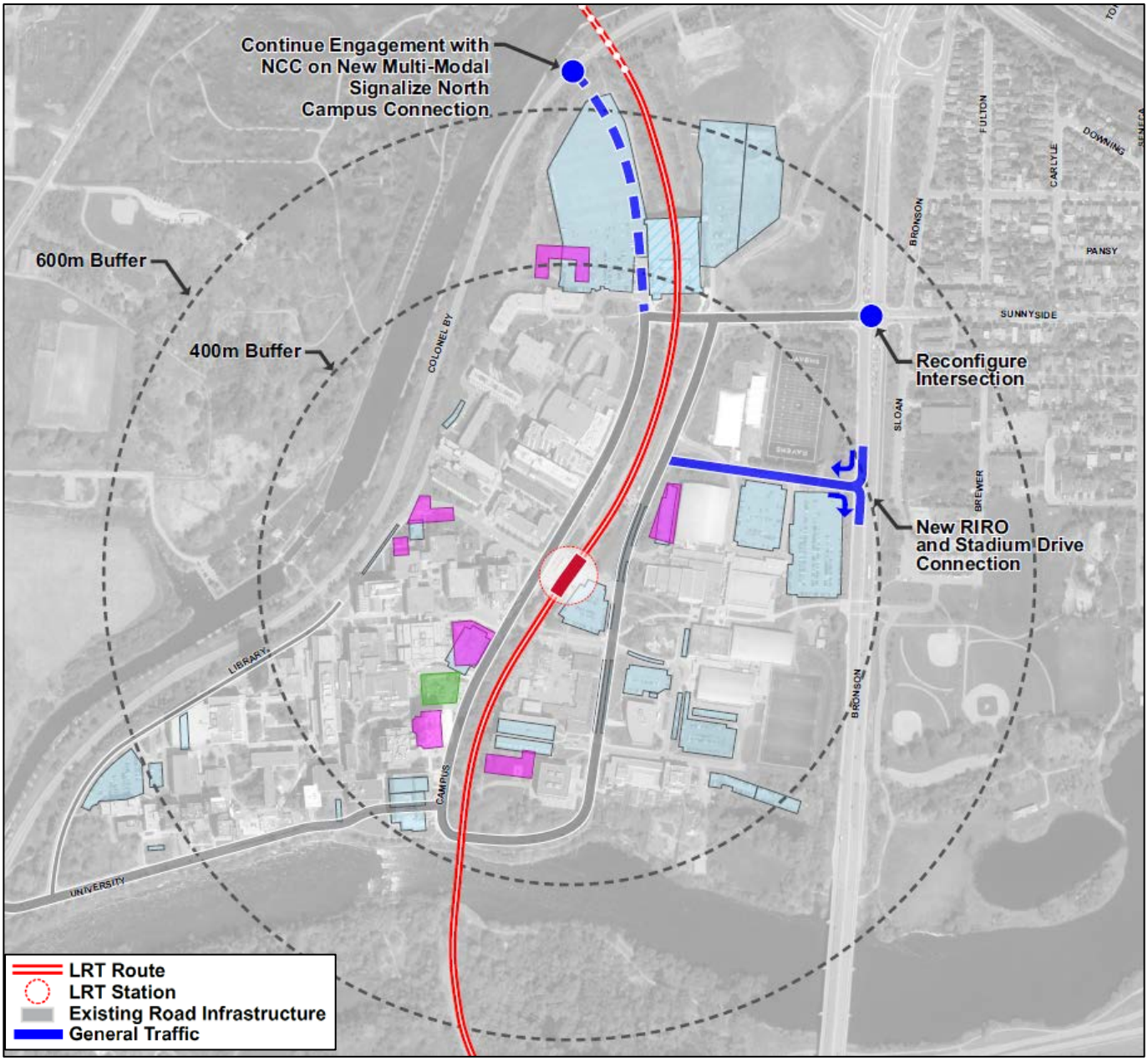
It is recommended that Carleton University implement the following road network modifications prior to the Hog's Back Swing Bridge Closure, as illustrated in **Figure 35**:

1. Complete construction of Stadium Way from Bronson Ave to University Dr. The access to Bronson Ave will be restricted to right-in right-out; Stadium Way design will incorporate or allow for future incorporation of active travel facilities, transit, pedestrian crossing treatments (PXOs), signage and lighting.
2. Consult with City of Ottawa to reconfigure the Bronson Ave and University Dr intersection to provide double EBL lanes, extend EBL storage lane and adjust the signal timing plan accordingly.
3. Continue consultation with the NCC in regard to a future north campus access off Colonel By Dr, in preparation for long-term implementation.

During the traffic evaluation, the north campus access was shown to be the most effective mitigation measure to reduce traffic demand on the University Dr – Campus Ave corridor. It is our understanding that the NCC is resistant to adding additional accesses off Colonel By Dr. One avenue to consider if the NCC will not permit the new access off Colonel By Dr would be to reduce the role of the existing Colonel By Dr access to the south or moving the existing intersection to the north campus location. The further north the Colonel By Dr access is, the more attractive it becomes as an overflow option to the University Dr/ Bronson Ave intersection without significantly impacting existing traffic routing. The traffic analysis confirmed there would be sufficient capacity at this intersection to accommodate this overflow.

The above recommendations are expected help mitigate the risks to the campus transportation network during the Hog's Back Swing Bridge closure.

Figure 35 Recommended Hog's Back Swing Bridge Interventions



6.5.3. SCENARIO 2: O-TRAIN LINE 2 CLOSURE (2020-2021)

The O-Train Line 2losure is expected to significantly increase bus traffic on campus. The R2 replacement bus service will be implemented for the duration of the Line 2 shutdown, and the frequency is expected to match the existing Line 2 service, up to 5-minute headway during the peak periods, and 10-minutes during the off peak.

The University Dr – Campus Ave corridor will be severely impacted by the increase in bus activity due to their size, slow movement and poor manoeuvrability. As such, the Hog's Back Swing Bridge mitigation measures may not be sufficient. The key pinch point was shown to be the Campus/ Campus intersection, which is an all-way stop today. Improving flow at this point will help reduce traffic congestion and impacts to transit.

This increase in bus traffic will significantly impact operations along the Campus Ave corridor, which has multiple bus stops, bi-directional traffic and limited layby space. The shut down will also exacerbate current concerns regarding unsafe vehicle-pedestrian interactions near the LRT and bus stop crossings.

It is recommended that Carleton University implement the following road network modifications prior to the Trillium Line Closure, as shown in **Figure 36** (note: this plan includes transit specific measures, which will be discussed further in **Section 7.5.3**):

1. Convert the section of Campus Ave between Campus Ave N and University Dr S (at the south end of campus) from two-way travel to one-way **southbound** travel to reduce vehicular-pedestrian safety risks and to improve transit operations and service along Campus Ave.
2. Convert the section of University Dr between the Lot P5 Access and University Dr from two-way travel to one-way **northbound** travel.
3. Reconfigure the Campus Ave N/ Lot P7 and University Dr intersection to:
    - Prohibit the WBL, EBR and SBT to support the one-way northbound conversion of University Dr; and,
    - Provide a channelized NBR with a direct receiving lane to improve NB flow
4. Construct a roundabout at the Campus Ave N and Campus Ave/ Lot P6 intersection, to better accommodate transit vehicles and reduce queue spillback
5. Modify the Campus Ave and University Dr S intersection to support the one-way southbound conversion of Campus Ave (e.g. signage, pavement markings, gate etc.)

A concept drawing showing the recommended University Dr – Campus Ave corridor modifications has been provided in **Figure 37**.

With the above recommendations, it's expected that the impacts from the Trillium Line closure can be accommodated by the campus road network. Note, specific design requirements for new intersections and noted reconfigurations will have to be confirmed.

Figure 36 Recommended O-Train Line 2 Shutdown Interventions

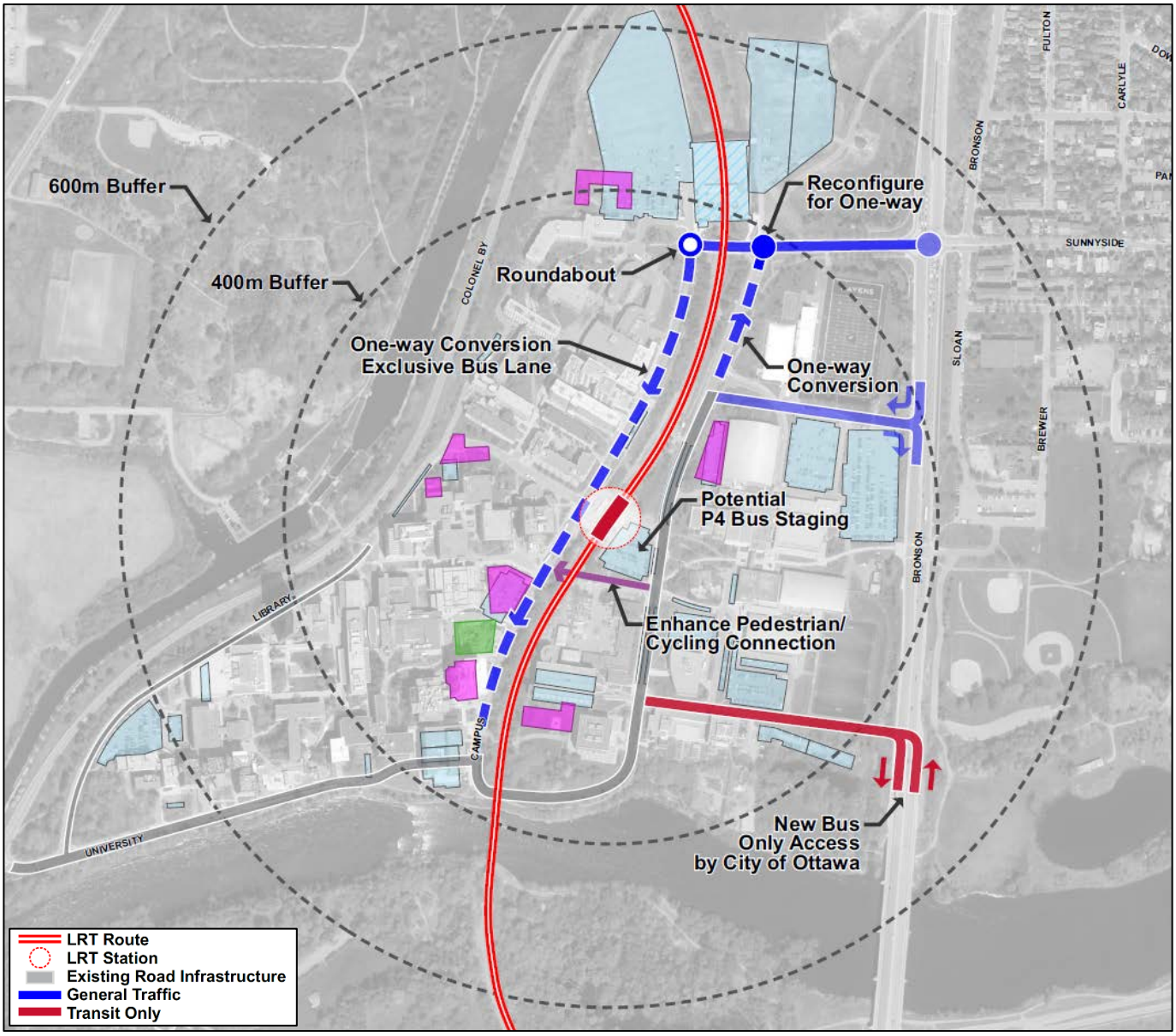


Figure 37 Short-Term University Dr Corridor Conceptual Design

6.5.4. SCENARIO 3: TRILLIUM LINE SOUTH OPERATIONAL (2021+)

Once the Trillium Line South is operational, LRT ridership is expected to increase significantly. Bus ridership is expected to plateau and bus activity on campus will drop due to the planned service route adjustments. Vehicular activity is expected to fluctuate with the opening of LRT and expansion of parking on campus; for the purposes of this study, it was assumed existing traffic volumes will remain constant.

Based on the traffic analysis of this future scenario, if all the previous recommendations were deployed, **no further mitigation measures were expected to be required**.

6.6. LONG TERM (5+ YEARS) RECOMMENDATIONS

The recommended road network mitigation measures were developed with the long-term vision outlined in the Carleton University Master Plan in mind. This plan is flexible and synergizes with the intents and goals heard throughout the consultation process, which focuses on reducing auto-usage on campus by supporting active transportation initiatives.

A favoured long-term plan that was presented to and endorsed by Carleton University was the idea of pedestrianizing Campus Ave between Campus Ave and University Dr (at the south end of campus). This plan would prohibit all general use vehicular activity on that section of the road network, with the exception of emergency/ service vehicles, deliveries and discretionary events (e.g. beginning and end of school year for moving).

With these long-term goals in mine, the recommended road network modifications as part of the Long-Term Strategy are as follows:

- Repurpose Campus Ave to a pedestrian/cycling promenade;
- Construct the North Campus road connection and access to Colonel By Dr;
- Construct a roundabout at Campus Ave/University Dr
- Convert University Dr between Stadium Way and University Dr to permit two-way traffic

The proposed roundabout and the conversion of University Dr back to two-way travel is required to support the pedestrianization of Campus Ave, which will prohibit general traffic. The roundabout will be designed to accommodate all vehicle types, which can then allow future transit service to be moved away from Campus Ave to University Dr. A concept of the future University Dr – Campus Ave corridor with back-to-back roundabouts is illustrated in **Figure 38**.

Additionally, long-term plans to relocate a significant portion of the campus parking supply to the north end of campus (e.g. P18) can be realized without additional modifications to the network to accommodate this traffic. A summary of the Long-Term Strategy is illustrated in **Figure 38** (note: the plan includes transit specific measures, but these items will be discussed further in **Section 7.6**).

Figure 38 Long-Term University Dr – Campus Ave Corridor Conceptual Design

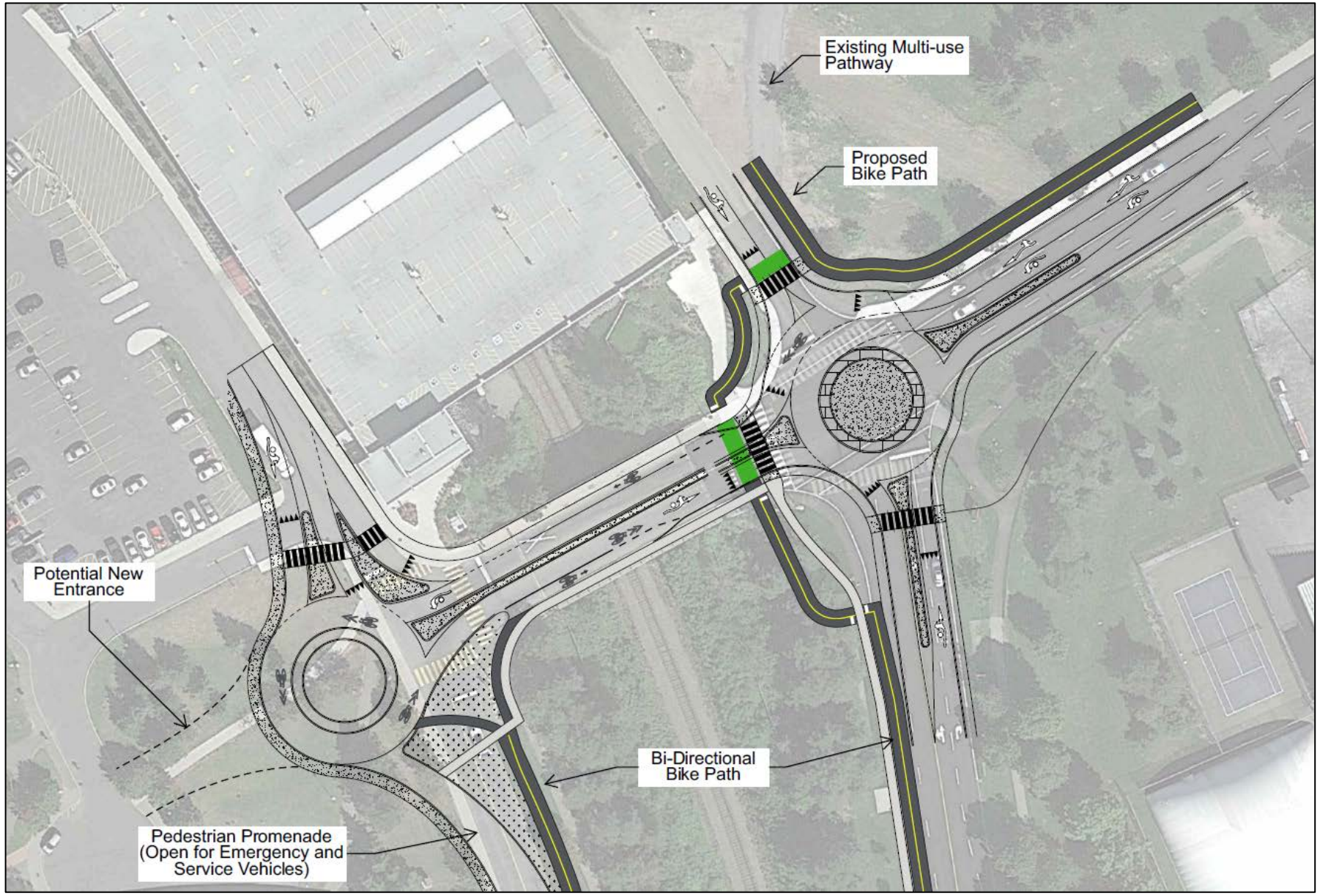
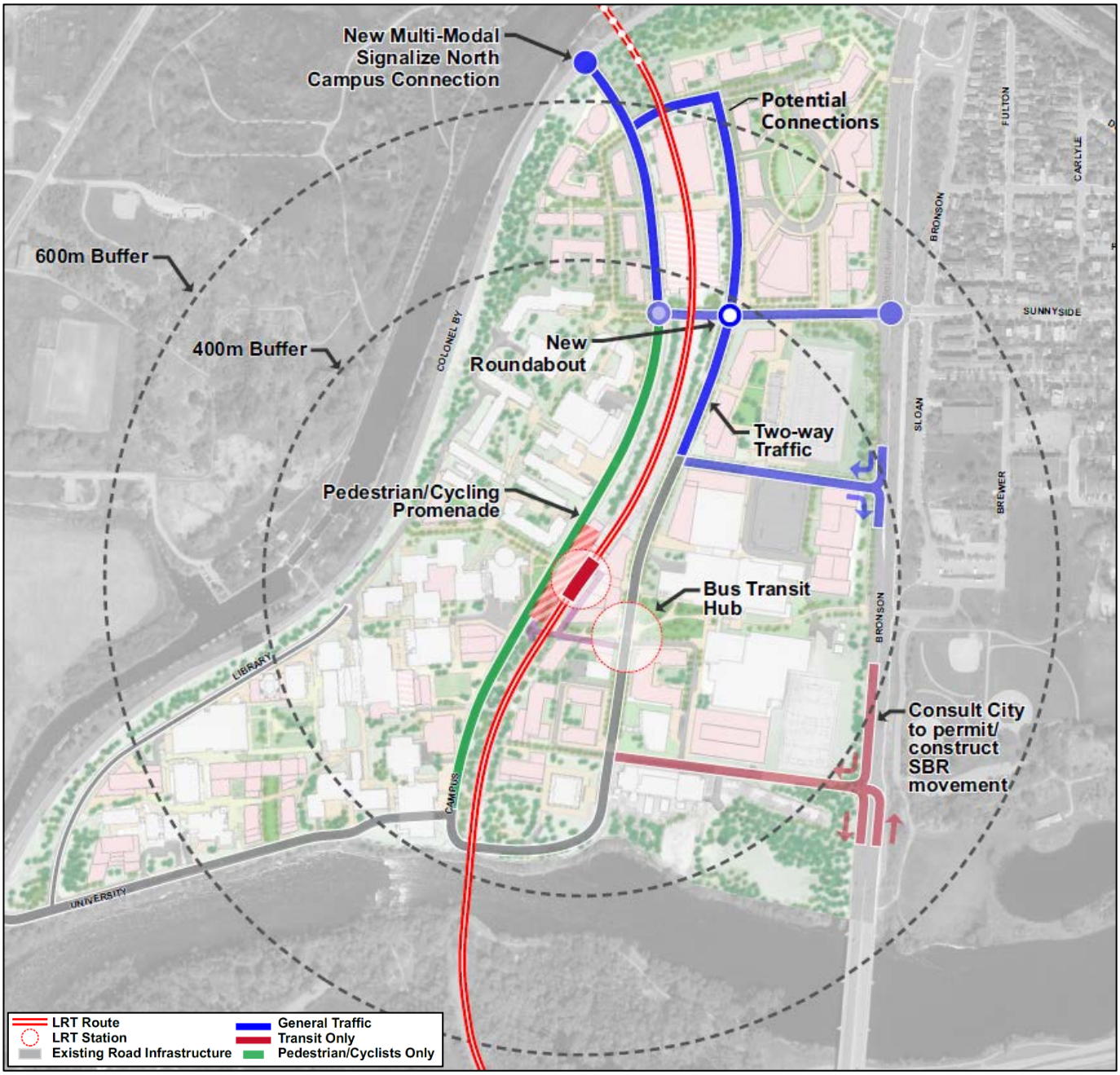


Figure 39 Recommended Long-Term Strategy



7. TRANSIT

7.1. EXISTING CONDITIONS

Carleton University is well serviced by transit. OC Transpo operates multiple routes to campus, via the Trillium Line LRT and conventional bus service. Existing transit conditions within campus are summarized below.

Transit Service

There are currently four bus routes and one LRT line that serve Carleton University, as described below.

- **LRT:** The current Trillium Line service operates between Bayview Station and Greenboro Station. Designated O-Train Line 2, it provides all-day service operating at 12-minute headways on weekdays, and between 12- and 15-minute headways on weekends.

Figure 40 O-Train at Carleton Station

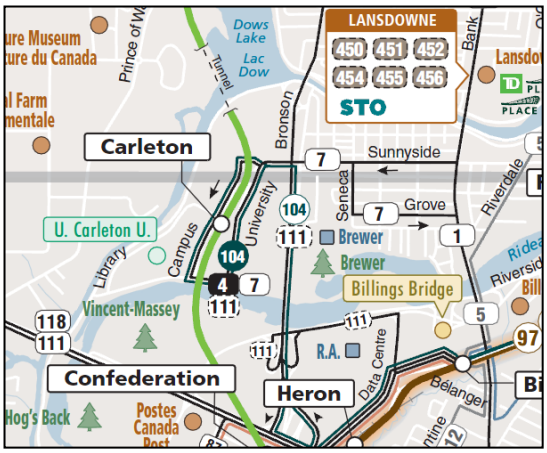
- **Bus:** There are four bus routes that enter Carleton University. In all cases, Carleton University is an end-point in the service line, meaning buses lay-up on-site to adhere to the service schedule and pick up passengers. A designated lay-by location is provided along University Dr. A summary of each transit service route is provided below:

Route #7 is an all-day service that operates on 12-minute headway during the morning and afternoon periods on weekdays. Off-peak service ranges between 12- and 15-minute headway. Weekend service operation ranges between 10- and 30-minute headway.

Route #10 (formerly Route #4) is an all-day service operating between Rideau Centre Station and Carleton University Station. This route operates on 15-minute headway during the weekday peak period, up to 30-minutes during the off-peak. Weekend service runs on 30-minute headway.

Route #104 is an all-day service operating between Place D'Orléans Station and Carleton University Station. The weekday service ranges between 10- and 30-minute headways; with 30-minute headway on weekends.

Figure 41 Existing Transit Route Map



Route #111 is an all-day service operating between Billings Bridge Station/ Carleton University Station and Baseline Station. The portion of the route between Billings Bridge and Carleton University only operates on weekdays and discontinues on weekends. The service runs on 12-minute headway during the weekday peaks, extending to 15-minutes during off-peak periods. This route operates on 30-minute headway on weekends.

OC Transpo also has detour R2 route, which is the replacement bus service that operates in lieu of the Trillium/ O-Train Line 2 during a shutdown. The service would generally operate on a similar frequency and schedule as the existing Line 2. However, confirmed schedule for the R2 route is only made available when Line 2 service is not running.

The existing campus OC Transpo route maps have been provided in **Appendix H**.

Transit Facilities

- **LRT:** The Trillium Line is an existing O-Train LRT line with 8 km of track and five stations between Bayview Station to the north, and Greenboro Station to the south, as illustrated in **Figure 42**.

  Carleton University Campus is among the three intermediate stops, between Carling Station and Mooney's Bay Station. The Carleton University Station facility is centrally located on campus, within the University Dr/ Campus Ave loop, as shown in **Figure 43**. The O-Train tracks have generally a north-south alignment, bisecting campus between University Dr and Campus Ave.

Figure 42 Existing Trillium Line

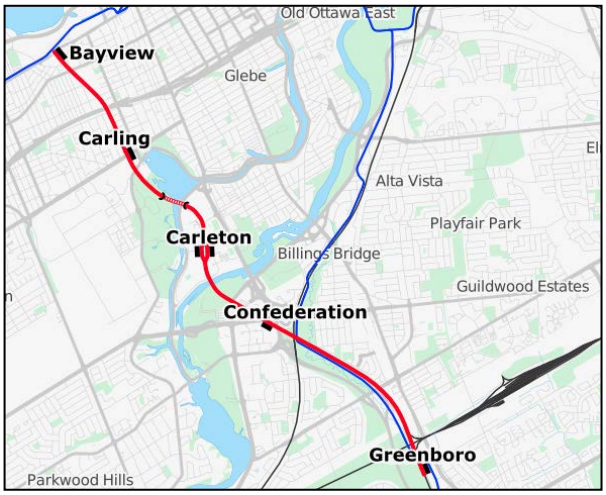
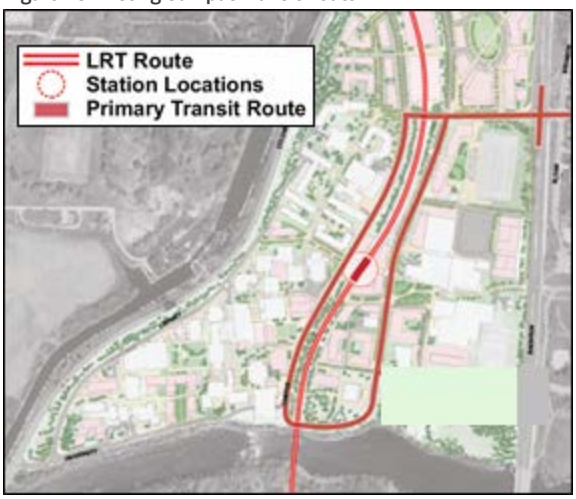


Figure 43 Existing Campus Transit Route



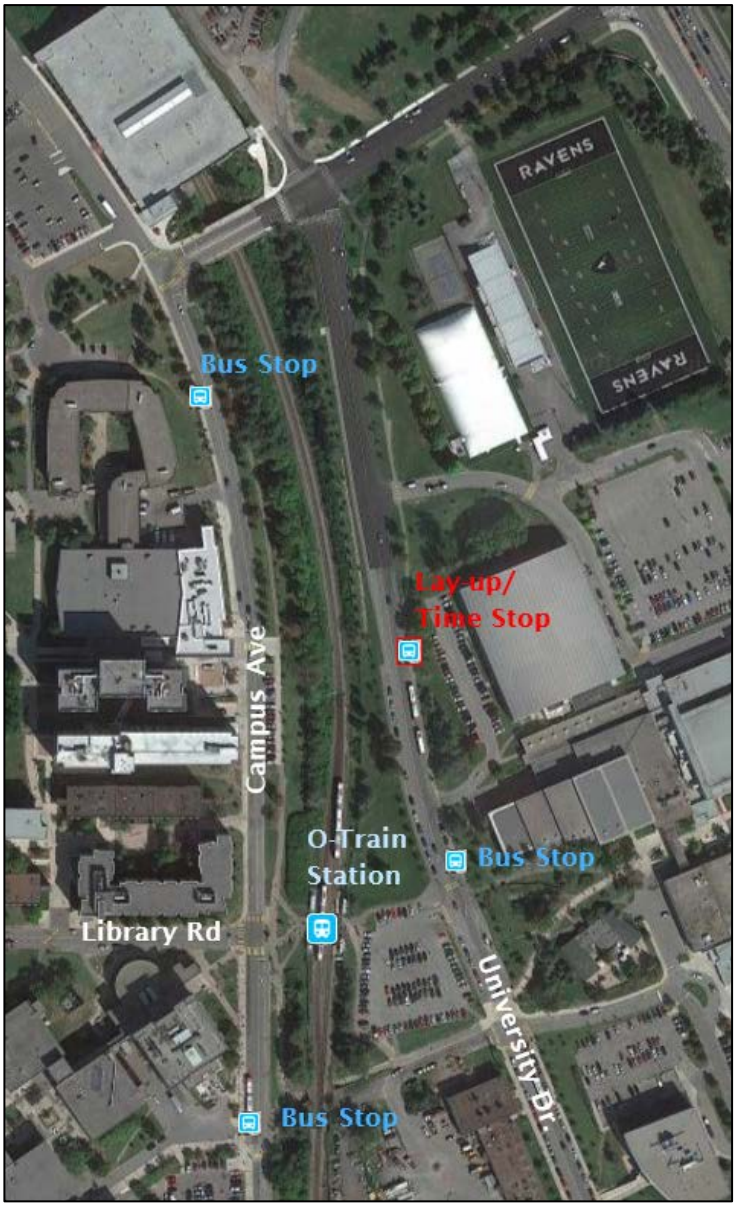
The O-Train Station platform for southbound trains is located on the west side of the tracks, which outlets passengers at the Campus Ave and Library Road intersection, adjacent to the Minto C.A.S.E building and the Prescott House Residence. The northbound platform is located on the east side of the tracks, which outlets passengers by the P4 surface parking lot off University Dr, near the Colonel By Child Care Centre and Carleton Athletics building. The station platforms provide heated shelters and asphalt pathways provide connections to adjacent network facilities.

- **Bus:** Buses make use of the University Dr and Campus Ave loop; there is a series of pick-up and/or drop-off stops on either side of the rail station, forming a transportation hub. The routing for all bus services is the same, entering via Bronson Ave and travelling counter-clockwise around the loop from Campus Ave. This path ensures pick-ups/ drop-offs are completed on the exterior of the loop where campus facilities are directly accessible, and prevent passengers from having to cross either University Dr or Campus Ave when going to/ from the bus stop. There are only two travel lanes (one in each direction) along the loop. However, bus stops are afforded laybys (segregated by curb extensions/ bulb outs) for loading/ unloading passengers, to avoid affecting general vehicular travel.

  As previously noted, Carleton University is the turn-around point for all bus routes arriving at campus. Therefore, the lay-up area along University Dr is where buses are required to stage to avoid disrupting or affect designated bus stops.

  The locations of the three designated bus stops and one designated lay-up area on campus is illustrated in **Figure 44**.

Figure 44 Existing Bus Stops

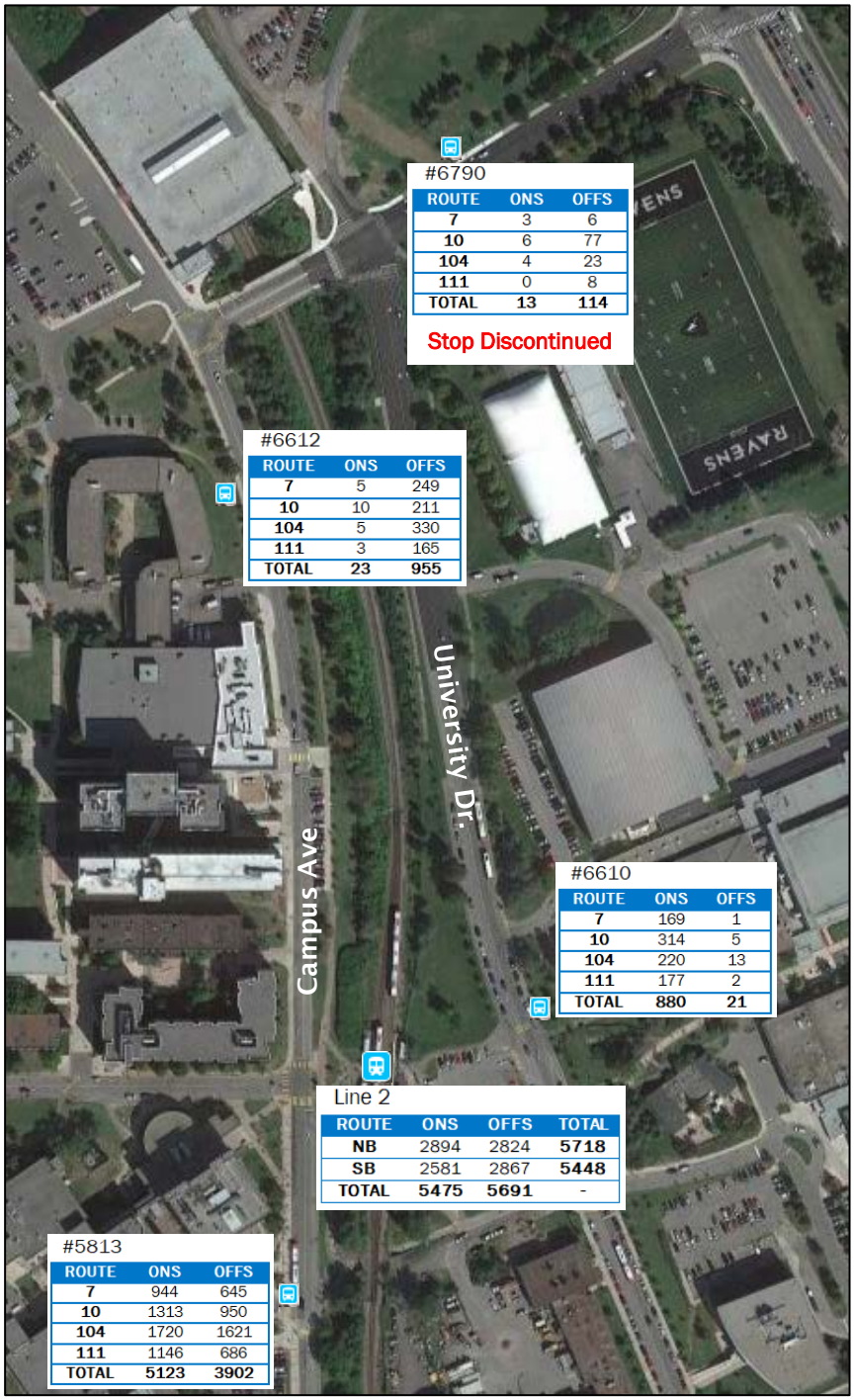


Two bus stops are located on Campus Ave and one located on University Dr. The first bus stop along Campus Ave is located by the Residence Commons buildings, approximately 60m south of the Campus Ave/ Campus Ave main road intersection. The second bus stop is approximately 350m further south, by the Minto C.A.S.E Building. The final bus stop is on University Dr, by the Physical Recreation Centre and the P4 parking lot. Both the Minto C.A.S.E bus stop and the Physical Recreation Centre Bus Stop bus stop are equipped with shelters, seating, and other amenities (receptacles, additional lighting etc.).

Transit Ridership

The most recent daily transit ridership data at all stops and at the Carleton University Station were provided by OC Transpo, and subsequently summarized in **Figure 45**. It is important to note that the stop on University Dr just west of Bronson was discontinued after the latest survey, however ridership information at this stop was presented for completeness.

Figure 45 Existing Daily Transit Ridership



The results show LRT ridership to be on par with bus ridership. This result was not unreasonable due to the current limits of the Trillium Line. Once the Confederation Line is operational and the Trillium Line Extension completed, LRT ridership on campus is expected to increase significantly.

Despite four separate bus stops, there is an overwhelming imbalance among bus stop utilization. Bus stop #5813, which is located by the Minto Building across, approximately 90m south of Library Road, is highly favoured over all other stops combined; over 5 to 1 for boardings and approximately 3 to 1 for alightings. This result is likely due to the vast majority of academic facilities being located in the southwest quadrant of campus. Therefore, most origin or destination points are located in this quadrant, and the closest stop would receive the highest amount of activity.

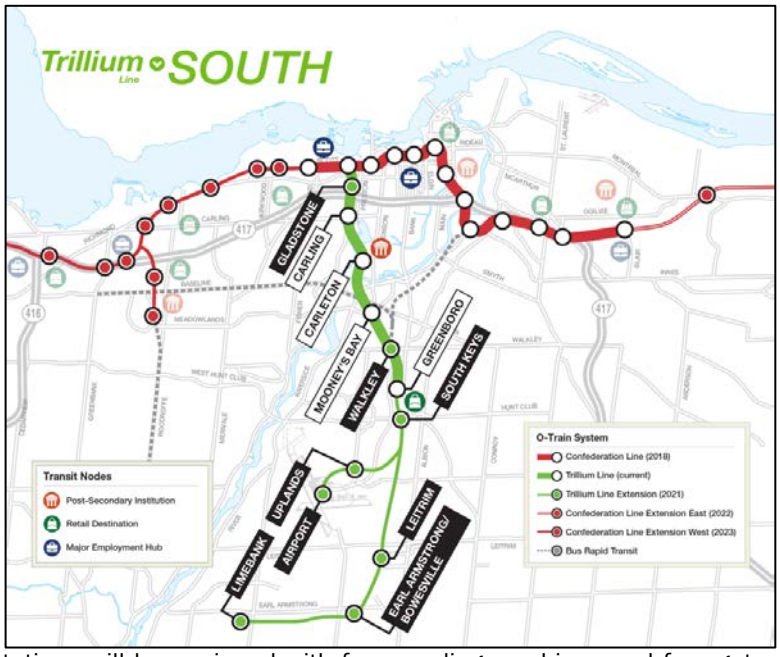
Route #104 had the highest ridership of all bus service, followed by Route #10 and Route #111. Route #7 had the lowest ridership.

7.2. FUTURE CONDITIONS

7.2.1. TRILLIUM LINE EXTENSION

Stage 2 LRT involves the extension of the Confederation Line east (to Trim) and West (to Moodie and Baseline), as well as the extension of the Trillium Line (OTrain) to Riverside South. Completion of the Trillium Line extension requires an estimated 18-month closure of the line for bridge rehabilitation and station enhancements along the route (including Carleton station). Planned closure is between May 2020 and late 2021.

Figure 46 Future Trillium Line South Route and Stations



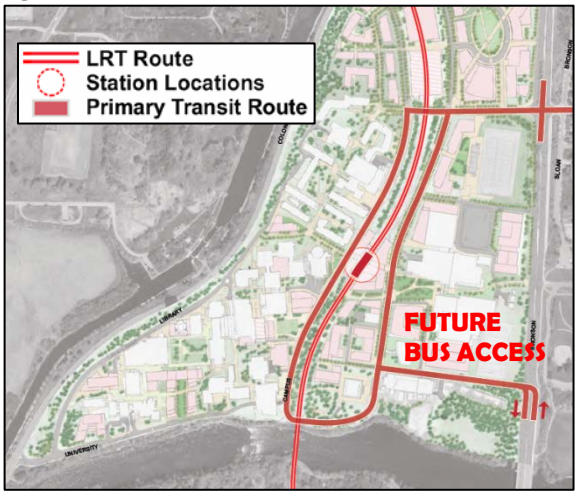
Trillium Line South is one of the three major extensions to Ottawa's light rail transit system, opening in 2021. The extension will see the Trillium Line continue from Greenboro to Limebank Road in Riverside South, along with an additional 3 km spur line to provide a connection to the Macdonald-Cartier International Airport. The extension of the Trillium Line, new stations and structures for grade separation will allow for future conversion to twin-track electric LRT. New stations will be equipped with fare vending machines and fare gates consistent with existing Trillium Line stations. In total, these extensions will add 16 km of track and eight new stations to the 8 km and five stations that Trillium Line provides today. (stage2lrt.ca)

Carleton Station is located in the heart of the Carleton campus, and is currently the most heavily used LRT station along the Trillium Line. In addition to providing service to Carleton University, Carleton Station also provides LRT service to the surrounding communities.

7.2.2. BUS SERVICE

Prior to the Trillium Line South opening, the existing Line 2 will be closed between 2020 and 2021 for construction. The R2 replacement bus service will be implemented for the duration of the Line 2 shutdown, between Bayview Station and Greenboro Station. The frequency is expected to match the Line 2 service, up to 5-minute headway during the peak periods, and 10-minutes during the off peak.

Figure 47 Future Raven Rd Bus Access



To help support the increase in bus activity on Campus from the R2 replacement service, OC Transpo is planning to construct a new bus-only access to Raven Rd off Bronson Ave, as shown in **Figure 47**. This new intersection will be signalized and only permit the northbound left-turn movement from Bronson Ave onto Raven Rd, and the reverse eastbound right-turn from Raven Rd onto Bronson Ave. With it, the R2 replacement service will be able to split the

northbound and southbound routes. The southbound route will follow the existing routing on campus, entering via University Dr/ Bronson Ave and stopping along Campus Ave, but it will exit at Raven Rd rather than University Dr. The northbound route will avoid Campus Ave altogether, entering via Raven Rd and stopping along University Avenue, then continue north via University Dr/ Bronson Ave. This intersection is planned to only accommodate the R2 replacement service.

Once the Trillium Line South is operational (post 2021), the R2 replacement line will cease. OC Transpo confirmed that the follow changes will be in implemented:

- Route #104 will be discontinued.
- Route #10 will be adjusted such that Carleton University will no longer be a turn-around point; the service will be extended to Parliament Hill and Hurdman Station. It is expected that this revised route will make use of the Raven Rd Access in the same way the R2 replacement service did during the Line 2 shutdown, e.g. northbound and southbound routes split between University Dr and Campus Ave utilizing Raven Rd. The frequency is expected to remain the same as existing operations.
- Route 111 is expected to operate in a similar manner to Route 10, entering via Raven Rd, and operating northbound via University Dr and exiting at the Bronson/Sunnyside intersection.
- Route #7 is the only route to remain unchanged post Trillium Line South opening.

7.3. AREAS OF CONCERN

The areas of concerns related to transit were stratified based on results of the online questionnaire, the site review process, and the upcoming O-Train shutdown. A summary of the key themes has been provided below.

7.3.1. EXISTING ISSUES

Online Questionnaire

Nearly 45% of all respondents to the online questionnaire were either dissatisfied or very dissatisfied with existing transit service. The top three transit specific comments were as follows:

1. *Buses overcrowded – increase frequency*
2. *Poor reliability – excessive delays*
3. *"Main" bus stop on campus is over-crowded and has insufficient bus capacity*

Two of the top three transit concerns were service related, which Carleton University has limited control over. Altering bus frequency and improving reliability is a network issue under the authority of OC Transpo, and may not be feasible to implement. However, there are localized issues that likely exacerbate these concerns, such as poor road network performance contributing to service delays. The third transit concern is directly related to bus stop design, which Carleton University can directly address. The existing transit ridership statistics, discussed in Section 2.3, highlight the disproportionately high number of passengers using the "main" bus stop on campus (located by the Minto Building), which likely triggers the poor performance.

Addressing these concerns must be a primary objective of the Transportation Strategy, since over 60% of respondents would be encouraged to take transit if the service/ facilities were improved. Reducing auto-oriented travel in favour of active modes is a key component of the Carleton University Master Plan.

With respect to bus service improvements, OC Transpo staff have previously indicated that they continually monitor ridership levels on all routes and propose adjustments to bus service in response to demand. Therefore, should more people take transit, OC Transpo will likely introduce additional service as warranted. Conversely, Carleton University would like to see increased bus service provided in order to encourage more employees, students and visitors to use transit to access their facilities. The two approaches are somewhat at odds with each other and represent the inherent disconnect which typifies transit service planning.

The on-line survey undertaken as part of this study is an attempt to address this disconnect. The data collected on general attitudes towards transit provide an ability to assess the most important issues and develop strategies which will hopefully encourage increased transit use and inform OC Transpo as they review potential service planning improvements.

General Site Review

A high-level review of the Carleton University exterior environment was completed to highlight some of the existing non-AODA compliant facilities. The details of this review related to transit facilities have been described below.

1. *Bus Stops – Various transit stop locations are non-compliant. Bench, garbage receptacle and accessible seating place are not provided. Benches and accessible seating places are particularly important for those with mobility disabilities.*
2. *Bus Shelters – Bus shelters appear to be in general conformance with AODA requirements. However, some online questionnaire respondents noted shelter capacity was insufficient and heaters were not working.*

Proactively addressing AODA non-compliance issues will help improve the overall quality of transit service, which reinforces the previous point; investing in improvements to service/ facilities is an important factor in encouraging auto-drivers to adopt transit.

7.3.2. FUTURE ISSUES

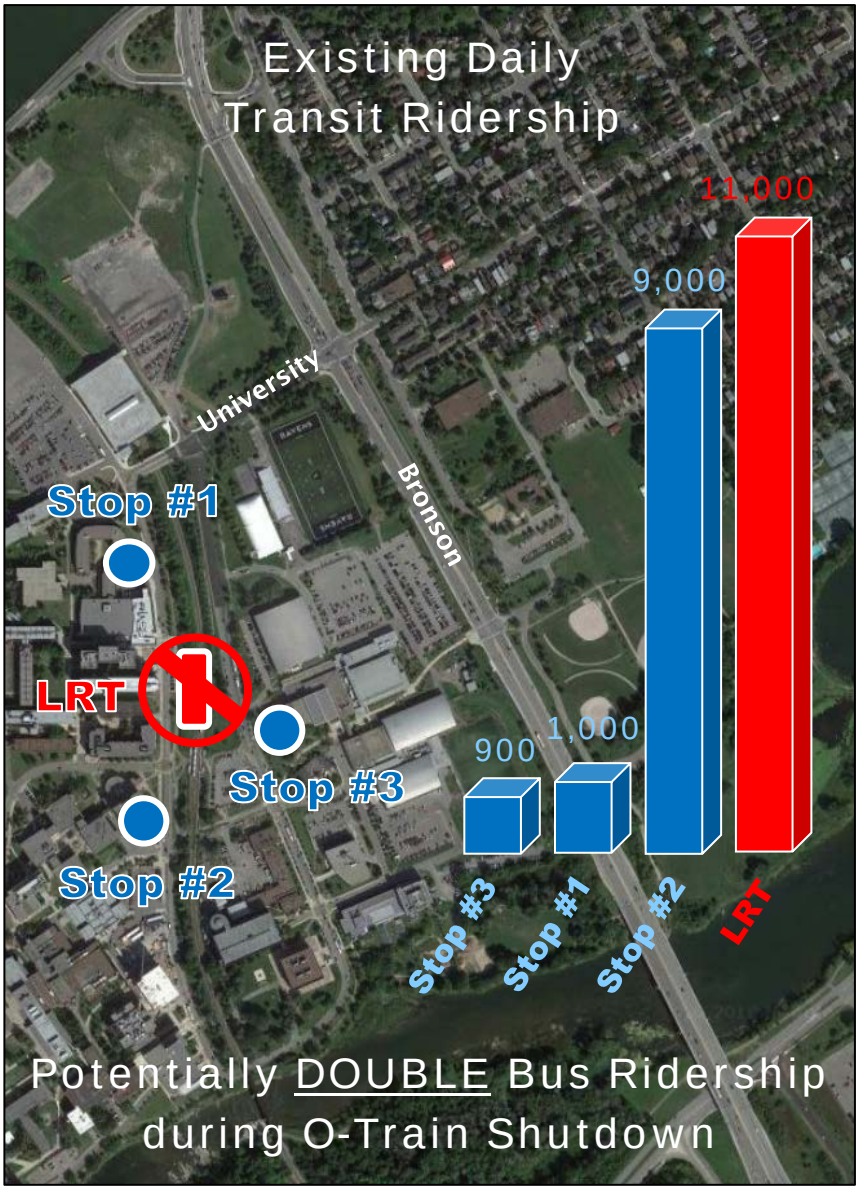
Hog's Back Swing Bridge

The Hog's Back Swing Bridge closure will only indirectly affect transit service operations by increasing congestion along the University Dr and Campus Ave coridor. The road network recommendations outlined in **Section 6.5.2** are expected to help mitigate these impacts; no specific transit interventions were required in this scenario.

O-Train Line 2 Shutdown

As previously discussed, the planned shutdown of O-Train Line 2 operations during construction of the Trillium Line Extension will trigger a significant increase in the number of buses entering campus during the peak periods via the R2 replacement service. Passenger demand at all bus stops will rise sharply, as outlined in **Figure 48**, creating additional strain at already congested platforms.

Figure 48 O-Train Line 2 Shutdown Ridership Impacts

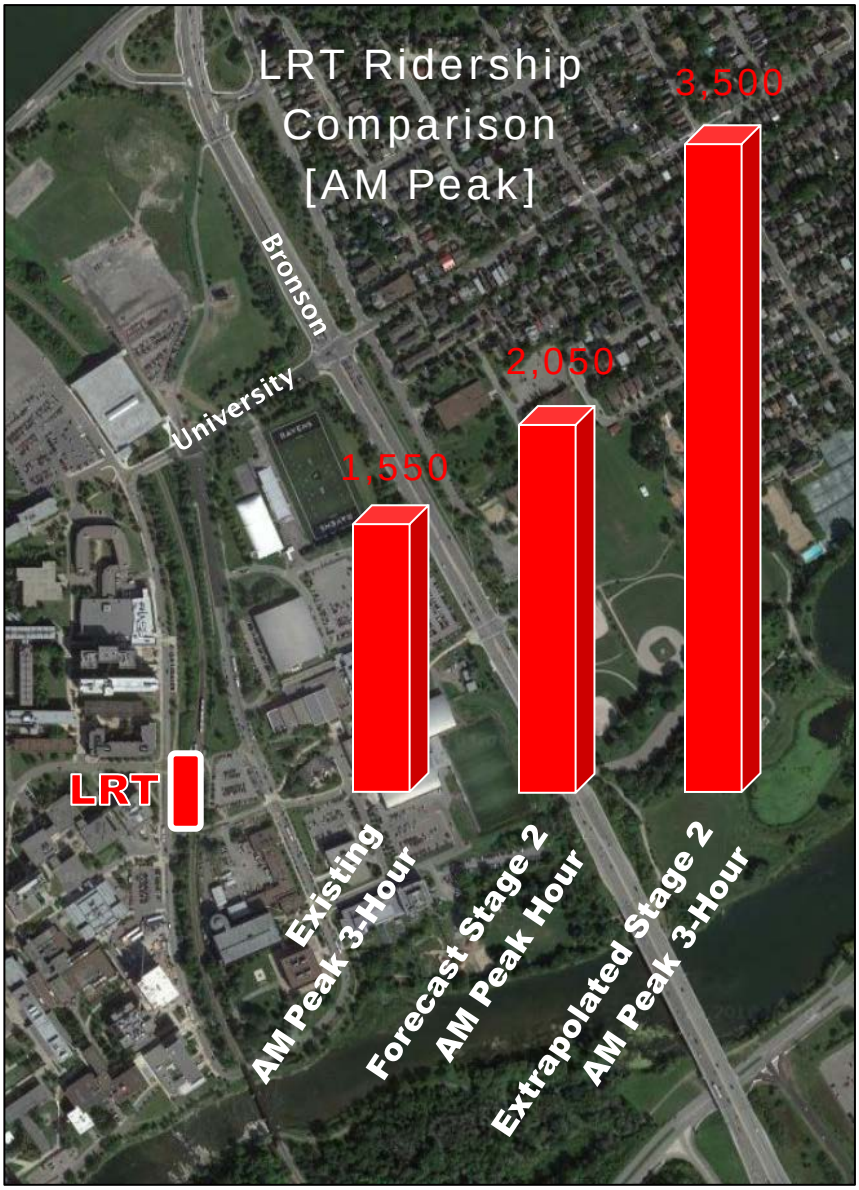


Managing the increase in bus traffic and passenger demand during the O-Train shutdown will be an important consideration in the overall transit strategy.

Trillium Line South Open

The opening of Trillium Line South will trigger an increase in campus LRT ridership. Bus traffic and ridership will decrease with the discontinuation of the R2 Bus Replacement Service, and OC Transpo plans to discontinue Route #104. The completion of the Stage 2 LRT (2023), LRT ridership at the Carleton University Station will increase significantly, as illustrated in **Figure 49**.

Figure 49 Trillium Line South Projected Ridership Comparison



The focus of the long-term transit strategy will need to address this increase in LRT ridership and how passengers connect to the campus active travel network. Existing concerns at the Campus Ave pedestrian crossings at Library Road and near the Minto Bus Stop will only be exacerbated once Stage 2 LRT is completed.

7.4. POTENTIAL MITIGATION MEASURES

A list of potential transit specific mitigation measures has been provided that can help reduce the risks and implications to transit service and facilities on campus. A summary of these mitigation measures, with a brief discussion of the expected benefit(s), has been provided below.

7.4.1. NEW RAVEN RD BUS ONLY ACCESS

As previously discussed, OC Transpo is planning to construct a new bus only access intersection off Bronson Ave at Raven Rd (towards the southeast end of campus). This new access intersection is being provided to accommodate the planned

R2 replacement bus service during the Trillium Line Extension closure (expected in 2020 and 2021). The current plan for the intersection only permits the northbound left-turn and eastbound right-turn movements.

This access intersection is an important component to the long-term transit strategy for Carleton University. It provides a secondary entry and exit point for buses that does not exist today (since Colonel By Dr does not permit bus traffic). Buses travelling northbound on Bronson Ave can now avoid having to travel along the entire campus loop, and remain on the east side of the LRT tracks (on University Dr). Having this redundancy also enables flexibility in service route allocation. Existing ridership numbers suggest the Physical Recreation Centre bus stop on University Dr is severely under-utilized and this new access can help balance passenger loading.

How this measure may address noted areas of concern:

- Reduces bus stop crowding by spreading pick-up/ drop-off passenger loads
- Improve service reliability by reducing the number of buses that travel the entire campus loop; avoiding the heavily congested Campus Ave corridor on the west side of the LRT tracks
- Improve service frequency with fewer overlapping routes, thereby potential route capacity increases

The potential benefits of this access may be further enhanced in the future if the City of Ottawa/ OC Transpo considered permitting the eastbound left-turn and southbound right-turn movements and/or, permit service vehicles or oversized vehicles to use this access. These enhancements would allow even more flexibility to re-route existing bus service and further reduce campus congestion along auto-dominated portions of the campus loop.

Potential challenges:

- Traffic implications on Bronson Ave

7.4.2. ADJUST BUS ROUTE ALLOCATION

In follow up to the previous mitigation measure, adjusting future bus routes to take advantage of the Raven Rd bus access intersection would help mitigate transit congestion along the Campus Ave corridor.

Existing ridership numbers confirmed that the vast majority of bus passengers board at the “main” bus stop on Campus Ave, by the Minto C.A.S.E Building. This is partly due to its location near campus facilities, but also due to route design. Online questionnaire respondents noted that passengers would be willing to use the Physical Recreation Centre bus stop on University Dr, but buses are full by the time they arrive. This was confirmed during onsite investigations. As a result, passengers are forced to use the bus stop that is further upstream, so they catch buses while they are not at capacity.

If the proposed Raven Rd bus access was modified to permit southbound right-turns, existing service routes could be split, with two routes completing all pick-up and drop-offs on University Dr. The negative impact to these passengers is the increased walking distance, to cross the LRT tracks. However, these impacts can be mitigated by provided enhanced pedestrian facilities, e.g. enhanced lighting, canopies/ sheltered facilities, widened sidewalk treatments etc.

How this measure may address noted areas of concern:

- Reduces bus stop crowding by spreading pick-up/ drop-off passenger loads
- Improve service reliability, by reducing the number of buses that travel the entire campus loop; avoiding the heavily congested Campus Ave corridor on the west side of the LRT tracks
- Improve service frequency with fewer overlapping routes, thereby potential route capacity increases
- Reduces bus stop crowding by spreading pick-up/ drop-off passenger loads

Potential challenges:

- Increases walking distance for passengers destined to southwest quadrant of campus
- Lack of protected/ enhanced connections across LRT tracks

7.4.3. INCREASE BUS STOP PLATFORM SIZE

A major concern cited by the online questionnaire respondents was the lack of passenger capacity at the "main" bus stop. The existing platform does not have sufficient capacity to accommodate all users. Furthermore, the platform also acts as a sidewalk within the boulevard, so it forces pedestrians simply passing through to either redirect or push through waiting transit users. Increasing the size of the platform, either lengthening or widening, would help accommodate the overflow of passengers.

However, a key constraint with increasing the size of the platform is whether there is available space to convert to the platform. Additional length may be accommodated by converting on-street parking, which is already in short supply. Extra width can be had by reclaiming existing lane space, which would adversely affect road network operations.

How this measure may address noted areas of concern:

- Reduce bus stop crowding by increasing the bus stop platform size

Potential challenges:

- Limited space – would require taking space from travel lanes or property for extra width or on-street parking/boulevard space for extra length

The 2nd Edition of the Transit Capacity and Quality of Service Manual (produced by the Transportation Research Board) provides Level of Service standards for passenger queuing areas. These standards are presented in **Table 12** below.

Table 12 Levels of Service for Passenger Queuing Areas

LOS	Average Pedestrian Area (ft^2/p)	Average Pedestrian Area (m^2/p)	Average Inter-Person Spacing (ft)	Average Inter-Person Spacing (m)
A	≥ 13	≥ 1.2	≥ 4.0	≥ 1.2
B	10-13	0.9-1.2	3.5-4.0	1.1-1.2
C	7-10	0.7-0.9	3.0-3.5	0.9-1.1
D	3-7	0.3-0.7	2.0-3.0	0.6-0.9
E	2-3	0.2-0.3	<2.0	<0.6
F	< 2	< 0.2	*Variable*	*Variable*

Source: Transit Capacity and Quality of Service Manual, 2nd Edition (TRB, 2003), Exhibit 7-8

The proposed platform extension will result in approximately 500 m2 of usable space, the platform can accommodate approximately 500 passengers at a time at LOS C (500 m2 / 1.0 m2/person = 500 passengers). The maximum platform loading in the PM peak hour is estimated to be less than 500 people. Thus, the proposed platform extension would appear to be adequate.

7.4.4. ONE-WAY ROAD CONVERSION

The University Dr and Campus Ave loop is currently bi-directional, with one travel lane in each direction. While this configuration provides greater mobility and accessibility within campus, it creates increases turning movement conflicts at intersections and crossing points. The most problematic location noted in the online questionnaire and during site investigations was the University Dr/Campus Ave intersection. An example of how this measure could be applied, would be to convert the south leg at this location to a northbound one-way configuration. This would prohibit the westbound left-turn, but greatly improve traffic flow.

An additional benefit of this measure is that it reclaims roadway space that can be used for alternative uses, ideally to support active transportation modes (i.e. transit, pedestrians and cyclists).

However, careful consideration has to be made when planning for this measure, to ensure long term plans for the campus are not adversely affected. One-way conversions can severely limit the accessibility to/from key facilities, which may create

enforcement issues that impact safety and general dissatisfaction of local users. Furthermore, one-way conversions will require up and downstream modifications (at additional cost) to ensure prohibited movements are enforced.

How this measure may address noted areas of concern:

- Improve vehicular traffic flow/ reduce vehicular congestion on the campus road network during the expected closure, which will help improve bus operations and reliability;
- Reclaimed lane space may be converted for alternative mode uses, e.g. transit platform width
- One-way operations improve safety at crossing points with pedestrians/cyclists

Potential challenges:

- May significantly reduce accessibility/ mobility on campus
- Potential impact to emergency services
- Impacts to general traffic operations

7.4.5. ENHANCE BUS STOP FACILITIES AND CONNECTIONS

Field investigations noted that only two bus stop locations (the Minto C.A.S.E building bus stop and the Physical Recreation Centre bus stop) have shelters and appropriate amenities. Some locations do not have shelters, benches, garbage receptacles and accessible seating, which do not comply with COADS/ AODA standards. Augmenting existing stop locations to adhere to these standards would help improve service quality (comfort and convenience), which helps increase the likelihood of future adoption by auto-drivers.

Enhancing connecting facilities would also help increase convenience and comfort to/ from existing bus stop locations. An example of this is the planned O-Train pedestrian underpass enhancement, where the City is widening the current 3m underpass to 9m, to better serve passengers crossing the LRT tracks. Covered treatments/ canopies and pathway enhancements to/ from bus stops that connect to the tunnel system and/or O-Train pedestrian underpass would build off the planned underpass enhancement.

How this measure may address noted areas of concern:

- Meets AODA/ COADS compliance standards for transit facilities
- Indirectly reduces bus stop crowding by improving transit comfort and convenience (transit service quality) that encourages use of the Physical Recreation Centre bus stop

Potential challenges:

- Throwaway costs if short-term measures do not fit long term transit strategy

7.4.6. MODIFY INTERSECTION DESIGN TO IMPROVE TRAFFIC OPERATIONS

The University Dr – Campus Ave corridor is extremely congested during the peak periods. This conclusion is supported by both onsite investigations and online questionnaire results. The noted recommendations in the **Section 6: Road Network** will help improve traffic flow and thereby, transit service.

How this measure may address noted areas of concern:

- Improve service reliability, by reducing congestion along the University Dr corridor

Potential challenges:

- Timing and feasibility of implementation prior to O-Train shutdown

7.5. SHORT TERM (0 TO 5 YEARS) RECOMMENDATIONS

The following set of transit specific recommendations have been staged based on the expected significant events within the Short-Term horizon. It was assumed that any modifications from the prior scenario will be completed for the following scenarios. This approach ensures continuity of the plan throughout.

There are expected to be simultaneous recommendations for other modes, i.e. Traffic, Pedestrian, Cycling and Parking Strategies, which will not be revisited in detail here. However, any overlapping measures that are essential to the Transit Strategy will be noted.

7.5.1. IMMEDIATE

It is recommended that Carleton University immediately implement the following measure:

1. Bus stops should be proactively upgraded to be made COADS compliant based on consultation with OC Transpo (as outlined in **Section 4**).

7.5.2. SCENARIO 1: HOG'S BACK SWING BRIDGE CLOSURE (2019)

It is recommended that Carleton University implement the corresponding road network modifications recommended in **Section 6.5.2** in lieu of the Hog's Back Swing Bridge closure. Those recommendations will help improve general traffic flow along the University Dr – Campus Ave corridor and help maintain transit service efficiency and reliability.

No transit specific measures are recommended.

7.5.3. SCENARIO 2: TRILLIUM LINE (O-TRAIN LINE 2) CLOSURE (2020-2021)

It is recommended that Carleton University implement the corresponding road network modifications recommended in **Section 6.5.3** in lieu of the Trillium Line closure. The transit specific mitigation measures from that plan, shown again in **Figure 50**, include the following:

1. Convert the section of Campus Ave between Campus Ave N and University Dr S (at the south end of campus) from two-way travel to one-way **southbound** travel to reduce vehicular-pedestrian safety risks and to improve transit operations and service along Campus Ave.
2. In conjunction with the one-way Campus Ave conversion southbound, convert the curb-side lane along Campus Ave to a designated transit lane, marked and signed accordingly, between Campus Ave N and University Dr S
3. Coordinate with OC Transpo to ensure completion of the Raven Rd bus only access intersection; investigate options to redirect either Route #104 or #111 to Raven Rd if Campus Ave bus stops become too congested
4. Enhance the existing pathway connection between the University Dr bus stop and the pedestrian underpass (e.g. provide separate bidirectional facilities for pedestrians and cyclists)
5. If passenger loading areas on University Dr are insufficient, consider converting Lot P4 into a bus staging area, to supplement the existing stops/ layby areas

The road network modifications are intended to further mitigate traffic flow disruptions on the campus road network during the expected O-Train closure, which will help improve bus operations and reliability. The one-way lane assignment on Campus Ave allows for an exclusive southbound bus-lane and a travel lane, which not only helps improve transit service reliability, but it accommodates an increase in frequency, since there will be more lane capacity for additional buses. Furthermore, the sections of Campus Ave where existing laybys exist can be reclaimed to widen the existing bus stop platforms, to reduce crowding and increase transit quality of service. A conceptual view of this arrangement is shown in **Figure 51**.

Figure 50 Recommended O-Train Line 2 Shutdown Interventions

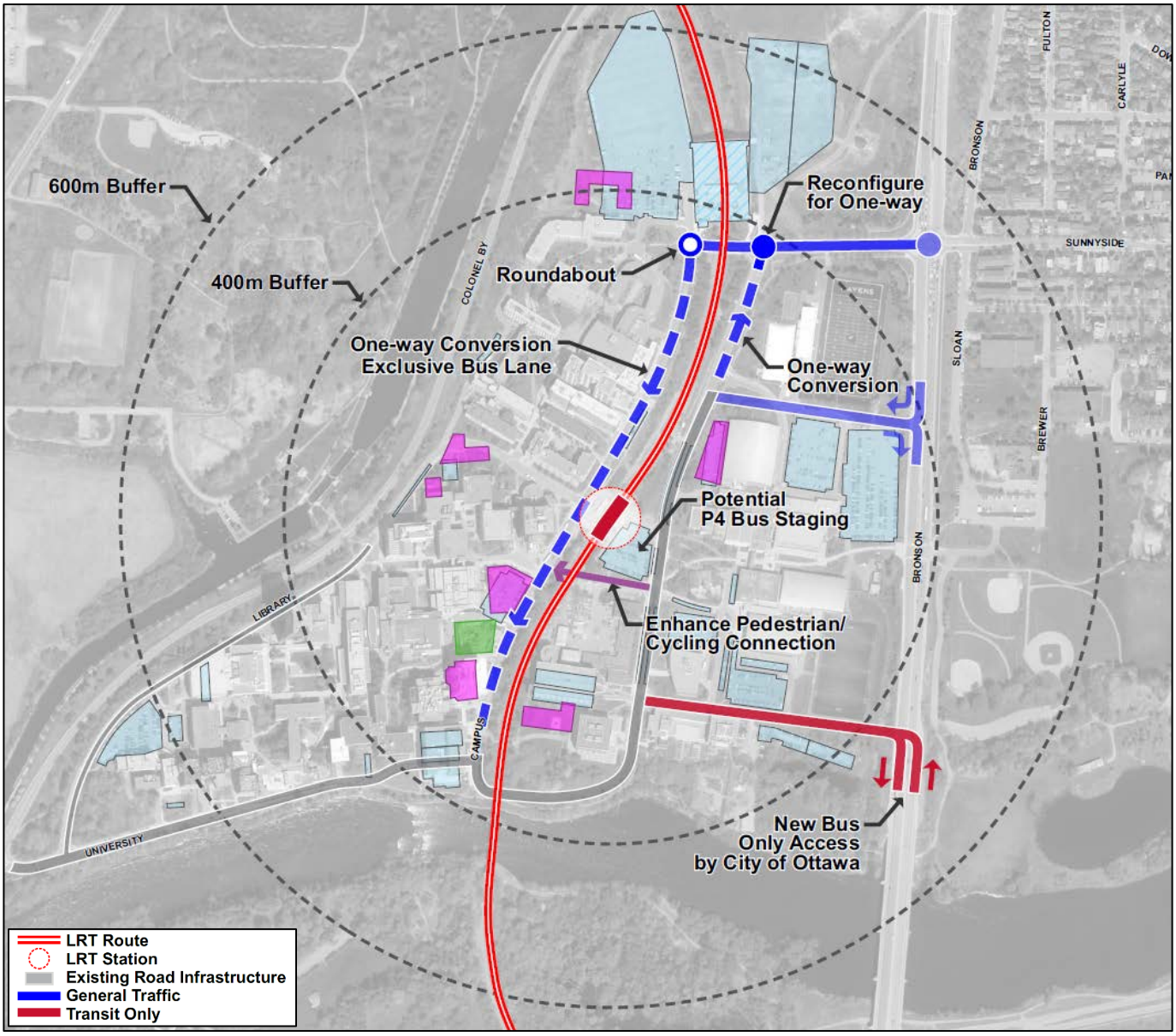
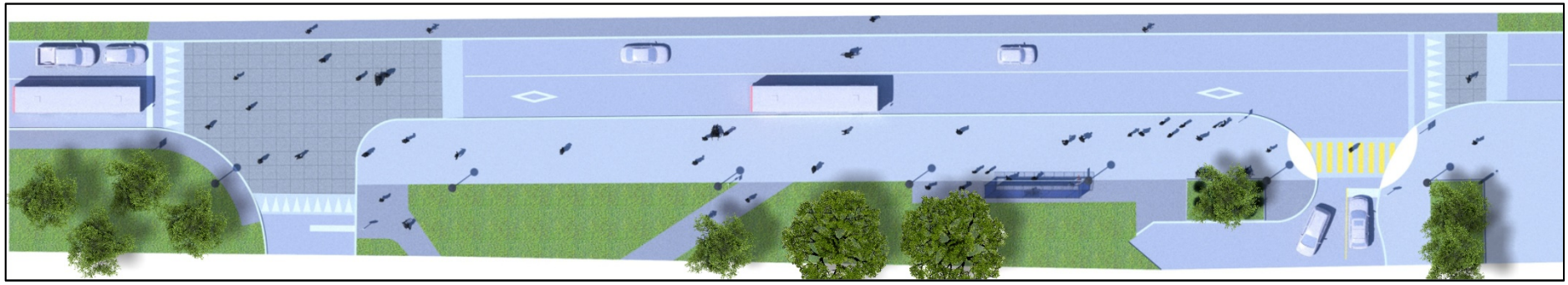
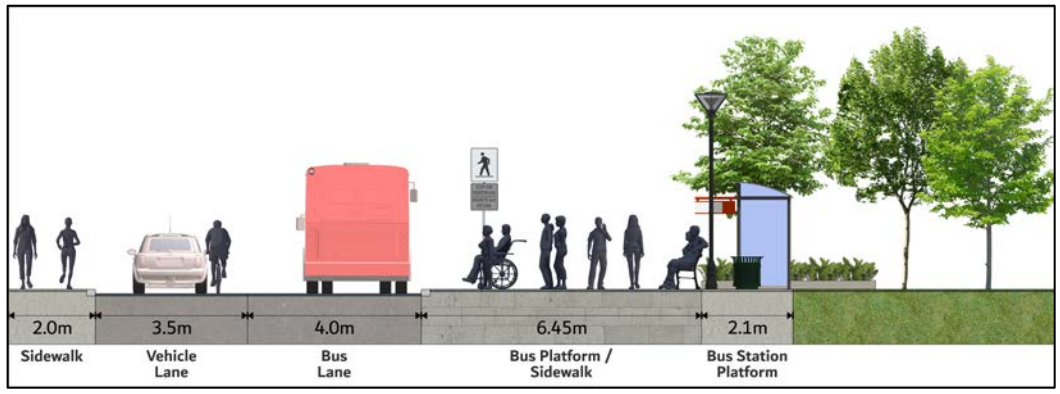


Figure 51 Campus Ave One-Way Conversion with Extended Bus Platform, Minto Bus Stop Concept





The Trillium Line closure will have considerable impacts on transit service and bus stop capacity; due to the significant increase in the number of buses expected on campus. The R2 replacement bus service is currently planned to operate on a 5-minute headway during the peak periods, which is in addition to current peak bus service operations. While the measures adopted for the Hog's Back Swing Bridge will help accommodate the increase in bus activity, the additional measures noted are instrumental to further reduce impacts to transit service.

Carleton University should ensure the OC Transpo completes the Raven's Road Bus Only Access Intersection prior to the O-Train Line 2 closure, which will reduce the number of new buses on the already congested Campus Ave corridor. However, this plan will increase passenger activity at the Physical Recreation Centre Bus Stop on University Dr. Enhancing connections to the O-Train pedestrian underpass will help increase comfort and convenience for the influx of passengers dropped off at this location, i.e. widened pathways to include bi-directional cycling facilities and enhanced lighting.

If bus service on Campus Ave, particularly at the Minto Building, is still over capacity with the aforementioned measures, Carleton University may consider consulting with OC Transpo to allow existing transit routes (e.g. #104 or #111) to use the new Raven's Road bus only access intersection so more buses stop on University Dr. If additional bus capacity is required to accommodate this, Carleton University may consider temporarily converting Lot P4 into a designated bus pick-up/ drop-off area, to supplement the existing stops.

The implementation of the noted recommendations is expected to provide significant relief from the impacts triggered by the Trillium Line shut down.

7.5.4. SCENARIO 3: TRILLIUM LINE SOUTH OPERATIONAL (2021+)

Once the Trillium Line South is operational, bus ridership bus traffic on campus is expected to decline due to the planned discontinuation of the R2 replacement bus service and Route #104. Route #10 will be adjusted so that Carleton University is no longer the endpoint of the line, but a midpoint. Therefore, it will operate similar to the previous R2 replacement bus service, which utilized the Raven Rd access and splitting the northbound and southbound buses between University Dr and Campus Ave respectively. This will reduce bus loading on Campus Ave.

In contrast, LRT ridership is expected to increase significantly with the opening of Trillium Line South, potentially doubling in the peak periods by 2023. As a result, the proposed mitigation measures for this scenario will focus on more on enhancing connectivity and the urban fabric at the transition areas between the LRT platforms and the area campus network, as illustrated in **Figure 52**.

As outlined in the active travel discussions earlier in this report, Campus Ave roadway and boulevard that interfaces with the west LRT platform is a key concern on campus. Poor crossing visibility and inefficient use of the available space creates crowding during the peak periods as passengers from the bus and LRT facilities interact with two-way traffic, mixed with cyclists and transit vehicles. The location is a focal point for pedestrian activity, but is currently auto-focused in design. The primary recommendation is to increase active travel priority by renewing the area in front of the west LRT platform into a public space forming an LRT hub, which integrates a raised intersection at Campus Ave and Library Road. This improvement, combined with the one-way conversion of Campus Ave noted in the previous scenario, not only raises the visibility and priority of active travel modes, but provides opportunities for placemaking, such as seating, public art, pop-up or temporary retail. A potential conceptual layout is provided in **Figure 53**.

There is also an opportunity to further enhance the pedestrian and cycling connections to the east LRT platform, that expands on the enhancements completed in the previous scenario between the University Dr bus stop and the pedestrian underpass. Widening the existing pathway between the east LRT platform to the pedestrian underpass and providing enhanced lighting will better accommodate the peak ridership demands when Stage 2 LRT is completed.

Figure 52 Recommended Trillium Line South Opening Transit Interventions

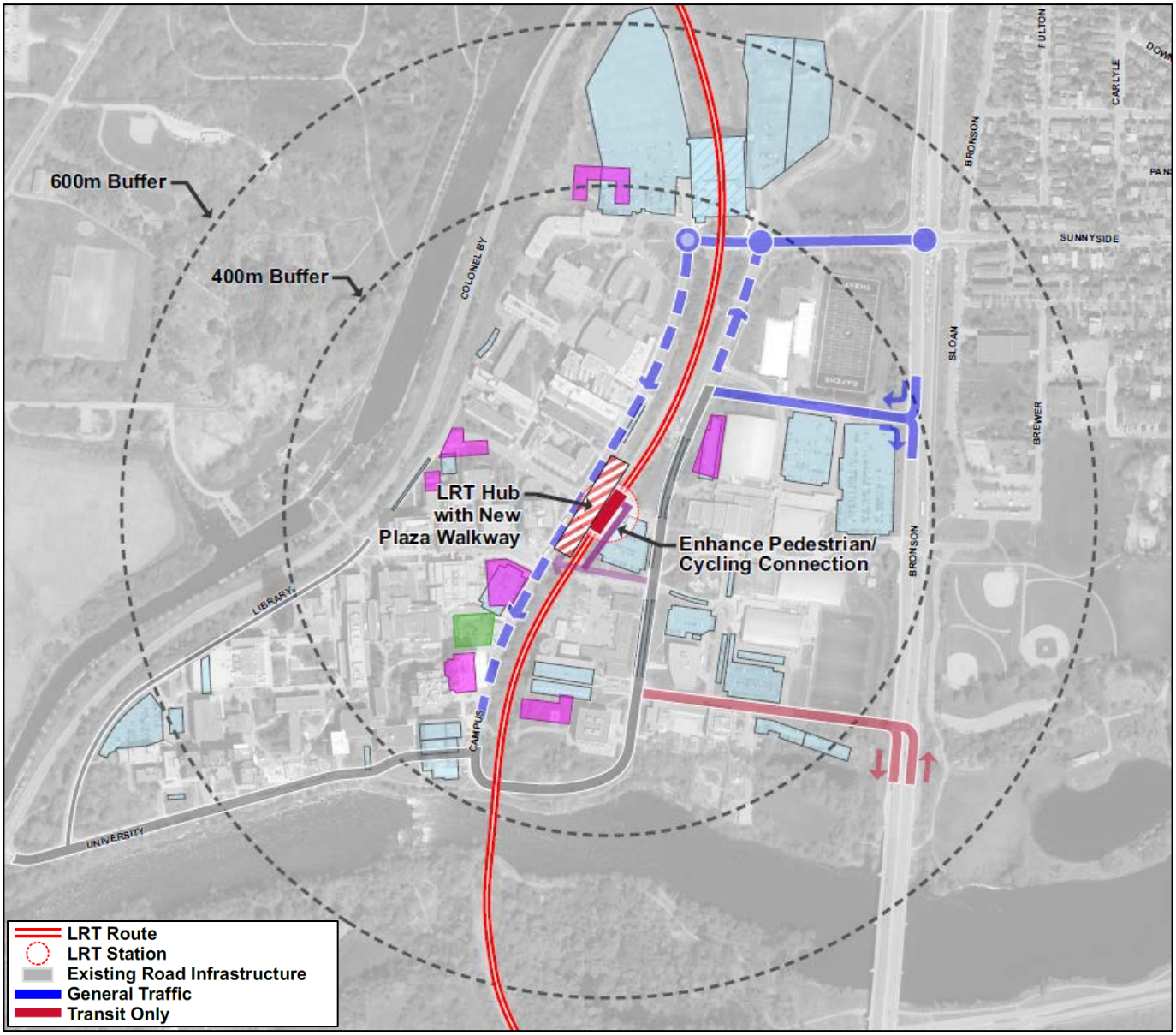


Figure 53 LRT Hub\ Plaza Concept

7.6. LONG TERM (5+ YEARS) RECOMMENDATIONS

The following long-term transit strategy is based on the recommendations in the long-term road network strategy from Section 6.6. It is expected all road network modifications/ interventions noted will be implemented. The following section will discuss the transit-oriented aspects of that plan.

The transit specific mitigation measures recommended in the previous scenarios were developed with the long-term vision in the Carleton Master Plan in mind. To recap, the 2016 Campus Master Plan Update emphasized the transportation priority, in decreasing order: pedestrians, bicycles, transit, cars, and trucks.

The Transit Strategy herein is flexible and synergizes with the intents and goals heard throughout the consultation process, which focuses on reducing auto-usage on campus by supporting active transportation initiatives. An example of this synergy includes the development of an LRT Hub/Plaza prior to the long-term initiative that was presented to and endorsed by Carleton University: pedestrianizing Campus Ave between Campus Ave and University Dr (at the south end of campus). This heavily utilized and contentious corridor with overlapping and conflicting modes would transition over time to prohibit

all general use vehicular activity, with the exception of emergency/ service vehicles, deliveries and discretionary events (e.g. beginning and end of school year for moving).

As part of this strategy, it is recommended that transit vehicles also be prohibited on Campus Ave. The evolution of campus traffic should be directed towards Bronson Ave to the east and Colonel By Dr to the north (i.e. the periphery of campus) rather than closer to core facilities to the west and south. In following with this evolution, bus transit routes and stops should be redirected to University Dr.

With these long-term goals in mine, the transit specific recommendations of the long-term strategy, shown in **Figure 54**, are as follows:

- Repurpose Campus Ave to a pedestrian/cycling promenade;
- Engage OC Transpo (prior to construction of the Raven Rd access in 2020) with the long-term plan to redirect campus bus routes to University Dr and to permit the southbound right-turn at the Raven Rd bus only access. There is an opportunity to plan for this modification in the future to reduce future costs, if there is no appetite in the short-term to construct the southbound right-turn.
- Develop a bus hub on the east side of the LRT tracks to accommodate future bus traffic and activity on University Dr; a concept of this hub has been provided in **Figure 55**.

The above Transit recommendations were formulated based on the latest information provided by OC Transpo. However, OC Transpo reserve the right to alter routes, schedules and frequencies as necessary and the recommendations herein should be revisited/ updated to reflect any significant changes to these services.

Figure 54 Recommended Long-Term Strategy

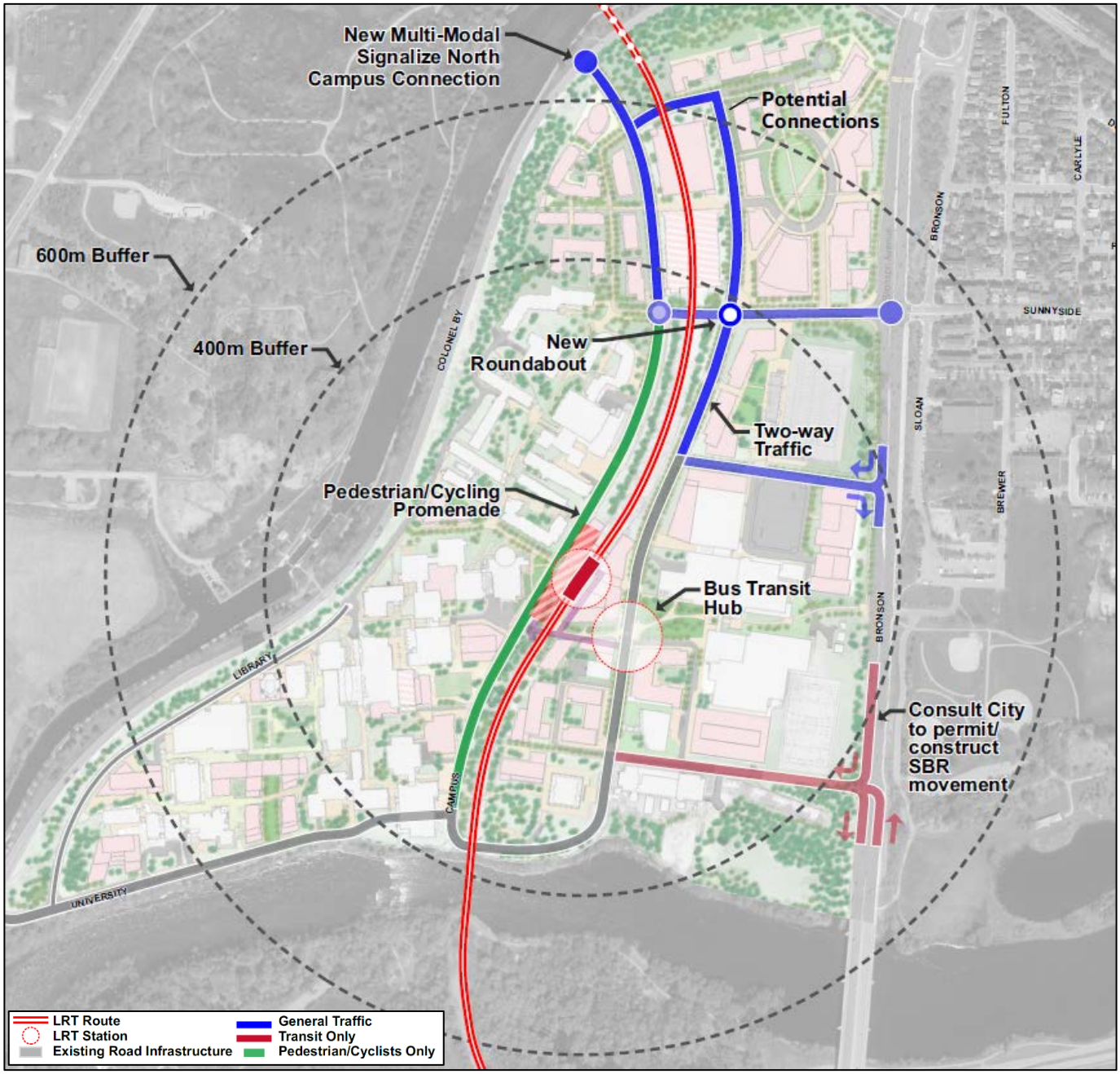


Figure 55 Long-Term University Dr Bus Hub Concept

8. IMPLEMENTATION PLAN AND COSTING

Table 13 provides an implementation plan with details of the proposed timing for each of the proposed transportation improvements, in addition to estimated cost. Phasing considerations included the year of need from an operational perspective, timing of future developments, interdependencies and synergies with other initiatives.

Table 13 Preliminary Implementation Plan and Cost Estimate

ACTION/PROJECT	LIMITS	URGENCY/ PRIORITY	NEEDED BY/ IMPLEMENTATION DATE	CLASS 'D' COST ESTIMATE ('000) LOW	HIGH	CONSIDERATIONS
Immediate						
Roads and Transit						
Bronson RIRO and Stadium Drive Connection	Bronson to University	High	Sept 2019	$1,500	$2,000	Design underway. Requires City approval (RMA and detailed design)
Lane Reassignment, Intersection Modifications and Signal Timing Adjustment	Bronson/University Intersection	High	Sept 2019	$100	$250	Requires City approval (RMA and detailed design)
Signal Timing Plan Adjustment	Colonel By/University	Low	-	$10	$10	Requires City approval (RMA and detailed design)
Engage City on Raven Road Access	Raven/Bronson	High	-	-	-	Construction by others - critical to transit functionality. Consult with City to plan for SBR to allow transit flexibility in the long-term horizon.
Parking						
Implement Parking Price Adjustments (as specified in Section 5.2.1)		High	May 2019	-	-	Provide early and effective communication; HR/Union considerations. Price adjustments may be implemented in either one year, or over multiple years
Initiate Campus Parking Survey Summer 2019		High	Summer 2019	$20	$20	Required prior to P18 Expansion
Investigate Smart Technologies		Medium	-			
Identify Potential Temporary off-site Parking Sites/Shuttle Service		High	-			Temporary off-site parking may or may not be needed during P18 shuyt-down in Summer 2020. Need will be determined based on the Summer 2019 parking demand survey.
Active Travel						
Implement TDM Measures		High	May 2019	-	-	Policy addressing which staff qualify for telecommuting and/or flexhours will likely be needed
PXO	Hartwell Locks/Colonel By	Medium	-	$50	$90	Requires NCC approval. Cost variation based on level of lighting needed.
Additional Supporting Studies						
- Way-Finding		Medium	-	$10	$10	Cost to be confirmed
- Signage		Medium	-	$10	$10	Cost to be confirmed
- Illumination Study		Medium	-	$10	$10	Cost to be confirmed
Accessibility						
Address low cost non-compliances AODA/COADS (as specified in Section 7.0)	Where applicable on campus	Medium		$50	$75	
			SUBTOTAL	**$1,760**	**$2,475**	
Short-Term						
Roads and Transit						
Roundabout	Campus/Campus	High	May 2020	$400	$800	Construction should coincide with Campus O-train bridge work. Cost estimate includes active travel facilities - does not include centre island specialized treatment/ feature.
Campus Ave One-Way Conversion and Bus Enhancements	Campus to Unversity S	High	May 2020	$250	$250	Reconfigure lane arrangements, extend bus platforms in existing layby areas, reconfigure University/Campus S intersection, PXOs, raised intersections and signage treatments. Cost dependent on level of treatments used ; minimum amount assumed. Needed prior to O-Train shutdown; consider including active travel recommendations (e.g. MUP).
University Dr Conversion	Campus to Stadium Way (P5)	High	May 2020	$250	$350	Reconfigure Campus/University/P7 intersection to prevent WBL; Channelize NBR at Campus/University/P7; Needed prior to O-Train shutdown
LRT Hub - Plaza with raised intersection	Campus/Library	High	Nov 2021	$500	$500	Cost dependent on level of treatment; minimum amount assumed. Needed prior to Trillium Line South opening
Parking						
Expand P18 Parkade	P18 Parkade	High	May 2020 - May 2021	-	-	Already planned by Carleton. 12 mth project. First 4 months, no access to existing p18 parking/part of bridge rehab; remaining 8 months existing parking available.
Implement Shuttle Service	Throughout Campus	Medium	May 2019	$500	$700	Cost assumes purchase of two vans, five years of salary for two employees, and five years of vehicle operation and maintenance fees
Parking Policy/ Programs				-	-	Programs to reduce auto usage during O-Train shutdown - needed prior to P18 closure
- Offer Flexible Work Option for staff		High	May 2019			Initiate discussions with HR and communications immediately.
- Transit Pass Program		Medium	May 2019	$1,000	$2,000	Cost highly dependent on # of participants and fee discussions with OC Transpo. Cost may be offset by new revenue sources.
- Car pool permits with price discounts		Medium	May 2019			
- Guaranteed ride home programs		Medium	May 2019			
- Parking utilization monitoring		Low	Regular Intervals			
Active Travel						
N/S MUP on east side of Campus	LRT Station to Campus	Medium	Nov 2021	$150	$250	Relies on construction of south section of N/S MUP by City during Stage 2
Connections to pedestrian underpass south of LRT Station	From University bus stop	High	May 2020	$100	$100	Cost dependent on level of treatment; minimum amount assumed. Needed prior to O-Train shutdown
	From east LRT Platform	High	Nov 2021	$100	$100	Cost dependent on level of treatment; minimum amount assumed. Needed prior to Trillium Line South opening
Bi-directional Bike Pathway to Ped Underpass by LRT	LRT Station to University	High	Nov 2021	$150	$250	Requires widening of pedestrian underpass by City during Stage 2; Potential loss of 19 parking spaces
Convert Library to Pedestrian/ Cycling Promenade	Campus to Library	Medium	Nov 2021	$250	$250	Cost dependent on level of treatment; minimum amount assumed. Ideal to copmlete prior to Trillium Line South opening
Additional Outdoor Bike Racks	Duncan Tower/ Steacie Bldg	Medium	-	-	-	50 spaces each
Additional Indoor Bike Racks	River/Library/Dunton	Medium	-	-	-	100/75/75 spaces respectively (20% of Total Supply)
Shower Facilities	New Facilities	Medium	-	-	-	Should be included in all new campus buildings.
Accessibility						
Address non-compliances AODA/COADS (as identified in Section 7.0)	Where applicable on campus	High				To be addressed as facilities are being upgraded.
Optional Projects						
P4 Bus Staging	P4 Lot	Low	May 2020 - Nov 2021	$100	$100	Provide bus overflow staging area in P4 Lot at expense of parking during O-Train shutdown if University Dr bus stops over crowded/ over capacity
			SUBTOTAL	**$3,750**	**$5,650**	
Long-Term						
Roads and Transit						
North Campus Intersection and Road Connection	Colonel By Drive to Campus	High		$700	$1,200	Requires City and NCC approval. Accelerate implementation if possible. Designed as complete street, protected intersection, auxiliary lanes all approaches, channelized NBR
Roundabout/ Convert University back to Two-way Traffic	Campus/University/P7	High		$1,200	$1,900	Required when pedestrianization of Campus Avenue occurs. Cost estimate includes active travel facilities, but does not include centre island specialized treatment/ feature.
Bus Hub	University Bus Stop/LRT	Medium		$250	$250	Cost dependent on level of treatment; minimum amount assumed.
Raven Road Bus Access SBR	Raven/Bronson	Medium		$300	$500	Requires City Approva. Ideal for more flexible routing options after pedestrianizing Campus. Opportunity for cost saving, consult City to plan for this during initial construction
Parking						
Provide Satellite Parking for City events		Low				Consultation with City of Ottawa needed. Earlier adoption provides additional revenue stream
Active Travel						
Campus Ave Pedestrian/Cycling Promenade	Campus to University	High		$250	$250	Cost dependent on level of treatment; minimum amount assumed.
Dedicated Bike Connection on University	P7 to Bronson	High		$100	$250	Cost dependent on type of facility
MUP north of River	Colonel By to Bronson	Low		$650	$650	Cost assumes no environmental conflicts/constraints
Campus Tunnel Projects	Residence to P18	High		-	-	Already planned by Carleton
	LRT to Campus	High		-	-	Already planned by Carleton
Accessibility						
Address non-compliances AODA/COADS (as identified in Section 7.0)	Where applicable on campus	High				To be addressed as facilities are being upgraded.
			SUBTOTAL	**$3,450**	**$5,000**	
			TOTAL	**$8,960**	**$13,125**	

9. NEXT STEPS / ADDITIONAL RECOMMENDATIONS

- Undertake preliminary designs for intersection reconfigurations at University Dr / Campus Ave and roundabout at Campus Ave / Campus Ave.
- Undertake preliminary design for Campus Ave one-way conversion and bus platform extensions.
- Collaborate with the City of Ottawa to advance/ secure approval for the following recommendations:
    - Stadium Way construction by September 2019
    - Bronson / Sunnyside eastbound lane arrangement and signal timing modification by end of 2019
    - Colonel By / University Dr signal timing modifications.
    - E-W pathway north of the Rideau River.
- Continue negations with NCC to secure approval for new Colonel By Dr connection.
- Collaborate with Stage 2 Office regarding Carleton Station design, potential Rideau River pedestrian/cycling bridge, new Multi-use Pathway connecting potential Rideau River pedestrian/cycling bridge to LRT Station, and LRT underpass widening.
- Initiate implementation of parking and transportation demand management solutions, including development of a communications plan.
- Undertake the following additional studies:
    - Wayfinding Study – Should include improvements to interior wayfinding within buildings through the use of increased signage and floor markings, in addition to providing way-finding signage at the main entry points to the campus.
    - Parking Study during Summer of 2019 to assess impact of planned P18 expansion closure
    - Illumination Study for all sidewalks, pathways and pedestrian crossing locations.
- Update parking map on the Parking Services website to include changes in parking locations, in addition to locations of new secure bike storage locations.
- Ensure that any new developments on campus consider the City's Transit Oriented Development Guidelines to optimize the benefits of the Carleton LRT station.
- Conduct an update to the Transportation strategy in conjunction with the Campus Master Plan update, including an on-line transportation survey, to identify new transportation trends and needs of students, faculty and staff.

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