PREPARED FOR

Brown University | Providence, Rhode Island

BROWN

Transportation Component

Brown University Institutional Master Plan

PREPARED BY

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FINAL REPORT

Transportation Component

Institutional Master Plan
Brown University

PREPARED FOR

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Introduction and Executive Summary

Introduction

This report presents the Transportation Component of Brown University's 2017 Institutional Master Plan (IMP). The purpose of this report is twofold:

1. Provide an update on progress made since the 2011 IMP; and
2. Assesses how the project seeking approval under the 2017 IMP impacts the on-campus and off-campus transportation systems (vehicles, pedestrians, bicyclists, and transit).

The majority of the projects from the 2011 IMP have been completed or are nearing completion. This report re-establishes a transportation baseline for the campus and accesses the impacts of the IMP project during construction and after completion. As part of this update, previously collected traffic data were reviewed to document changes in travel demands on area roadways.

This report presents an analysis of the transportation system serving Brown University today, a projection of how this system would operate in 5 years without the planned IMP project, and an assessment of the effect of the project.

This study concludes that the IMP project seeking approval, the Watson Institute Expansion, is not expected to negatively impact the area transportation system (short-term or long-term), largely because it does not include new parking, there are no changes to roadway circulation or access, and it does not substantially change the concentration of students, faculty, or

staff. The construction impacts are also expected to be minimal due to the fact that it is a relatively small scale expansion on a site that currently contains surface parking and can easily be fenced off and self-contained during construction.

It is not expected that roadway or sidewalk closures would be needed, except for brief periods when materials are being delivered to the site or when construction debris is being removed from the site.

Brown University will continue to enhance its proactive transportation demand management (TDM) program. Brown will continue to offer free RIPTA service for faculty, staff, and students and enhance its shuttle service, specifically focusing on the South Street Landing site in the Jewelry District where approximately 400 staff will be relocated. The existing policy that all new construction and major renovations are required to install bicycle racks as part of their projects will apply to the Watson Institute Expansion.

Brown will also continue to partner with the City of Providence and invest in public realm enhancements to sidewalks and crosswalks. Since 2000, over 17,000 linear feet of sidewalks have been upgraded and 100 street trees have been planted. Last year alone, Brown invested $2.6 million in these public realm upgrades.

Executive Summary

The Transportation Component of the IMP provides a comprehensive review of the transportation system serving the University and provides an analysis of the projected impact of the proposed IMP project on this system. The following tasks were completed as part of this study:

- The surrounding roadway infrastructure was inventoried.
- Traffic, pedestrian, and bicycle data were collected.
- Planned transportation improvement projects were identified.
- Other planned projects in the area surrounding the University that may affect future transportation system operation were identified.
- The potential impact of the IMP project on the transportation system was quantified.
- Short-term construction impacts associated with the IMP project were identified.

Additionally, enhancements to the University's transportation demand management (TDM) program, transit services and parking strategy were also reviewed as part of this study.

Existing Conditions

Over the past 5 years since the 2011 Plan, Brown has invested $162 million in new construction, $310 million in major renovations, over $41 million in infrastructure enhancements, and over $2.6 million in public realm improvements. Since 2000, Brown has replaced over 17,000 linear feet of sidewalks and installed over 100 street trees. The public realm improvements completed since the last IMP include:

- Widening of sidewalks at Cushing Street and Meeting Street;
- New sidewalks along Brook Street; and
- Thayer Street enhancements to include new street furniture, street trees (100 total), solar trash compactors, and a parklet.

Since the completion of the 2011 Plan, the following projects and initiatives that were referenced in the 2011 Plan have been completed or are underway:

- Extended the connectivity of "The Walk" south of Waterman Street;
- Completed a 300-space parking garage at the athletic complex;
- Converted three existing Brown buildings to residence halls;
- Constructed a new soccer stadium within the athletic complex;
- Completed the 450 Brook Street project;
- Construction of the new School of Engineering research building (scheduled for completion in 2018);
- Shifting of 13 administrative units (or approximately 400 staff) to renovated space at the South Street Landing site in Providence's Jewelry District (scheduled for summer 2017);
- Purchasing on-street parking spaces, which Brown leases;
- Replacement/repair of sidewalk throughout the campus and along public streets;
- Providing free RIPTA access to faculty, staff, and students;
- Creation of a shuttle service to the Jewelry District and the hospitals;
- Expansion of the Zip Car program from two cars to 15 cars;
- Elimination of student parking except for special circumstances;
- Increasing parking fees by 55 percent; and
- Continuation of off-street parking requirements for contractors for major projects.

The transportation analysis contained in this updated report is consistent with the expanded study area used in the 2011 study. The study area is generally bounded by Lloyd Avenue to the north, Power Street to the south, Arlington Avenue to the east and Benefit Street to the west. Daily and peak hour traffic volumes were collected for the major roadway corridors and at sixty-three (63) intersections within the study area. The new traffic data was analyzed to understand the quality of the traffic

operations within the study area. For this IMP update, pedestrian and bicycle counts were taken at each study area intersection to establish a baseline of this activity.

Pedestrian activity on the campus continues to be much higher during the afternoon and evening peak hours compared to the morning peak hour period, due to the lower levels of student activity and commercial activity on Thayer Street during the morning peak hour period. Pedestrian volumes along Thayer Street, Angell Street, Waterman Street and Brook Street and at the primary street crossings along Angell Street and Waterman Street continue to be very high.

At the unsignalized intersections of Brown Street with Angell Street, with Waterman Street and George Street, pedestrians crossing the roadways interfere with flow of traffic, which results in areas of congestion during peak periods, especially in the evening. Along Thayer Street between Cushing Street and George Street, several factors cause restrictions to traffic flow throughout the day. These factors included truck loading/deliveries, pedestrians crossing against the traffic signals and at mid-block locations, bus maneuvers, parking maneuvers, and double-parked vehicles.

Vehicular capacity analysis results indicate that the majority of the intersections operate at acceptable calculated levels of service during the peak hour periods. However, based on field observations, many of the intersections appear to operate at poorer levels of service with longer delays and queues than the operations analysis suggests. This is commonly the result of queuing generated at adjacent intersections, blocking the flow of these intersections as well as disruptions to traffic flow caused by non-University related factors.

Future Conditions

The changes in transportation demand is estimated based on changes in parking supply, projections for faculty/staffing growth, graduate student enrollment growth, and building program information provided by the University.

Since the planned project (the Watson Institute Expansion) included in this IMP does not include new parking, and in fact eliminates 17 spaces, there is no expected change in vehicular trips, rather a minor redistribution of the existing users of the 17 parking spaces.

In addition to accounting for the Watson Institute Expansion, general traffic growth increases in the area as well as potential non-campus related transportation and development projects were also considered in the estimation of future conditions traffic volumes.

Overall, since the estimated transportation demand for the Watson Institute Expansion is not substantial, the future conditions analysis shows no changes in operational levels of service compared to future conditions without the project.

Improvement Measures

Although the Watson Institute Expansion does not generate significant transportation demand, the University is committed to continuing to reduce the number of vehicles to and from campus.

Enhancements to the Transportation Demand Management Program

Brown University continues to provide a number of successful transportation demand management (TDM) programs in response to the needs of the students, faculty, and staff and in concert with the urban environment of the campus. These programs, which are designed to encourage alternatives to driving and parking at the campus, include:

- RIPTA U-Pass program;
- Brown University shuttle;
- The Zipcar program;
- Electric vehicle charging stations;
- Commuter flexible spending benefit;
- Improved campus shuttle routes with more frequent headways; and
- A pilot bike-share program.

Additional Pedestrian Related Enhancements

Although there are no traffic, pedestrian, or bicycle impacts are associated with the Watson Institute Expansion, Brown is committed to continue to improve the overall operations and pedestrian environment throughout the campus.

As in the past, Brown will continue to partner with the City of Providence to invest in public realm streetscape and pedestrian improvements on city streets including sidewalk replacement, accessible curb cuts, new street trees, and crosswalks at various locations in the campus. The University has been involved with the painting of over 100 crosswalks with enhanced signing for pedestrians throughout the campus.

The University will work with the City of Providence Department of Public Works and Division of Traffic Engineering to identify and implement additional measures to further enhance the overall pedestrian environment around the Brown University campus. These measures would complement the capacity enhancement and pedestrian improvement measures that have already been implemented around the campus, and they can be tailored to meet specific needs of the individual locations where such improvements are necessary.

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Existing Conditions

Introduction

As part of this chapter, VHB reviewed existing traffic, pedestrian, parking, and public transportation conditions on and around the campus. The first section describes the University's surroundings and the study focus area. The subsequent three sections describe in detail each of the primary transportation modes serving the campus:

- Vehicular access including roadway operations and parking;
- Public Transportation; and
- Pedestrian and bicycle activity.

The final two sections of this chapter briefly describe the University's loading and service vehicle access procedures and the University's transportation demand management (TDM) programs, which are intended to minimize its impacts on the transportation system serving the University and its neighbors.

Study Area

Brown University is located primarily within the College Hill neighborhood of Providence's East Side and is surrounded by different neighborhoods within the city. The Blackstone and Wayland neighborhoods border the campus to the east, and the Fox Point neighborhood borders the campus to the south.

The 2006 transportation study focused on the northern portions of the campus and surrounding area and the 2011 transportation study expanded the study area to the south to include several roadways and intersections extending to Power Street. For

this study, the limits have remained the same as the 2011 transportation study. The study area is generally bounded by Lloyd Avenue to the north, Power Street to the south, Arlington Avenue/Hope Street to the east and Prospect Street/Benefit Street to the west, as shown in Figure 2-1. To maintain consistency with prior analyses performed on the campus, additional intersections outside of the general study area were also included for the purpose of identifying existing traffic patterns to/from the University campus area and to help establish a baseline for traffic operations around the campus that will be used to assess the impacts of future projects. In total, this study includes the following intersections:

1. Angell Street/Gano Street (signalized)
2. Angell Street/Hope Street (signalized)
3. Angell Street/Brook Street (signalized)
4. Angell Street/Thayer Street (signalized)
5. Angell Street/The Walk (signalized)
6. Angell Street/Brown Street
7. Angell Street/Prospect Street (signalized)
8. Angell Street/Thomas Street/Benefit Street (signalized)
9. Waterman Street/Benefit Street (signalized)
10. Waterman Street/Prospect Street (signalized)
11. Waterman Street/Brown Street
12. Waterman Street/The Walk (signalized)
13. Waterman Street/Thayer Street (signalized)
14. Waterman Street/Brook Street (signalized)
15. Waterman Street/Hope Street (signalized)
16. Waterman Street/Governor Street (signalized)
17. Lloyd Avenue/Arlington Avenue
18. Lloyd Avenue/Moses Brown East Drive
19. Lloyd Avenue/Moses Brown West Drive
20. Hope Street/Olney Street (signalized)
21. Hope Street/Barnes Street/Moses Brown Drive
22. Hope Street/Lloyd Avenue/Brook Street (signalized)
23. Hope Street/Bowen Street
24. Hope Street/Cushing Street
25. Hope Street/Meeting Street
26. Hope Street/George Street
27. Hope Street/Benevolent Street
28. Hope Street/Charlesfield Street
29. Hope Street/Power Street
30. Brook Street/Bowen Street

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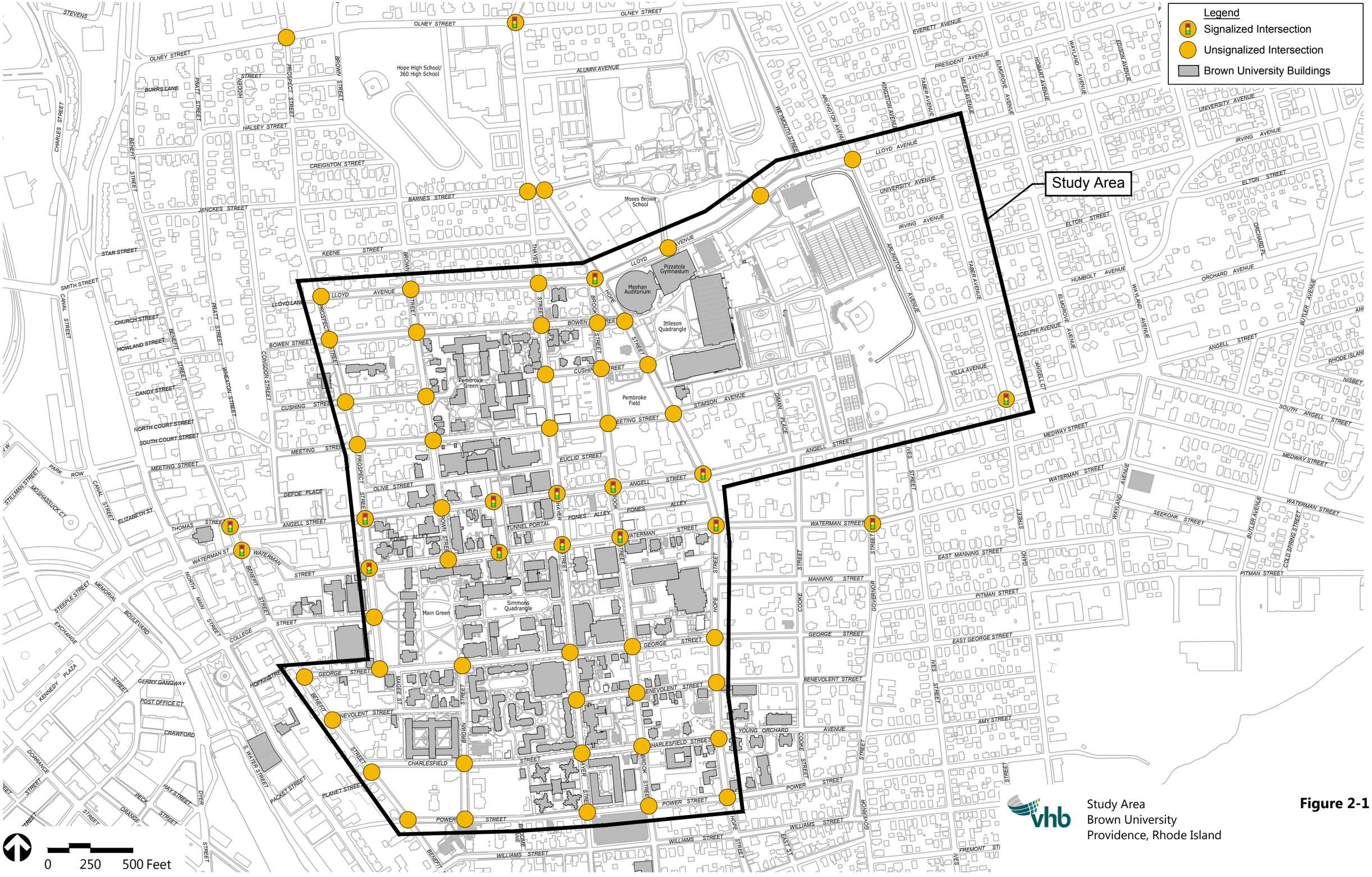


Study Area
Brown University
Providence, Rhode Island

Figure 2-1

31. Brook Street/Cushing Street
32. Brook Street/Meeting Street
33. Brook Street/George Street
34. Brook Street/Benevolent Street
35. Brook Street/Charlesfield Street
36. Brook Street/Power Street
37. Thayer Street/Barnes Street
38. Thayer Street/Lloyd Avenue
39. Thayer Street/Bowen Street
40. Thayer Street/Cushing Street
41. Thayer Street/Meeting Street
42. Thayer Street/George Street
43. Thayer Street/Benevolent Street
44. Thayer Street/Charlesfield Street
45. Thayer Street/Power Street
46. Brown Street/Lloyd Avenue
47. Brown Street/Bowen Street
48. Brown Street/Cushing Street
49. Brown Street/Meeting Street
50. Brown Street/George Street
51. Brown Street/Charlesfield Street
52. Brown Street/Power Street
53. Prospect Street/Olney Street
54. Prospect Street/Lloyd Avenue
55. Prospect Street/Bowen Street
56. Prospect Street/Cushing Street
57. Prospect Street/Meeting Street
58. Prospect Street/College Street
59. Prospect Street/George Street
60. Benefit Street/George Street
61. Benefit Street/Benevolent Street
62. Benefit Street/Charlesfield Street/Planet Street
63. Benefit Street/Power Street

These study area intersections were evaluated in detail using industry standard traffic engineering analysis techniques to establish the baseline that will be used to identify incremental impacts of future traffic growth and site-generated traffic.

In addition to understanding traffic and pedestrian flow through various locations spread throughout the campus, the effect of specific large generators of

transportation demand within the campus was also factored into the analysis. Notably, several neighboring institutions around the campus have a direct impact on transportation operations. Along with the University, these neighboring institutions rely on an efficiently functioning transportation system that is comprised of several different modes including automobiles, public transportation, bicycles, and walking. The following institutions are near the campus within the College Hill neighborhood:

- The Wheeler School, a private institution with total enrollment of approximately 800 students from nursery school through high school, is located within the Brown University campus area. The Wheeler School campus is bounded by Angell Street to the south, Brook Street to the west, Meeting Street to the north, and Hope Street to the east.
- Moses Brown School, a private institution with total enrollment of approximately 775 students from nursery school through high school, is located to the north of the Brown University campus. The Moses Brown School campus is generally bounded by Lloyd Avenue to the south, Hope Street to the west, Alumni Avenue to the north, and Weymouth Street to the east.
- Hope High School, a public high school with enrollment of approximately 850 students are located to the north of the Brown University campus. The Hope High School campus is generally bounded by Barnes Street to the south, Brown Street to the west, Olney Street to the north, and Hope Street to the east.
- 360 High School, a public high school is co-located on the Hope High School Campus. It opened in 2015 with approximately 80 9th grade students and will continue to grow one grade level each year.
- Rhode Island School of Design (RISD), a private institution of higher learning has a total enrollment of approximately 2,500 students and is located to the west of the Brown University campus primarily in the area north of College Street and south of Meeting Street.

Vehicular Access and Roadway Conditions

The following section describes the University campus vehicular access, roadway circulation, observed conditions, traffic volumes and traffic operations.

The University is bisected by two one-way principal arterial roadways: Angell Street, which is one-way westbound, and Waterman Street, which is one-way eastbound. The campus is also bisected by two urban collector roadways: Brook Street, which is a two-way north-south roadway, and Thayer Street, which is a one-way southbound from Hope Street to Waterman Street. In addition, Hope Street, which is classified as a minor urban arterial, runs north-south through the eastern portion of the campus. These roadways plus several city streets such as Prospect Street, Brown Street, Lloyd Avenue, Gano Street, and College Street, provide primary vehicular access to the campus.

The primary roadways providing access to the University campus, including academic and administrative buildings, residential halls, athletic facilities, and both on-street and off-street parking areas, are described below.

Angell Street

Angell Street is a one-way westbound principal arterial roadway from South Angell Street to Benefit Street. The Angell Street corridor, which includes South Angell Street to the east and Thomas Street/Steeple Street to the west, provides a direct connection westbound from East Providence to Downtown Providence beginning at the Henderson Bridge over the Seekonk River. This connection also functions as a diversionary route into Providence when incidents or backups occur on Route I-195. In the vicinity of the University, Angell Street is approximately 25 feet wide with parking prohibited along the south side and time restricted parking generally allowed along the north side from Prospect Street to Brook Street. Due to the on-street parking and limited pavement width, Angell Street operates as one westbound travel lane between Hope Street and Prospect Street during most times of the day. On the westbound approach to Hope Street, Angell Street operates as two travel lanes (a shared left-turn/through lane and a right-turn only lane) during the peak hour periods, as parking along the north side of Angell Street is prohibited between 6:00 AM and 9:30 AM and between 3:30 PM and 6:00 PM from Diman Place to Hope Street. The Wheeler School is located on the north side of Angell Street between Hope Street and Brook Street.

Within the study area, traffic signals exist at the Angell Street intersections with Gano Street, Hope Street, Brook Street, Thayer Street, The Walk, Prospect Street, and Benefit Street. The unsignalized intersections along Angell Street are controlled by stop-signs on the north-south "minor street" approaches.

Waterman Street

Waterman Street is a one-way eastbound principal arterial roadway from Benefit Street to the Henderson Bridge over the Seekonk River. Waterman Street, which runs parallel to Angell Street, provides a direct connection from Washington Street in Downtown Providence to East Providence. In the vicinity of the University, Waterman Street is approximately 26′ wide with parking prohibited along the north side and two-hour parking allowed on the south side. Due to the on-street parking and limited pavement width, Waterman Street operates as one eastbound travel lane through the study area during most times of the day

Within the study area, traffic signals exist at the Waterman Street intersections with Benefit Street, Prospect Street, The Walk, Thayer Street, Brook Street, Hope Street, and Governor Street. The unsignalized intersections along Waterman Street are controlled by stop-signs on the north-south "minor street" approaches.

Hope Street

Hope Street is a north-south minor urban arterial, which runs from East Avenue in Pawtucket to George M. Cohan Boulevard south of Wickenden Street in Providence.

Within the study area, Hope Street is approximately 34′ wide south of Barnes Street and approximately 40′ wide north of Barnes Street with various levels of parking restrictions on both sides of the road. Hope High School is located on the west side of Hope Street between Barnes Street and Olney Street, Moses Brown School is located on the east side of Hope Street north of Lloyd Avenue, and Wheeler School is located on the west side of Hope Street between Angell Street and Meeting Street. The Brown University Athletic Complex is located on the east side of Hope Street between Meeting Street/Stimson Avenue and Lloyd Avenue.

Traffic signals exist at the Hope Street intersections with Olney Street, Lloyd Avenue/Brook Street, Angell Street, and Waterman Street. The intersections with George Street and Power Street are controlled by four-way stop signs, and the remaining unsignalized intersections along Hope Street within the study focus area are controlled with stop-signs on the east-west "minor street" approaches.

Brook Street

Brook Street is a north-south urban collector roadway which runs from Hope Street to George M. Cohan Boulevard south of Wickenden Street. Within the study area, Brook Street is between 30′ and 32′ wide with various levels of parking restrictions on both sides of the road. The Wheeler School is located on the east side of Brook Street between Angell Street and Meeting Street.

Traffic signals exist at the Brook Street intersections with Hope Street/Lloyd Avenue, Angell Street, and Waterman Street. The intersections with Bowen Street, Cushing Street, George Street, and Power Street are controlled by four-way stop signs. The remaining unsignalized intersections along Brook Street within the study focus area are controlled with stop-signs on the east-west "minor street" approaches.

Thayer Street

Thayer Street is a north-south urban collector roadway which runs from Hope Street to Transit Street north of Wickenden Street. Thayer Street is one-way southbound between Hope Street and Waterman Street, two-way between Waterman Street and Power Street, and one-way northbound between Transit Street and Power Street. Within the study area, Thayer Street is approximately 30′ wide, with the exception of between Angell Street and Waterman Street, where it is approximately 40′ wide. The entrance to a bus tunnel that runs from Thayer Street to South Main Street is located on the west side of Thayer Street between Angell Street and Waterman Street. Land use along Thayer Street is mostly commercial between Cushing Street and Waterman Street and academic/residential to the north and south.

Traffic signals exist at the Thayer Street intersections with Angell Street and Waterman Street. The intersections with Barnes Street, Lloyd Avenue, George Street, Charlesfield Street, and Power Street are controlled by all-way stop signs. The remaining unsignalized intersections along Thayer Street within the study focus area are controlled with stop-signs on the east-west "minor street" approaches.

Prospect Street

Prospect Street is a north-south local roadway that runs from Olney Street to George Street. Prospect Street is approximately 30' wide south of Meeting Street and approximately 24' wide north of Meeting Street. Various levels of parking restrictions exist along both sides of Prospect Street through the study area. Prospect Street is the signed route to Brown University for vehicles traveling eastbound on Olney Street.

Traffic signals exist at the Prospect Street intersections with Angell Street and Waterman Street. The intersections with Lloyd Avenue, Bowen Street, Cushing Street, Meeting Street, and College Street are controlled by four-way stop signs. The remaining unsignalized four-way intersections along Prospect Street within the study focus area are controlled with stop-signs on the east-west "minor street" approaches.

Lloyd Avenue

Lloyd Avenue is an east-west roadway, which is classified as an urban collector between Hope Street and Blackstone Boulevard and a local roadway between Prospect Street and Hope Street. Lloyd Avenue is approximately 30' wide west of Hope Street and approximately 40' wide east of Hope Street. Parking is allowed, with various restrictions, in areas along both sides of Lloyd Avenue. East of Hope Street, Moses Brown School is located on the north side of Lloyd Avenue, and the Brown University Facilities Management Building and Athletic Complex is located on the south side of Lloyd Avenue.

A traffic signal exists at the intersection of Lloyd Avenue with Hope Street/Brook Street. The Lloyd Avenue intersections with Prospect Street, Brown Street, Thayer Street and Arlington Avenue are controlled by all-way stop signs.

George Street

George Street is an east-west local roadway that runs from Benefit Street to Governor Street. It is approximately 28 feet wide within the study area. Parking is generally restricted along the north side of George Street, while parking is allowed for segments along the south side.

There are no signalized intersections along George Street. At the intersections of George Street with Thayer Street, Brook Street, and Hope Street, traffic is controlled by all-way stop signs. At the intersections of George Street with Brown Street and Prospect Street, the cross streets have stop signs, while at its intersection with Benefit Street, George Street traffic is under stop sign control.

Benefit Street

Benefit Street is a north-south urban collector roadway that runs from North Main Street to Wickenden Street. It is approximately 32 feet wide. There are various parking restrictions along Benefit Street through the study area, including no parking on the west side of the roadway.

Benefit Street has two signalized intersections in close proximity to one another at the intersections with Angell Street and Waterman Street. The unsignalized intersection of Benefit Street and Power Street is controlled by four-way stop signs. The remaining unsignalized intersections on Benefit Street within the study area consist of stop-signs on the east-west "minor street" approaches.

Benevolent Street

Benevolent Street is an east-west local roadway that runs from Benefit Street to Brown Street and from Thayer Street to Governor Street. It is approximately 30 feet wide, except at the intersection with Benefit Street, where it is 70 feet wide. Parking is restricted on the south side of Benevolent Street, while parking is allowed on the north side of the roadway within the study area.

There are no signalized intersections along Benevolent Street. The intersections along the street are controlled by stop-signs, with Benevolent Street approaches operating as the stop controlled approaches.

Charlesfield Street

Charlesfield Street is an east-west local roadway that runs from Benefit Street to Hope Street. It is approximately 30 feet wide. Parking is restricted on the south side of Charlesfield Street, while parking is allowed on the north side of the roadway.

There are no signalized intersections along Charlesfield Street. All-way stop-signs are in place at Thayer Street and Brown Street, and two-way stop control for Charlesfield Street is at the intersections with Benefit Street, Brook Street, and Hope Street.

Power Street

Power Street is an east-west local roadway that runs from South Water Street to Gano Street. It is approximately 26 feet wide. Various levels of parking restrictions exist along both sides of Power Street through the study area.

There are no signalized intersections along Power Street. The intersections of Power Street with Benefit Street, Thayer Street, Hope Street, and Brook Street are controlled by all-way stop signs. At the intersection with Brown Street, traffic is controlled by a stop sign on Brown Street.

Observed Conditions

VHB observed traffic conditions along the various roadways and intersections and adjacent to large generators of transportation demand within the study area. The following observations are relevant for consideration in the traffic analysis and interpretation of the results.

Moses Brown School Operations

The Moses Brown School has three driveways within the study area. The west drive is located on Lloyd Avenue approximately 450 feet east of Hope Street. A second drive is located on Lloyd Avenue approximately 600 feet east of the west driveway, and a third drive is located on Hope Street across from Barnes Street.

The majority of the parent drop-off/pick-up activity was observed to occur on campus, with parents/guardians entering at the east Lloyd Avenue driveway and exiting at the Hope Street driveway. At times during the morning arrival period, the queue of vehicles entering the east Lloyd Avenue driveway backed up onto Lloyd Avenue impacting the flow of traffic along Lloyd Avenue for brief periods.

The majority of the school bus drop-off and pick-up activity occurs on Lloyd Avenue at the west driveway, as most school buses do not enter the Moses Brown property. The majority of the school bus students were observed to be dropped off on Lloyd Avenue heading westbound. Some students were dropped off by buses on Lloyd Avenue eastbound and crossed Lloyd Avenue to the west driveway with the help of a crossing officer. During this time period, the queue of buses extended to Hope Street, but cleared very quickly. By 8:15 AM, most school related activity had stopped along Lloyd Avenue. The crossing officer was observed to leave around this time as well.

Most student pedestrian traffic was observed entering the west drive. Some students walked from Hope Street while some older students parked their vehicles along the north side of Lloyd Avenue. Students walking along the south side of Lloyd Avenue used the designated crosswalk with the help from a crossing guard. Approximately half of the pedestrian traffic along Lloyd Avenue was observed to be Moses Brown School related. When dropping off their children, parents would pull over anywhere there was space, regardless of parking restrictions.

Before the afternoon dismissal (3:00 PM), school buses started to line up along the south side of Lloyd Avenue, within the designated bus parking area. Three buses were observed to be waiting before the afternoon dismissal. During the dismissal, two additional school buses were observed to pick-up students on the north side of Lloyd Avenue, heading westbound. In general, vehicular traffic doesn't impact the surrounding area roadway network during the afternoon as it does in the morning. By 3:15 PM, most school related activity had stopped along Lloyd Avenue, and the crossing officer was observed to leave around that time.

Wheeler School Operations

Student drop-off and pick-up activities at the Wheeler School were observed to cause congestion on the adjacent roadway network during school arrival and departure periods. The departure periods impacted the surrounding roadway network less than the morning though. The school buses drop off and pick up students along Hope Street in the morning and Angell Street in the afternoon. Parent drop-off/pick-up for the younger children is designated along Meeting Street, and parent drop-off/pick-up of older students was observed to occur along Angell Street, Hope Street, and to a lesser extent, Brook Street. A large number of

students gather at the intersection of Hope Street and Meeting Street, where a crossing officer is positioned during the school arrival and departure periods. Students being dropped off and faculty/staff parking in the Wheeler School parking lot on the east side of Hope Street often cross Hope Street at a midblock crossing between Meeting Street and Angell Street. Delays from traffic yielding to pedestrians at this crossing result in a vehicle queue that extends to Angell Street during the school peak periods.

Parents drop-off/pick-up at any open location regardless of parking restrictions. Parents dropping off students in the morning sometimes double-park on Angell Street, which restricts the flow of through traffic along Angell Street. This was also observed along Meeting Street. The disruptions in traffic flow during the morning peak period caused by Wheeler School activities were observed to last until approximately 8:00 AM.

For afternoon student pick-ups, Wheeler School closes Meeting Street to through traffic between approximately 2:30 PM and 3:30 PM, and the roadway is designated for student pick-ups only. Parents in cars were observed to begin lining up at approximately 2:30 PM, while students began to get out of school at approximately 2:50 PM. Younger students, which are only allowed to be picked up along Meeting Street, are not allowed to leave the school grounds until the parent/guardian vehicle arrives in front of the pick-up area and the student's name is called. This activity along Meeting Street caused vehicle queues that extended back to Brook Street and along Brook Street to Angell Street. During the height of afternoon student pick-up activity, the vehicle queue impacted the flow of traffic along Angell Street, although not as substantially as the am drop-off period. School buses picking up students on Angell Street in the afternoon caused traffic congestion, as they would stop all traffic on Angell Street to pick students up, rather than pulling into the parking lane. The congestion in the area at the end of the school day is made worse by the vehicle queues from the nearby traffic signals, on-street parking maneuvers, and pedestrian activity. The disruptions in traffic flow during the afternoon peak period caused by Wheeler School activities were observed to last until approximately 3:15 PM.

Brown/Fox Point Early Childhood Education Center Operations

Student drop-off and pick-up activities at the Brown/Fox Point Early Childhood Education Center, which is located on the west side of Hope Street between Benevolent Street and Charlesfield Street, causes minor congestion on Hope Street adjacent to the facility during school arrival and departure periods. This is primarily because parents are required to walk the children into/out of the building, and most parents were observed to park along the curb rather than use the parking lot behind the building (Brown Lot 57) which can be accessed via Benevolent Street and Charlesfield Street. Due to the nature of the center's program, morning drop-off is any time between 7:30 AM and 9:30 AM and afternoon pick-up is any time before 5:30 PM. Generally, the disruption to traffic flow seems to be minimal due to the low traffic volumes on Hope Street adjacent to the facility and the spacing of the drop-off and pick-up times.

Signal Observations

The following observations made during the signal inspections:

- The controller programming for vehicle detection at Hope Street and Olney Street was found to contain incorrect data, which was causing Hope Street northbound vehicles (phase 1) to call and extend the Olney Street approaches (phase 2). The controller programming was corrected by VHB in the field and vehicle detection is now functioning properly.
- Vehicles were observed parking over the right loop on Olney Street westbound approach adjacent to the Tortilla Flats restaurant (Hope Street), which generates a constant call to the controller until the vehicle is tuned out. No parking signs and pavement striping could address this issue.
- On the northeast corner of Olney Street and Hope Street there is a detectable warning system mat peeling off the wheelchair ramp.
- Campus-wide there are low hanging tree canopies that affect sight distance and create visibility issues with signal heads. The tree canopies also restrict the sight distance of the Opticom transit signal priority equipment.
- At signalized intersections within the study area, pedestrians generally waited for the "walk" signal indications during periods of heavy traffic. During off-peak periods, pedestrians were observed to cross at various times in the traffic signal cycles.
- At the unsignalized intersections of Brown Street with Angell Street and with Waterman Street, pedestrians crossing the roadways disrupted traffic flow, which resulted in areas of congestion during peak periods.
- The large number of pedestrians, parking maneuvers, and buses related to the Hope High School and 360 High School restrict the flow of traffic along Hope Street during the afternoon school dismissal peak period.
- Several factors caused restrictions to traffic flow throughout the day along Thayer Street between Cushing Street and Waterman Street. These factors included truck loading/deliveries, pedestrians crossing against the traffic signals and at mid-block locations, bus maneuvers, parking maneuvers, and double-parked vehicles.

Traffic Volumes

An extensive transportation data collection program was conducted in October 2016 to establish base traffic conditions within the study area. This effort included conducting morning and evening peak hour manual turning movement counts (TMCs) and observations at various times between 7:00 AM and 9:00 AM and between 4:00 PM and 6:00 PM throughout the study area. Traffic counts and observations were observed in the areas adjacent to Moses Brown School and the Wheeler School.

Daily automatic traffic recorder (ATR) data were collected along several roadways throughout the study area. Table 2-1 presents a summary of the observed daily and

peak hour traffic from the ATR data. Table 2-2 shows a comparison of the 2011 and 2016 daily ATR data showing the decreases in traffic.

In addition, traffic data collected and analyses performed on the campus by VHB for other projects in recent years were reviewed, including the following:

- 2006 and 2011 Transportation Component of the IMP;
- 2008 Design Study Report for the Angell Street/Waterman Street Traffic Signal Coordination project;
- 2010 Traffic Impact Analysis for the Fitness Center Project;
- 2010 Angell Street/Waterman Street Pedestrian Crossing Review and Campus-Wide Pedestrian Crossing Inventory;
- 2013 Brown Street, Benevolent Street, and Olive Street Abandonment;
- 2013-2015 Providence Road Improvement Program;
- 2014 Bumpout Installation on Waterman Street at Brown Street;
- 2016 Brook Street Parking Lot Installation between Cushing Street and Meeting Street; and
- 2016 South Street Landing Shuttle Study.

Based on a review of the new traffic count data, the study area's overall morning peak hour was determined to occur between 7:30 AM and 8:30 AM, and the overall evening peak hour was determined to occur between 4:45 PM and 5:45 PM. The peak hours along Lloyd Avenue east of Hope Street occurred at the same AM peak and between 2:30 PM and 3:30 PM due to the activity related to the Moses Brown School.

The new traffic count data was compared to the data collected in 2011 at various locations within the study area. In general, many of the area roadways experienced a decrease in traffic from 2011 to 2016. The weighted average decrease was 10 percent. The reduction in traffic volumes could be attributable to various reasons, including the effect of the aggressive TDM measures implemented on the campus in conjunction with stringent parking management policies, construction related activity on the campus at any given time of the year which could divert traffic to alternate routes, the general state of the economy/ employment levels in the region that could influence traffic flow through the campus to/from downtown Providence, and finally, the effect of major infrastructure enhancements to the I-95/I-195 interchange that could have resulted in downtown traffic choosing to stay on the freeway until it gets to the downtown area rather than exit onto local streets before reaching congested sections of the freeway.

Notwithstanding the differences, since one of the goals of this updated study is to reestablish a baseline for understanding campus traffic operations, the latest 2016 count data was used in the analysis.

In addition to a comparison of old and new peak hour traffic volumes, an equally important exercise is the comparison of the corresponding overall distribution of campus traffic via the various roadways serving the campus. This comparison would help understand if any of the campus projects, policies and initiatives since the 2011

Plan have resulted in a notable change in the usage of certain streets by vehicular traffic than others. The distribution of traffic entering/exiting the study area based on the 2016 data is shown in Figure 2-2. As shown, approximately 72% of the traffic accesses the study area along the arterial roadways of Angell Street, Waterman Street, and Hope Street, which is consistent with the finding presented in the 2011 Plan.

Seasonal Traffic Variation

To evaluate the potential for seasonal fluctuation of traffic volumes on roadways within the study area, monthly RIDOT seasonal adjustment factors were reviewed. According to the RIDOT statistics, traffic on urban facilities such as the roadways within the study area, in the month of October is higher than the average month. To present a conservative analysis, RIDOT seasonal adjustment factors were not applied to the higher than average traffic counts collected in October 2016. The existing weekday morning peak hour traffic volumes are presented in Figures 2-3 and 2-4, and the existing weekday evening peak hour traffic volumes are presented in Figures 2-5, and 2-6.

Table 2-1 Existing Traffic Volume Summary

Location	Daily	Weekday Morning Peak Hour			Weekday Evening Peak Hour		
	Weekday (vpd)[1]	Volume (vph)[2]	"K" Factor[3]	Directional Distribution	Volume (vph)	"K" Factor	Directional Distribution
Waterman Street (west of Prospect Street)	4,910	310	6.3	99% EB	400	8.2	97% EB
Angell Street (east of Hope Street)	7,600	785	10.3	100% WB	615	8.1	100% WB
Prospect Street (north of Olive Street)	2,570	160	6.1	61% SB	305	11.8	52% NB
Brown Street (north of Olive Street)	1,820	95	5.3	59% SB	160	8.7	51% SB
Waterman Street (east of Governor Street)	8,860	315	3.6	100% EB	620	7.0	100% EB
Thayer Street (south of Meeting Street)	4,130	225	5.4	100% SB	280	6.7	100% SB
Hope Street (between Meeting Street and Angell Street)	8,100	435	5.4	50% SB	775	9.5	56% SB
Brook Street (north of Euclid Avenue)	3,965	170	4.3	74% NB	360	9.1	72% NB
Lloyd Avenue (east of Hope Street)	3,600	225	6.2	62% EB	370	10.2	57% EB
Thayer Street (south of Charlesfield Street)	1,610	95	5.8	75% SB	120	7.2	75% SB
Brook Street (south of Charlesfield Street)	3,200	255	7.9	53% SB	270	8.3	57% NB
Hope Street (south of Charlesfield Street)	4,880	400	8.2	54% SB	425	8.7	51% NB

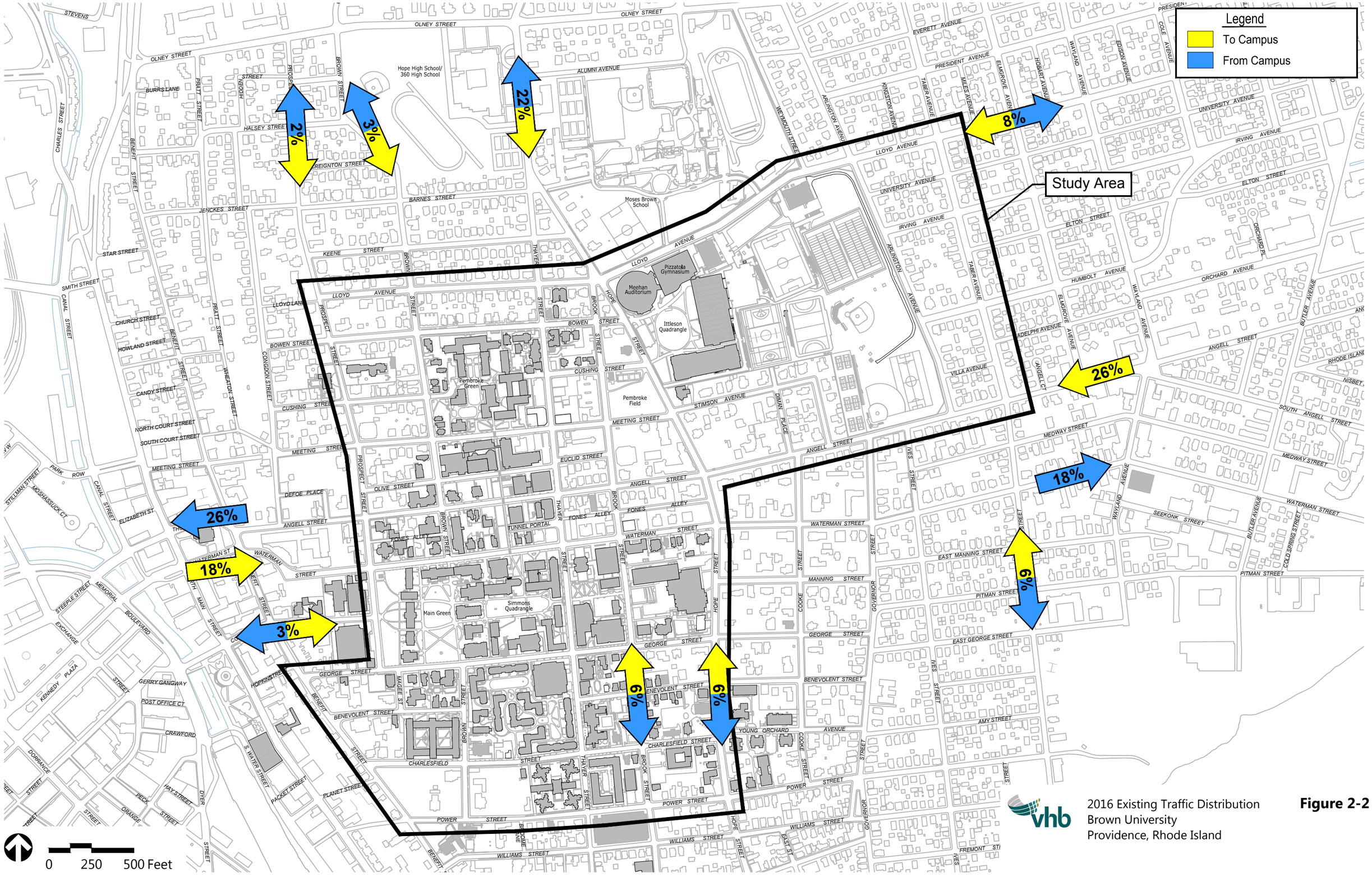
Source: Compiled by VHB from traffic data collected in October 2016

1 Daily traffic expressed in vehicles per day (vpd)

2 Peak hour volumes expressed in vehicles per hour (vph).

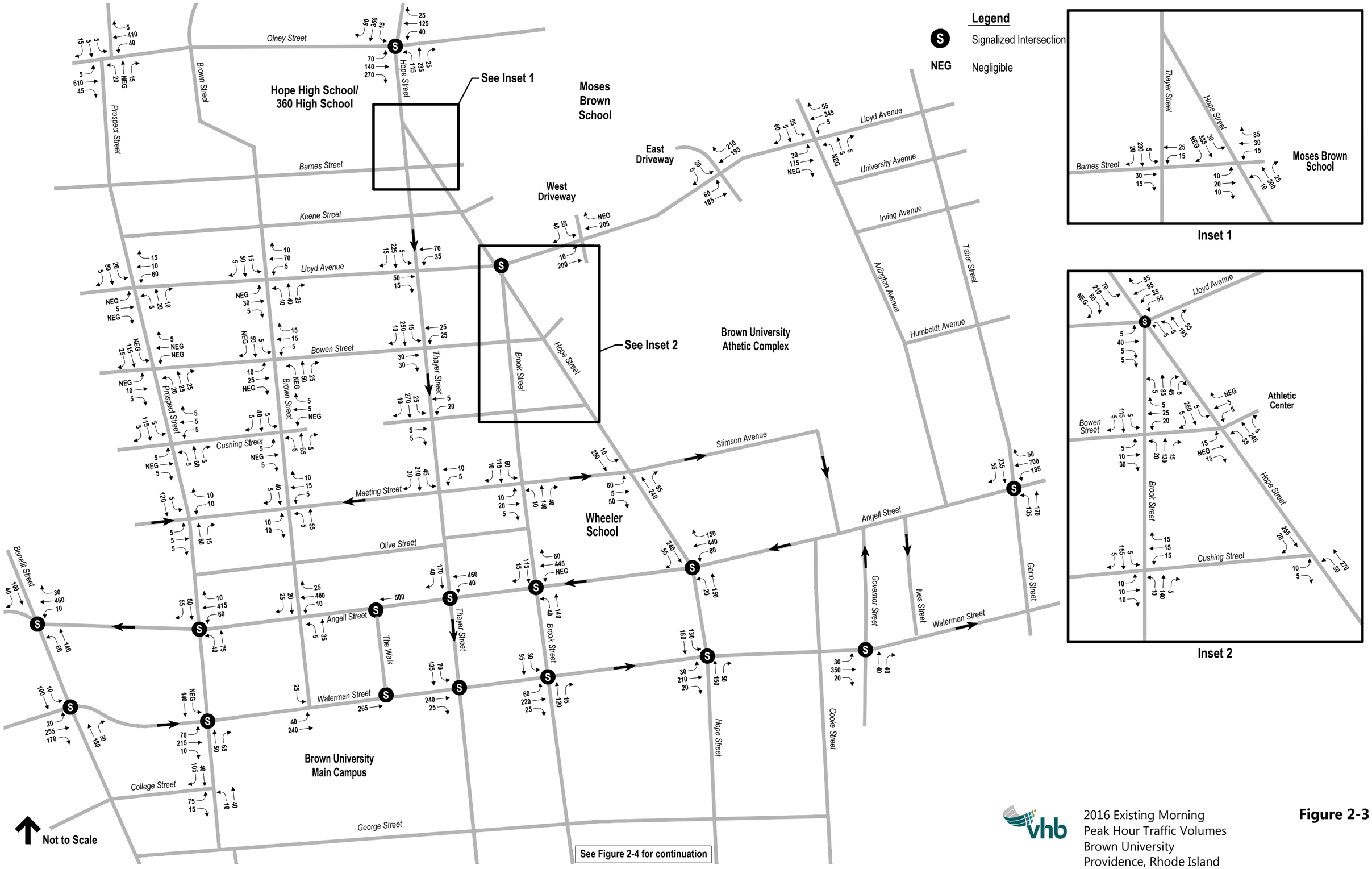
3 "K" factor = percent of daily traffic that occurs during the peak hour

\\Ri-data\projects\72806.00\graphics\FIGURES\PDI Figure\FIG2-2 - Ex-Traffic Distribution (72806).dwg



2016 Existing Traffic Distribution
Brown University
Providence, Rhode Island

Figure 2-2



2016 Existing Morning Peak Hour Traffic Volumes
Brown University
Providence, Rhode Island

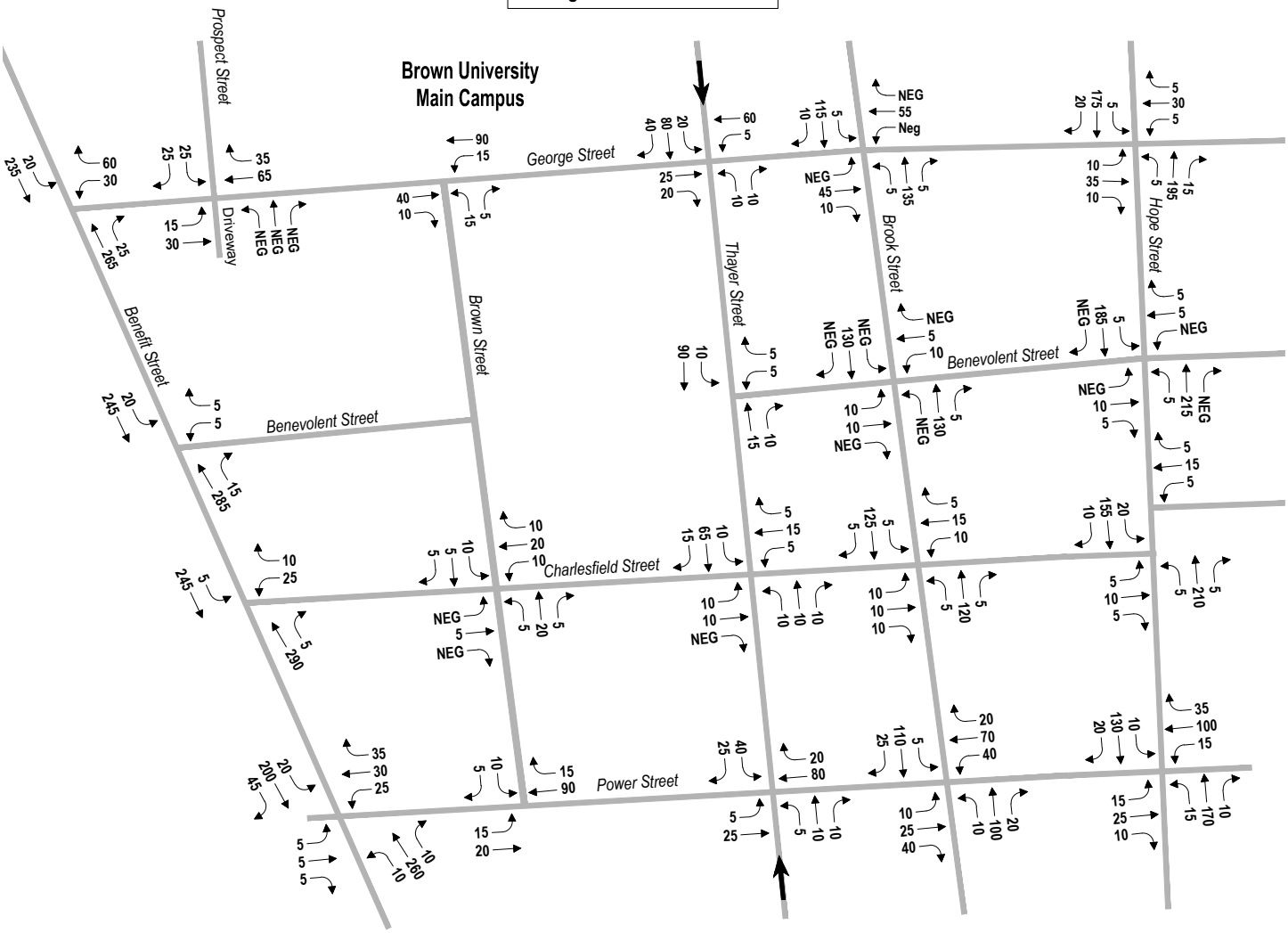
Figure 2-3

Legend

S — Signalized Intersection

NEG — Negligible

See Figure 2-3 for continuation



Not to Scale

2016 Existing Morning
Peak Hour Traffic Volumes
Brown University
Providence, Rhode Island

Figure 2-4

Legend

S Signalized Intersection

NEG Negligible

Olney Street
Brown Street
Hope Street
Prospect Street
Barnes Street
Keene Street
Lloyd Avenue
Bowen Street
Cushing Street
Meeting Street
Olive Street
Benefit Street
Angell Street
Waterman Street
College Street
George Street
The Walk
Brook Street
Thayer Street
East Driveway
West Driveway
University Avenue
Irving Avenue
Arlington Avenue
Taber Street
Humboldt Avenue
Stimson Avenue
Governor Street
Ives Street
Gano Street
Cooke Street

Hope High School/
360 High School

Moses
Brown
School

Brown University
Athletic Complex

Wheeler
School

Brown University
Main Campus

See Inset 1

See Inset 2

See Figure 2-6 for continuation

Not to Scale

Inset 1

Inset 2

Athletic
Center

2016 Existing Evening
Peak Hour Traffic Volumes
Brown University
Providence, Rhode Island

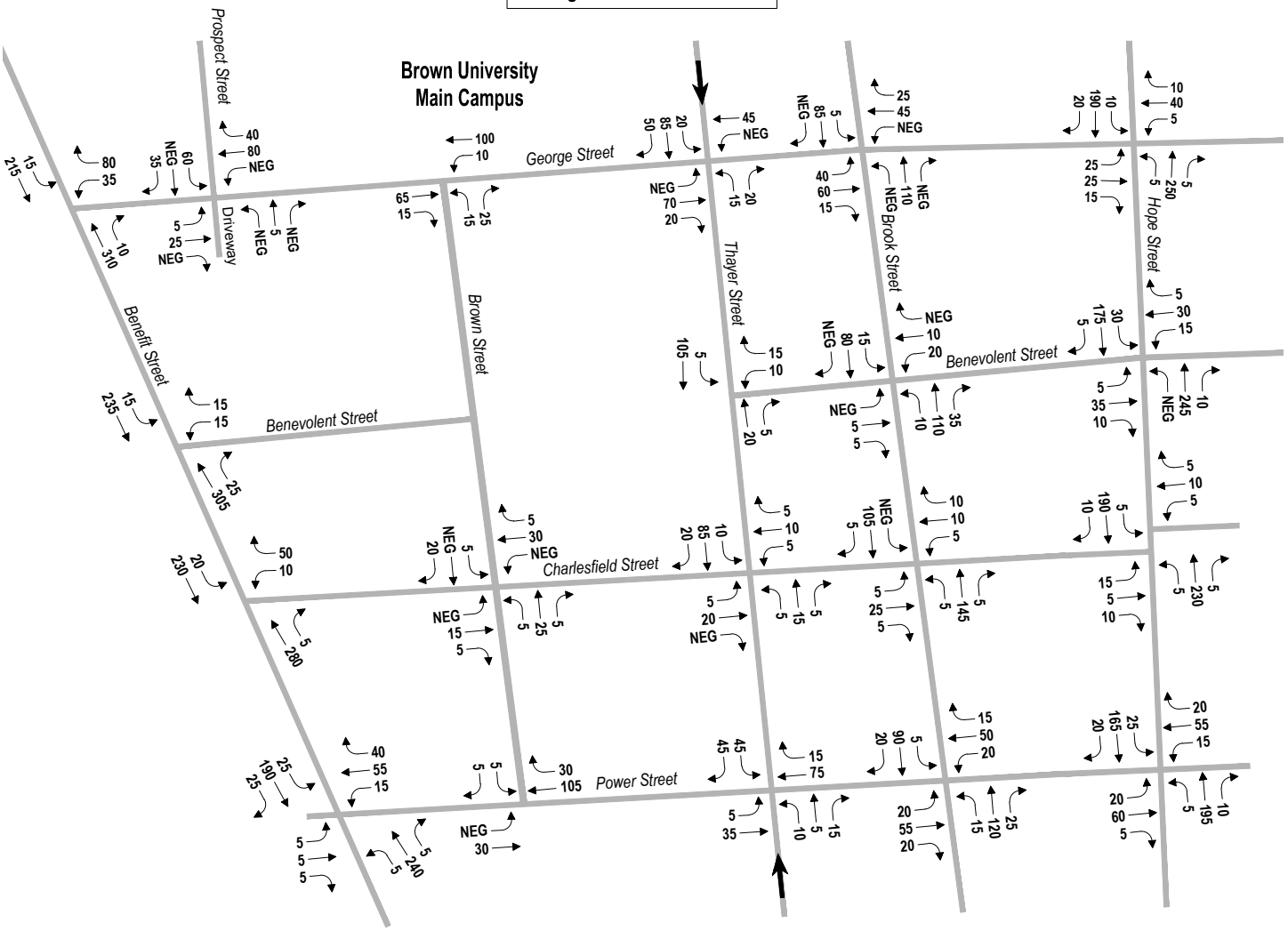
Figure 2-5

Legend

S — Signalized Intersection

NEG — Negligible

See Figure 2-5 for continuation



Not to Scale

2016 Existing Evening
Peak Hour Traffic Volumes
Brown University
Providence, Rhode Island

Figure 2-6

Table 2-2 Automatic Traffic Recorder (ATR) Comparison Table

Location	2011 Weekday (vpd[1])	2016 Weekday (vpd[1])	% Change
Waterman Street (west of Prospect Street)	5,410	4,910	-9%
Angell Street (east of Hope Street)	8,030	7,600	-5%
Prospect Street (north of Olive Street)	2,600	2,570	-1%
Brown Street (north of Olive Street)	3,510	1,820	-48%
Waterman Street (east of Governor Street)	8,860	8,860	0%
Thayer Street (south of Meeting Street)	4,530	4,130	-9%
Hope Street (between Meeting Street and Angell Street)	8,520	8,100	-5%
Brook Street (north of Euclid Avenue)	4,930	3,965	-20%
Lloyd Avenue (east of Hope Street)	4,620	3,600	-22%
Thayer Street (south of Charlesfield Street)	2,510	1,610	-36%
Brook Street (south of Charlesfield Street)	3,680	3,200	-13%
Hope Street (south of Angell Street)	8,520	n/a	n/a
Hope Street (south of Charlesfield Street)	n/a	4,880	n/a

Source: Compiled by VHB from traffic data collected in 2011 and 2016

1 Daily traffic expressed in vehicles per day (vpd)

Traffic Operations Analysis

Measuring existing traffic volumes quantifies traffic flow within the study area. To assess quality of flow, intersection capacity analyses were conducted using existing traffic volumes, intersection geometry, and traffic control. Capacity analyses provide an indication of how well the roadway facilities serve the traffic demands placed upon them. Roadway operating conditions are classified by calculated levels of service.

Level-of-service (LOS) is the term used to denote the different operating conditions which occur on a given roadway segment under various traffic volume loads. It is a qualitative measure of the effect of a number of factors including roadway geometrics, speed, travel delay and freedom to maneuver. Level-of-service provides an index to the operational qualities of a roadway segment or an intersection. Level-of-service designations range from A to F, with LOS A representing the best

operating conditions with little or no delay and LOS F representing the worst operating conditions with highly congested operations and long delays. In an urbanized area, LOS D or better is generally considered an acceptable operating condition. The evaluation criteria used to analyze area intersections are based on the 2000 Highway Capacity Manual.

Level-of service designation is reported differently for signalized and unsignalized intersections. For signalized intersections, the analysis considers the operation of each lane or lane group entering intersection and the LOS designation is for overall conditions at the intersection. For unsignalized intersections, however, the analysis assumes that traffic on the mainline is not affected by traffic on the side streets. The LOS is only determined for left turns from the main street and all movements from the minor street. The overall LOS designation is for the most critical movement, which is often the left turn out of the side street.

Signalized Intersections

Capacity analyses were conducted at the sixteen signalized intersections included in this study. Traffic signal timings used for the analyses were based on actual field measurements or extracted traffic signal controller data obtained by VHB. A summary of the signalized intersection capacity analyses results for "2016 Existing Conditions" is presented in Table 2-3.

It is important to note that the capacity analysis software analyzes the operation at the intersections only. Interruptions to traffic flow caused by pedestrians, crossing guards, bus blockages, delivery trucks, parking maneuvers, double parked vehicles, and extended vehicle queues from adjacent traffic signals often occur between the signalized intersections. These interruptions can block traffic from getting to and/or through the signalized intersections resulting in congestion between intersections. Blockages of traffic on approaches or departures of a signalized intersection will degrade the overall operation of the intersection and can result in severe congestion if the volume of traffic at the intersection is at or near capacity. The capacity analysis software is a tool used to identify problem areas and to provide a comparison between existing and future conditions.

As shown in Table 2-3, the results of the capacity analyses indicate that all of the signalized intersections within the study area operate at acceptable calculated level of service (LOS) D or better during both peak periods analyzed except Hope Street at Olney Street and Lloyd Avenue/Brook Street. Field observations revealed lengthy queues and long delays for some of the approaches to the intersections due to surrounding primary and upper educational schools' drop-off and pick-up times. This is commonly the result of queuing generated at adjacent intersections, caused in part by poor traffic signal timings, blocking the flow through these intersections and additional disruptions to traffic flow discussed previously. Based on field observations, several intersections appear to experience these issues and operate at lower levels of service than the operations analysis suggests.

Table 2-3 Existing Conditions Signalized Intersection Capacity Analysis Summary

Location	Peak Hour	2016 Existing		
		V/C[1]	Delay[2]	LOS[3]
Angell Street/ Gano Street/Taber Avenue	Weekday Morning	0.80	20.0	C
	Weekday Evening	0.71	15.7	B
Angell Street/ Hope Street	Weekday Morning	0.68	12.7	B
	Weekday Evening	0.62	10.9	B
Angell Street/ Brook Street	Weekday Morning	0.79	19.8	B
	Weekday Evening	0.63	11.3	B
Angell Street/ Thayer Street	Weekday Morning	0.63	17.7	B
	Weekday Evening	0.59	20.4	C
Angell Street/ The Walk	Weekday Morning	0.45	2.8	A
	Weekday Evening	0.38	2.3	A
Angell Street/ Prospect Street	Weekday Morning	0.66	11.4	B
	Weekday Evening	0.51	7.9	A
Angell Street/ Benefit Street	Weekday Morning	0.44	8.3	A
	Weekday Evening	0.50	8.8	A
Waterman Street/ Benefit Street	Weekday Morning	0.36	11.4	B
	Weekday Evening	0.42	13.2	B
Waterman Street/ Prospect Street	Weekday Morning	0.47	7.8	A
	Weekday Evening	0.49	8.0	A
Waterman Street/ The Walk	Weekday Morning	0.23	4.5	A
	Weekday Evening	0.35	5.3	A
Waterman Street/ Thayer Street	Weekday Morning	0.39	9.1	A
	Weekday Evening	0.55	10.4	B
Waterman Street/ Brook Street	Weekday Morning	0.47	8.0	A
	Weekday Evening	0.66	12.0	B
Waterman Street/ Hope Street	Weekday Morning	0.64	11.4	B
	Weekday Evening	0.81	21.0	C
Waterman Street/ Governor Street	Weekday Morning	0.41	5.4	A
	Weekday Evening	0.62	7.9	A
Hope Street/ Olney Street	Weekday Morning	>1.00	46.9	D
	Weekday Evening	>1.00	102.2	F
Hope Street/ Lloyd Avenue/Brook Street	Weekday Morning	>1.00	>120.0	F
	Weekday Evening	>1.00	>120.0	F

Source: Synchro 9 software using the procedures in the 2000 Highway Capacity Manual.
1 V/C = volume to capacity ratio.
2 Delay = Vehicle delay expressed in seconds per vehicle. See Note below.
3 LOS = Level of service
Note: Interruptions to traffic flow caused by pedestrians, bus blockages, delivery vehicles, parking maneuvers, and double parking vehicles were observed at times. These interruptions caused congestion along these roadways during the peak hour periods. During these times, the observed delay times at some intersections may exceed the calculated values.

Unsignalized Intersections

Capacity analyses were conducted at the unsignalized intersections included in the study area. A summary of the unsignalized intersection capacity analysis results for existing conditions is presented in Table 2-4.

Table 2-4 Existing Conditions Unsignalized Intersection Capacity Analysis Summary

Location	Peak Hour	2016 Existing			
		Critical Movement[1]	Demand[2]	Delay[3]	LOS[4]
Angell Street/Brown Street	Weekday Morning	NB LT	40	24.2	C
	Weekday Evening	NB LT	60	≥50.0	F
Waterman Street/Brown Street	Weekday Morning	SB L	25	15.9	C
	Weekday Evening	SB L	55	≥50.0	F
Lloyd Avenue/Arlington Avenue	Weekday Morning	WB LTR	405	29.3	D
	Weekday Evening	SB LTR	225	12.9	B
Lloyd Avenue/Moses Brown East Drive	Weekday Morning	SB LR	25	19.1	C
	Weekday Evening	SB LR	30	11.2	B
Lloyd Avenue/Moses Brown West Drive	Weekday Morning	SB LR	95	14.1	B
	Weekday Evening	Driveway closed during this peak period			
Hope Street/Barnes Street/ Moses Brown	Weekday Morning	WB LTR	130	44.7	E
	Weekday Evening	EB LTR	20	34.0	D
Hope Street/Bowen Street	Weekday Morning	WB LTR	10	18.5	C
	Weekday Evening	WB LTR	10	18.5	C
Hope Street/Cushing Street	Weekday Morning	EB LR	15	16.6	C
	Weekday Evening	EB LR	15	25.9	D
Hope Street/Meeting Street	Weekday Morning	EB LTR	115	36.1	E
	Weekday Evening	EB LTR	65	26.4	D
Hope Street/George Street	Weekday Morning	SB LTR	200	10.1	B
	Weekday Evening	NB LTR	260	10.3	B
Hope Street/Benevolent Street	Weekday Morning	EB LTR	15	12.1	B
	Weekday Evening	WB LTR	50	17.7	C
Hope Street/Charlesfield Street	Weekday Morning	WB LTR	25	17.3	C
	Weekday Evening	EB LTR	30	28.5	D
Hope Street/Power Street	Weekday Morning	NB LTR	195	10.0	B
	Weekday Evening	SB LTR	210	10.6	B
Brook Street/Bowen Street	Weekday Morning	NB LTR	165	9.0	A
	Weekday Evening	NB LTR	175	8.6	A
Brook Street/Cushing Street	Weekday Morning	SB LTR	165	9.3	A
	Weekday Evening	NB LTR	165	8.7	A
Brook Street/Meeting Street	Weekday Morning	SB LTR	185	47.0	E
	Weekday Evening	NB LTR	245	18.2	C
Brook Street/George Street	Weekday Morning	NB LTR	145	8.2	A
	Weekday Evening	EB LTR	115	8.3	A
Brook Street/Benevolent Street	Weekday Morning	EB LTR	20	11.5	B
	Weekday Evening	WB LTR	30	13.4	B
Brook Street/Charlesfield Street	Weekday Morning	WB LTR	30	15.1	C
	Weekday Evening	EB LTR	35	23.2	C
Brook Street/Power Street	Weekday Morning	NB LTR	130	9.4	A
	Weekday Evening	NB LTR	160	9.1	A
Thayer Street/Barnes Street	Weekday Morning	SB LTR	255	9.7	A
	Weekday Evening	SB LTR	210	8.7	A

Table 2-4 (cont.) Existing Conditions Unsignalized Intersection Capacity Analysis Summary

Location	Peak Hour	2016 Existing			
		Critical Movement[1]	Demand[2]	Delay[3]	LOS[4]
Thayer Street/Lloyd Avenue	Weekday Morning	SB LTR	245	10.7	B
	Weekday Evening	SB LTR	215	9.2	A
Thayer Street/Bowen Street	Weekday Morning	WB LT	50	18.7	C
	Weekday Evening	WB LT	45	22.2	C
Thayer Street/Cushing Street	Weekday Morning	WB LT	25	35.1	E
	Weekday Evening	WB LT	40	≥50.0	F
Thayer Street/Meeting Street	Weekday Morning	WB LT	15	21.2	C
	Weekday Evening	WB LT	30	≥50.0	F
Thayer Street/George Street	Weekday Morning	SB LTR	140	8.3	A
	Weekday Evening	SB LTR	155	8.3	A
Thayer Street/Benevolent Street	Weekday Morning	WB LR	10	9.6	A
	Weekday Evening	WB LR	25	12.6	B
Thayer Street/Charlesfield Street	Weekday Morning	SB LTR	90	7.7	A
	Weekday Evening	SB LTR	115	7.8	A
Thayer Street/Power Street	Weekday Morning	WB TR	100	8.0	A
	Weekday Evening	WB TR	90	7.8	A
Brown Street/Lloyd Street	Weekday Morning	WB LTR	85	7.8	A
	Weekday Evening	NB LTR	45	7.2	A
Brown Street/Bowen Street	Weekday Morning	EB LTR	35	7.5	A
	Weekday Evening	SB LTR	55	7.4	A
Brown Street/Cushing Street	Weekday Morning	WB LTR	10	11.5	B
	Weekday Evening	WB LTR	5	14.5	B
Brown Street/Meeting Street	Weekday Morning	NB LT	60	7.7	A
	Weekday Evening	SB TR	75	7.8	A
Brown Street/George Street	Weekday Morning	NB LR	20	12.5	B
	Weekday Evening	NB LR	40	≥50.0	F
Brown Street/Charlesfield Street	Weekday Morning	WB LTR	40	7.6	A
	Weekday Evening	NB LTR	35	7.1	A
Brown Street/Power Street	Weekday Morning	SB LR	15	9.3	A
	Weekday Evening	SB LR	10	9.4	A
Prospect Street/Olney Street	Weekday Morning	NB LTR	35	≥50.0	F
	Weekday Evening	NB LTR	115	45.5	E
Prospect Street/Lloyd Avenue	Weekday Morning	WB LTR	85	8.3	A
	Weekday Evening	SB LTR	90	7.9	A
Prospect Street/Bowen Street	Weekday Morning	SB LTR	140	7.6	A
	Weekday Evening	NB LTR	90	7.6	A
Prospect Street/Cushing Street	Weekday Morning	SB LTR	125	8.2	A
	Weekday Evening	NB LTR	110	7.8	A
Prospect Street/Meeting Street	Weekday Morning	SB LT	125	8.2	A
	Weekday Evening	SB LT	120	8.2	A
Prospect Street/College Street	Weekday Morning	EB LR	90	8.5	A
	Weekday Evening	EB LR	200	9.5	A
Prospect Street/George Street	Weekday Morning	SB LTR	50	10.5	B
	Weekday Evening	SB LTR	95	14.4	B

Table 2-4 (cont.) Existing Conditions Unsignalized Intersection Capacity Analysis Summary

Location	Peak Hour	2016 Existing			
		Critical Movement[1]	Demand[2]	Delay[3]	LOS[4]
Benefit Street/George Street	Weekday Morning	WB LR	90	15.0	C
	Weekday Evening	WB LR	115	17.4	C
Benefit Street/Benevolent Street	Weekday Morning	WB LR	10	13.6	B
	Weekday Evening	WB LR	30	15.4	C
Benefit Street/Charlesfield Street	Weekday Morning	WB LR	35	12.5	B
	Weekday Evening	WB LR	60	11.3	B
Benefit Street/Power Street	Weekday Morning	SB LTR	265	11.8	B
	Weekday Evening	NB LTR	250	10.5	B

Source: Synchro 9 software using the procedures in the 2000 Highway Capacity Manual. Compiled by VHB.

1 L= Left-turn movement, T= Through movement, R= Right-turn movement

2 Demand = Demand of critical movement, expressed in vehicles per hour

3 Delay = Vehicle delay expressed in seconds per vehicle (See note below)

4 LOS = Level of service

Note: Interruptions to traffic flow caused by pedestrians, bus blockages, delivery vehicles, parking maneuvers, and double parking vehicles were observed at times. These interruptions caused congestion along these roadways during the peak hour periods. During these times, the observed delay times at some intersections may exceed the calculated values.

As stated in the signalized intersections analysis section, the capacity analysis software analyzes the operation at the intersections only and does not entirely take into account disruptions to traffic flow between intersections. As a result, the reported delay times and resulting levels of service can be underestimated. In this case, the capacity analysis software is a tool used to identify problem areas and to give a comparison between existing, no-build, and build conditions.

The intersection of Prospect Street at Olney Street experiences high delays during the morning and evening peak hours due to queues from the signal at Prospect Street at Hope Street and due to the high number of commuters arriving at and departing from Brown University via Prospect Street. During the weekday morning peak hour period, delays are experienced at the intersections of Hope Street and Barnes Street/Moses Brown School, Hope Street at Meeting Street, and Brook Street at Meeting Street due to the traffic volumes along Hope Street and the traffic at Moses Brown School and Wheeler School over a concentrated peak period. The delays experienced at many of the other intersections with deficient calculated levels of service during the weekday evening peak period are primarily due to the large number of pedestrians crossing the roadways.

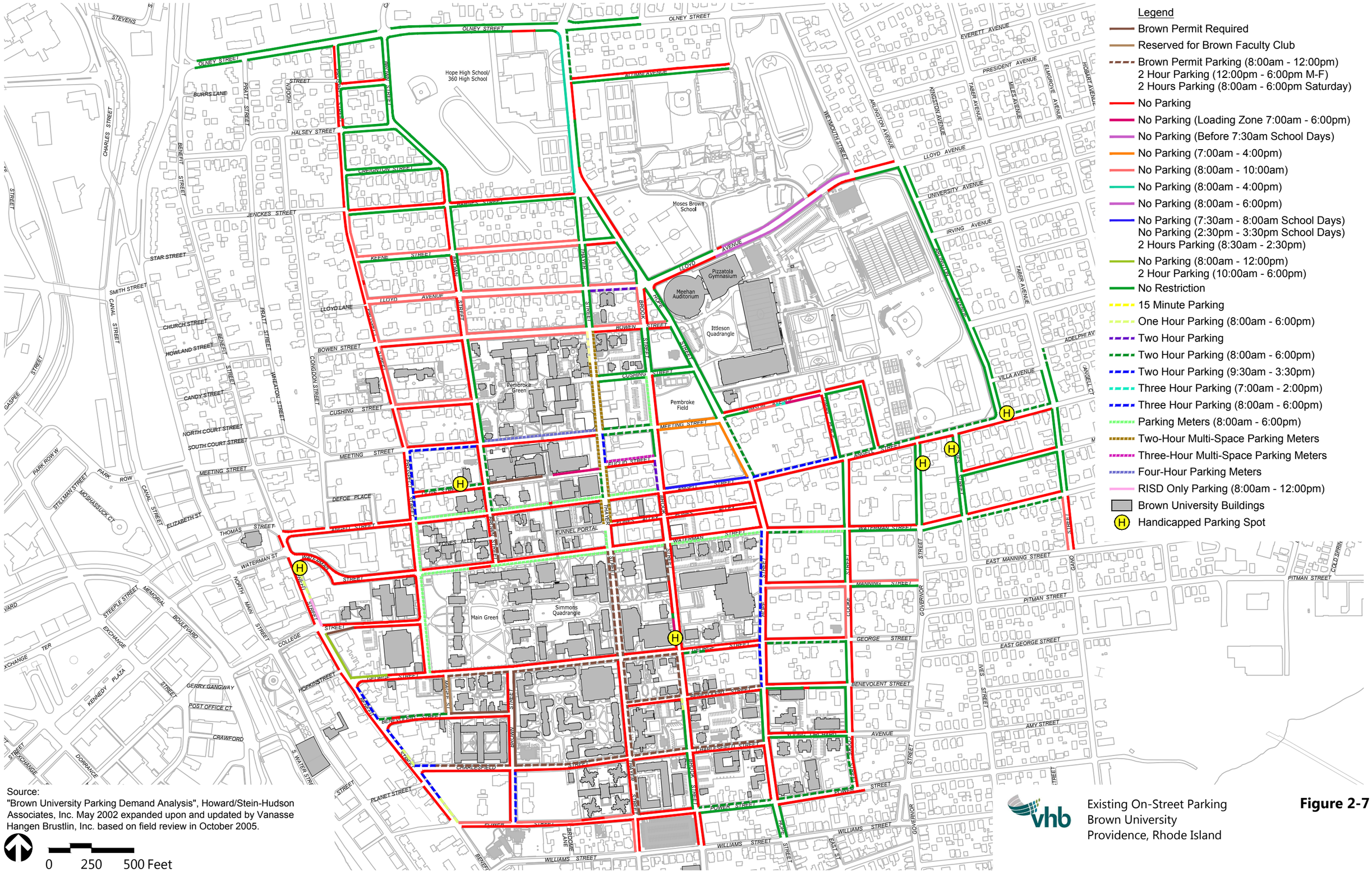
Parking

This section provides a summary of on- and off-street parking.

On-street Parking

On-street parking supply surrounding the University shown in Figure 2-7. Changes to the 2011 Plan on-street parking have occurred in the past five years as a result of various changes/projects on the campus, the general location, extent and types of use restrictions of parking that has been reflected in the updated graphic.

\\Ri-data\projects\72806.00\graphics\FIGURES\PDI Figure\FIG2-7 - Ex On-StreetParking (72806).dwg



Source:
"Brown University Parking Demand Analysis", Howard/Stein-Hudson Associates, Inc. May 2002 expanded upon and updated by Vanasse Hangen Brustlin, Inc. based on field review in October 2005.

0 250 500 Feet

vhb

Existing On-Street Parking
Brown University
Providence, Rhode Island

Figure 2-7

According to the 2008 College Hill Parking Task Force report, there were over 3,040 on-street parking spaces in the College Hill area generally bounded by Olney Street to the north, Benefit Street to the west, Williams Street to the south, and Arlington Street/Ives Street to the east. There is a limited amount of metered parking along sections of Prospect Street, Angell Street, and Waterman Street, although the College Hill Parking Task Force recommended the installation of meters on various additional roadways adjacent to the Brown University campus. The Task Force also recommended a "logical and comprehensive plan on a street-by-street basis for short-term, long-term, and all-day parking."

Leased Parking Arrangements

In 2012, Brown University applied to license 250 parking spaces on city streets near the campus for its exclusive use from 8:00 A.M. to noon. These leased spaces are located on Brown Street, between Meeting and Waterman; George Street, between Magee and Brook; Charlesfield between Magee and Hope; Thayer Street between Waterman and Power; and Brook Street between Waterman and Power. This allows Brown to charge for the use of on-street parking spaces while the City of Providence collects the revenues from violations. Brown University also owns all the parking along Olive Street, between Brown and Thayer, which is Brown Permit Parking Only.

Brown is currently evaluating their parking price structure to determine the best program that will meet the Universities needs while at the same time encouraging the use alternative transportation.

Off-Street Parking

Brown University's current off-street parking supply within, or in close proximity to, the main campus area consists of approximately 100 parking areas including five structured parking garages. These lots range in size from 1 space to approximately 400 spaces and total 3,164 parking spaces.

Based on the City of Providence Zoning requirements, the required number of parking spaces for Brown University is 3,849 spaces (one space for every 3 employees, one space for every 8 on-campus students, and one space for every 2 off-campus students). In addition, a shortage of 931 parking spaces has been grandfathered through previous approvals with the City of Providence. The shortfall is made up by on-street parking on the city streets surrounding the campus. With the grandfathered 931 space shortage, the revised required number of off-street parking spaces is 2,918 spaces. Based on the existing supply of 3,164 off-street parking spaces, there is an existing surplus based on the City of Providence Zoning requirements of 246 spaces.

Car Sharing/Zipcar

Car sharing provides convenient access to vehicular transportation for residents who do not own a vehicle. Vehicles can be rented by the hour or day and all vehicle costs are included in the rental fee. Vehicles are check out for a specific time period and returned to their designated location. The local car sharing provider, Zipcar,

offers short-term rental services for its members. Brown University Zipcar is part of the larger City of Providence program. Although the vehicles are located on Brown property, the Zipcar program is open to general public use.

Due to increasing popularity, there are 6 locations throughout campus with 25 vehicles, which includes 6 hybrid vehicles. The Zipcar program was recently expanded into the Jewelry District. Zipcar estimates that each car removes 15 vehicles from the road on a daily basis.

Brown's Zipcar locations are as follows:

1. East Side – 127 Angell Street – J Walter Wilson Building (2 vehicles, including 1 hybrid)
2. 217 Bowen Street – Lot 7 (8 vehicles, including 2 hybrids)
3. East Side – Brook Street and Power Street Garage (9 vehicles, including 2 hybrids)
4. East Side – Brown Street and Olive Street (2 vehicles)
5. East Side – Young Orchard Avenue – Orwig Musical Building (2 vehicles, including 1 hybrid)
6. Medical School (2 vehicles)

Public Transportation

The University is served by the Rhode Island Public Transit Authority (RIPTA) and various safeRIDE shuttle services. Six bus routes, including a Providence LINK trolley route serve the Brown University campus and the surrounding area. All of these routes connect to RIPTA's Transit Center at Kennedy Plaza, where connections can be made to other bus routes throughout the state of Rhode Island. The connection from Brown University to Kennedy Plaza is facilitated by the College Hill Bus Tunnel from Thayer Street to South Main Street.

SafeRIDE Shuttle service is a scheduled fixed-route and on-call shuttle service around the Brown University and Rhode Island School of Design (RISD) campuses. These shuttles, which circle around designated routes and are also available on-call during the evening hours, are available to all Brown and RISD students, faculty, and staff with a valid identification.

Shuttle

Figure 2-8 illustrates the public transportation routes in the area showing RIPTA service in relation to the Brown shuttle. Brown University recognizes the important of its shuttle service, especially with the pending relocation of staff to South Street Landing. In February 2016, Brown commissioned The South Street Landing Shuttle Study which was completed by Nelson Nygaard. The study determined that:

› Shuttle routes operate in one-way loops which may be more inconvenient to some riders heading in a different direction;

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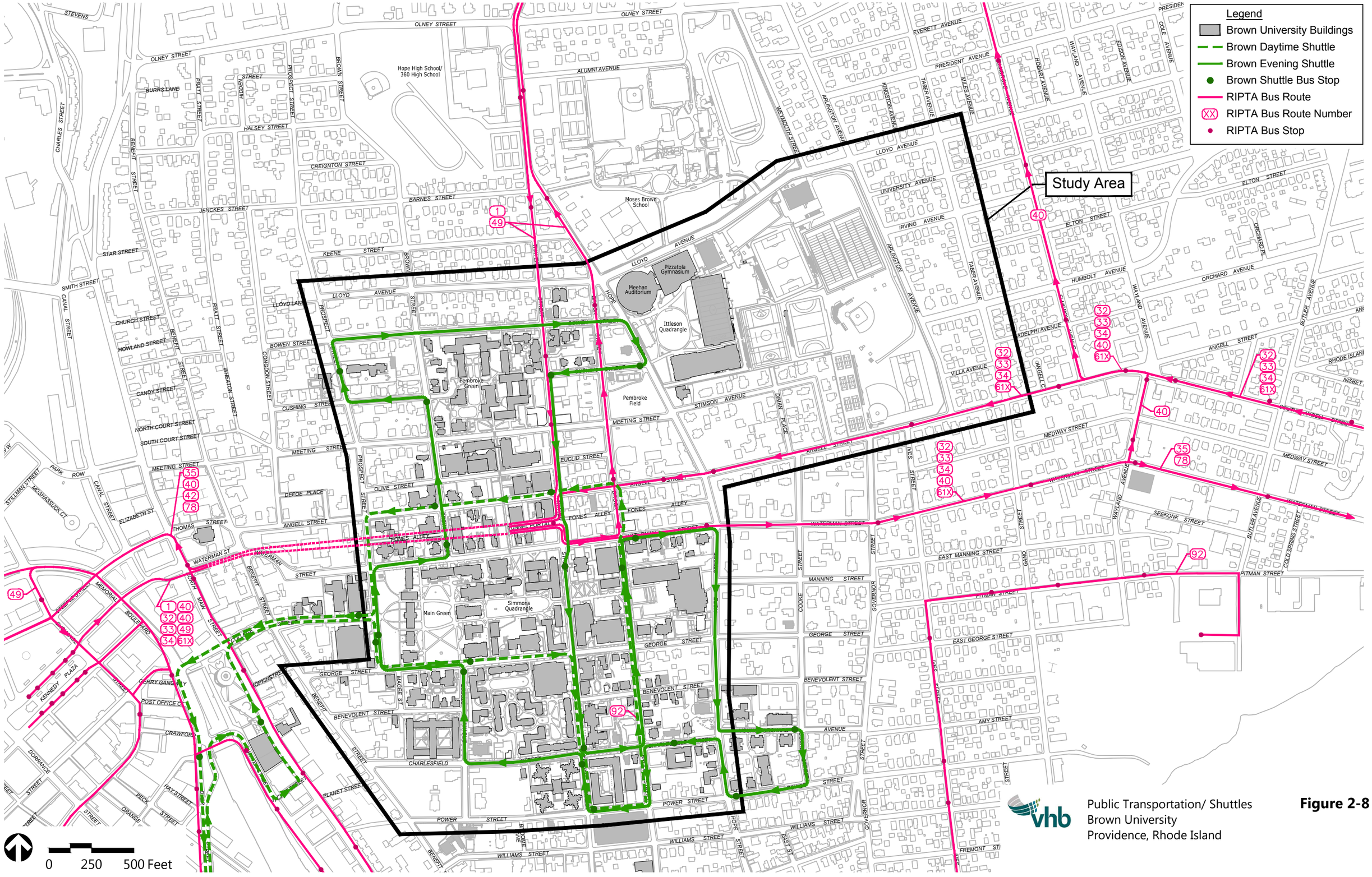


Public Transportation/ Shuttles
Brown University
Providence, Rhode Island

Figure 2-8

- The use of the East Side Transit Tunnel would not increase efficiency and would eliminate key destinations;
- Eliminating a stop on South Main Street would significantly decrease overall travel time per trip; and
- Shuttle service hours should be expanded.

Brown is in the process of assessing and implementing many of the study recommendations, especially as they relate to South Street Landing connectivity.

Rideshare

As part of the expansion to the South Street Landing, Brown currently has a Business, Entrepreneurship and Organizations (BEO) capstone being completed by a student group to evaluate rideshare programs and opportunities.

RIPTA (U-PASS)

The University Pass Program (U-Pass), which is funded by participating colleges and universities, allows students to receive reduced fare transit. Current students, faculty and staff are able to ride any RIPTA bus or trolley anytime, anywhere in the state at no charge by using their Brown University ID. Brown University encourages staff, faculty and students to utilize this program by handing out materials during staff/faculty/student orientation and by representing at both the Orientation Fair and Benefits Fair.

For Fiscal Year 2016, on average 2,428 students used their UPASS for approximately 190,933 rides and on average 885 faculty/staff used their ID for 169,443 rides.

Brown University Shuttle (BUS)

Brown University Shuttle (BUS) is a safety-oriented transportation service offered to the Brown community for students, faculty, and staff of Brown and hospital affiliates who have a Brown ID. Brown significantly expanded the shuttle program in 2013. Brown invests approximately $1.9 million in support of this transportation initiative that has:

- Three fixed-route daytime shuttles Monday - Friday (13 passenger/shuttle);
- One daytime SEAS OnCall shuttle;
- One daytime Express shuttle Monday - Friday (121 S. Main St. - Alpert Medical School);
- Three fixed-route evening shuttles Sunday - Saturday (13 passenger/shuttle); and
- Seven evening OnCall shuttles Sunday - Saturday (7, 10, or 13 passenger)

The ridership for fiscal year 2016 for all shuttles was approximately 272,941, which is a 75 percent increase since the 2011 Plan.

Pedestrian and Bicycle Activity

This section discusses existing pedestrian and bicycle activity on campus. Pedestrian and bicycle activity was observed and recorded at various locations within the study area during the morning and evening peak periods on typical weekdays during October 2016.

Pedestrian Activity

Pedestrian volumes were counted in the study area in conjunction with the traffic volumes, as previously described, on typical weekdays during the weekday morning and weekday evening peak hour periods. Figures 2-9 and 2-10 present the peak hour pedestrian flows during the commuting peak periods. Pedestrian volumes at some locations are much higher during other parts of the day, when there is less automobile traffic.

The pedestrian activity during the afternoon and evening peak hours were generally much higher than during the morning peak hour period, due to the lower levels of student activity and commercial activity on Thayer Street during the morning peak hour period.

In general, the highest pedestrian volumes in the area during the morning and evening peak hour periods occurs along Thayer Street, Angell Street, Waterman Street, and Brook Street. Higher pedestrian activity on Brook Street, however is generally concentrated in the vicinity of Angell Street and Waterman Street, with diminishing volumes as the distance from the main campus increases. Charlesfield Street also experiences higher levels of pedestrian activity in the vicinity of the main campus.

The construction of "The Walk" was projected to result in a noticeable shift in north-south pedestrian traffic from the Brown Street and Thayer Street crosswalks across Angell Street and Waterman Street to the new mid-block crossings at "The Walk", as stated in the 2011 Plan. Comparison of the previously projected vs. actual observed pedestrian volume at the Walk shows that there has in fact been a noticeable shift in pedestrian volumes from the Brown Street and Thayer Street crosswalks to the Walk since its construction. Overall Bowen Street has experienced decreased pedestrian activities over the past 5-10 years due to the construction of "The Walk." However, there is still a considerable amount of pedestrian activity at the Thayer Street crosswalk.

Bicycle Activity

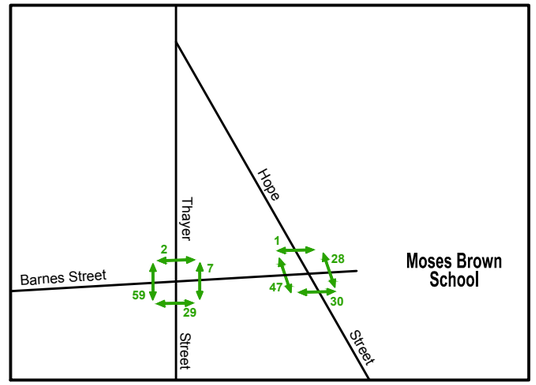
The University provides resources and promotes programs related to biking to and around campus. Brown has bicycle racks in convenient places all around campus, offers bicycle registration to discourage theft, has a student group renting and repairing bikes (repair station) called Bikes@Brown, a Bike Share, and is working with various civic groups to help promote cycling in the City.

Legend

- Ⓢ Signalized Intersection
- xxx 0 to 100 Pedestrians
- xxx 100 to 200 Pedestrians

Olney Street
Hope High School/ 360 High School
Hope Street
See Inset 1
Brown Street
Barnes Street
Prospect Street
Thayer Street
Keene Street
Moses Brown School
East Driveway
West Driveway
Lloyd Avenue
University Avenue
Irving Avenue
Humboldt Avenue
Arlington Avenue
Taber Street
Elmgrove Avenue
Brown University Athletic Complex
Bowen Street
Brook Street
See Inset 2
Cushing Street
Stimson Avenue
Angell Street
Meeting Street
Olive Street
Wheeler School
Waterman Street
Gano Street
Ives Street
Governor Street
Cooke Street
The Walk
Brown University Main Campus
College Street
George Street
Driveway
Benevolent Street
Brown Street
Charlesfield Street
Power Street
Benefit Street

Inset 1



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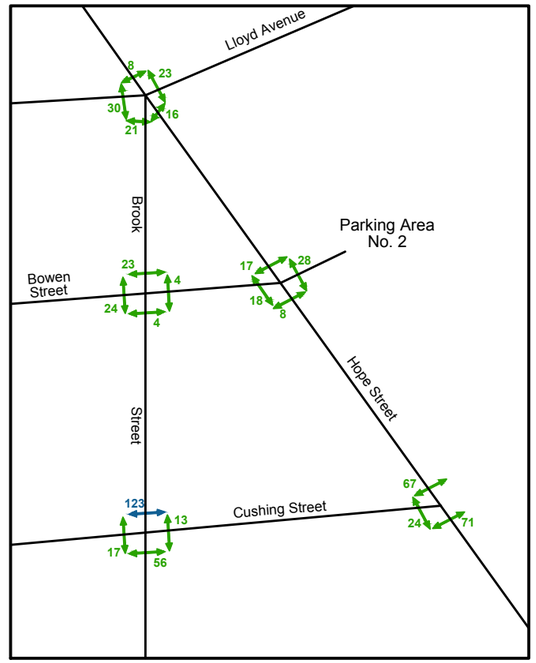


Not to Scale

2016 Existing Weekday Morning Peak Hour Pedestrian Volumes
Brown University
Providence, Rhode Island

Figure 2-9

Legend

- Signalized Intersection
- 0 to 100 Pedestrians
- 100 to 200 Pedestrians
- 200 to 400 Pedestrians
- Greater than 400 Pedestrians

Not to Scale

Inset 1

Inset 2

2016 Existing Weekday Evening Peak Hour Pedestrian Volumes
Brown University
Providence, Rhode Island

Figure 2-10

As shown in Figures 2-12 through 2-15, bicycle usage was observed throughout the campus with the most activity occurring along Thayer Street and Hope Street, both of which are primary area bicycle routes along with Angell Street and Waterman Street.

A significant number of additional bicycle racks have been installed in the campus over the past five years as part of each project. All new construction and major renovations are required to install bicycle racks as part of their projects. In addition to Brown having bicycle racks in convenient locations throughout their campus, they offer bicycle registration to discourage theft and is working with various civic groups to help promote cycling in the City of Providence.

Additionally, Brown University is in the process of compiling all the components to apply for the Bike Friendly University (BFU) designation from the League of American Bicyclists. The League's Bicycle Friendly America program provides a roadmap, hands-on assistance and recognition for universities. The BFA is a tool for universities to make bicycling a real transportation and recreation option for all.

Bike Share

Brown's Sustainability Strategic Planning and Advisory Committee (SSPAC) continues to encourage and work towards implementing a bike share program. It is critical that Brown's program ultimately be tied into a City program. Determining the right program and obtaining funding are the current challenges of implementing this program on a larger scale.

Current bicycle share programs at Brown include:

- Bikes at Brown, a student initiative, began a bike-sharing program in March 2009 utilizing University funds to purchase several bikes. Bikes at Brown now has a fleet of thirty-two bicycles, which can be signed out for a week at a time at no charge and for no deposit and offer free limited bicycle repair services.
- Brown's Facilities Management Department Bike Share Fleet has approximately 12-18 bicycles that are available to 379 employees.
- Brown Department of Public Safety (DPS) have bicycles for officers to use during work.

Overall, the significant level of investment in bicycle accommodations speaks of the level of success achieved on the campus in the promotion of bicycling as a viable alternate mode of transportation. Every new project or major renovation is required to provide bicycle parking.

Loading, Service, and Emergency Access

There are nine major delivery points (17 loading zone spaces) on the University campus (as shown on Figure 2-11):

1. Brown Office Building and the Creative Arts Center (via Olive Street)

2. J. Walter Wilson Student Resources and Services Building (via Angell Street)
3. Faunce House (via Waterman Street)
4. Sciences Library/Watson Center (via Waterman Street)
5. Rockefeller Library (via George Street)
6. Sharpe Refectory (via Thayer Street)
7. Verney Whoolley (via Thayer Street)
8. Prince Lab/Barus & Holley (via Brook Street)
9. Facility Services (via Lloyd Avenue)

All campus mail is distributed through a centralized facility in the J. Walter Wilson student resources and services building. A mail truck provides parcel delivery to all departments on campus and limited first class mail delivery/pick-up service. University departments that do not receive first class mail delivery collect the mail from department mailboxes. Some deliveries of supplies such as those by courier and express delivery companies occur within the public right-of-way.

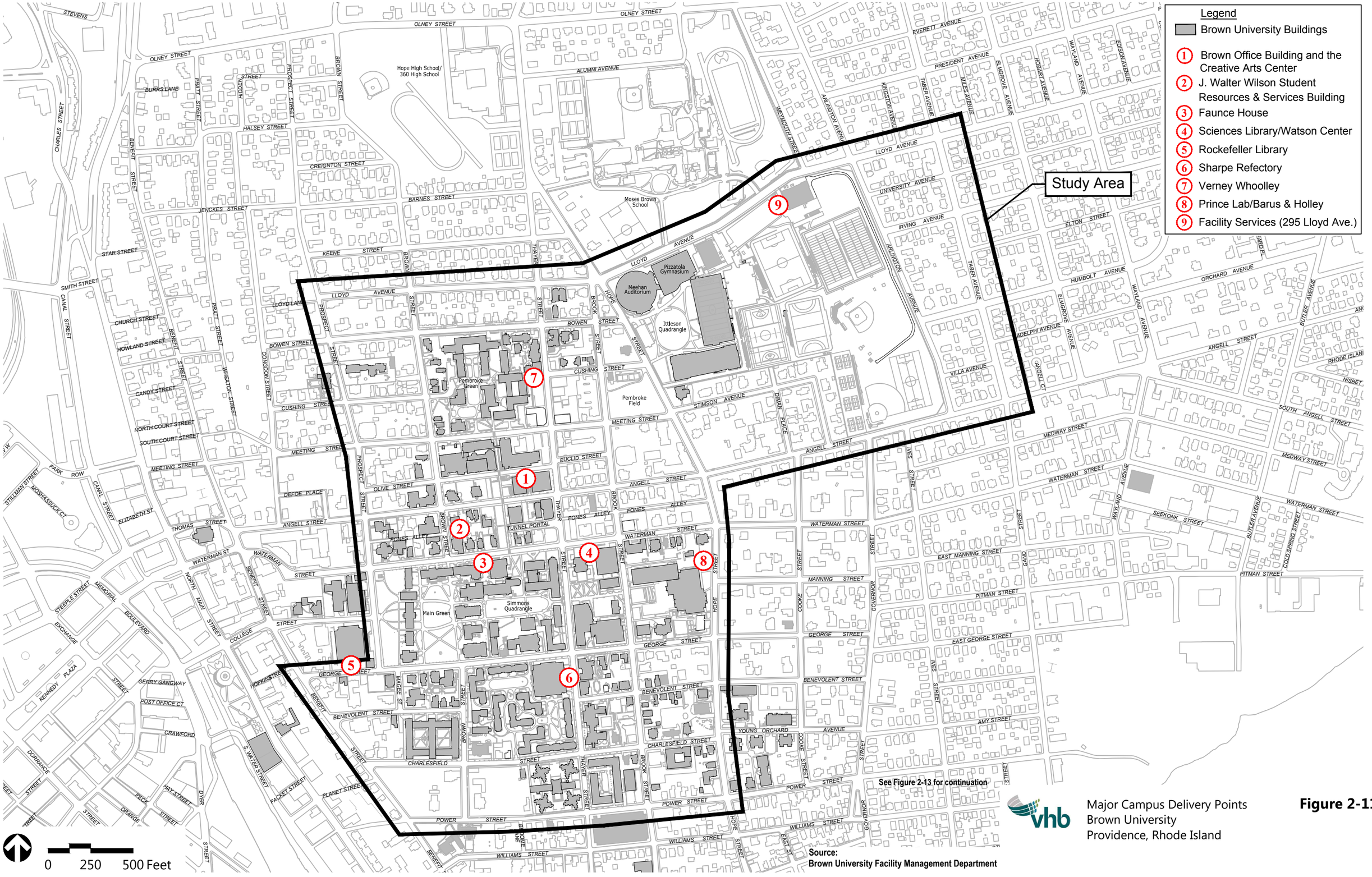
Emergency access to the campus is provided by the city street network, principally the arterial streets of Angell Street, Waterman Street, and Hope Street. Access into the campus is provided by local streets and a network of service roadways and pathways through the campus.

Transportation Demand Management

Brown University continues to provide a number of successful transportation demand management (TDM) programs in response to the needs of the students, faculty, and staff and in concert with the urban environment of the campus. These programs, which are designed to encourage alternatives to driving and parking at the campus, include:

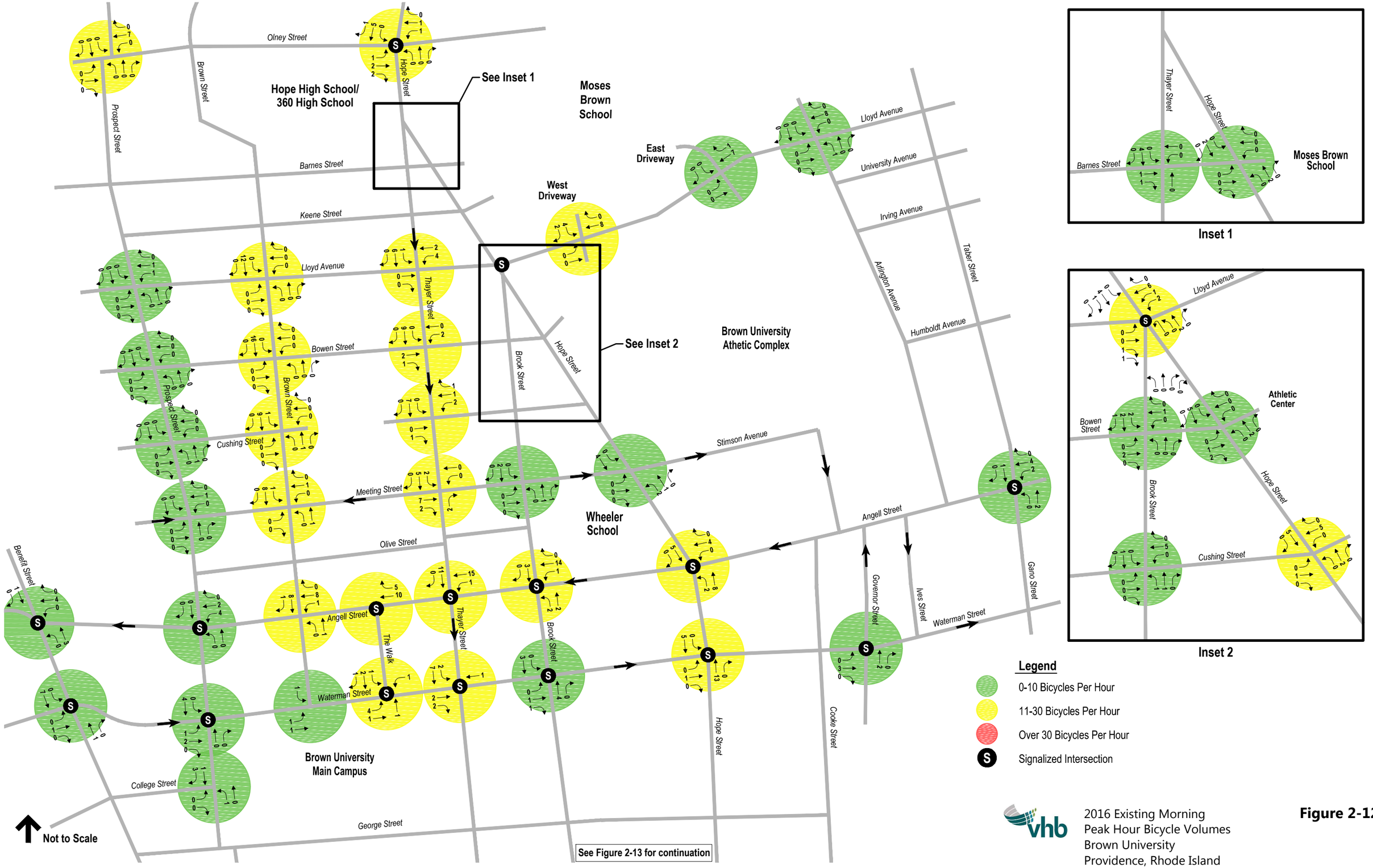
- RIPTA U-Pass program allows current students, faculty and staff to ride any RIPTA bus or trolley anytime, anywhere in the state at no charge. Brown's investment in the UPASS program continues to support the transportation initiatives benefiting the Brown community. The program provides more than 30,000 rides per month.
- Brown University shuttles connect the main campus to the Jewelry District and Rhode Island Hospital. Ridership has increased by 75% from 2011 to 2016. The increase in ridership is due, in part, to the OnCall Shuttle Service that began in 2013 and provides transportation to and from a Brown campus building to a rider's registered off-campus residence from 5:00 P.M. to 3:00 A.M.
- The Zipcar program has expanded from 15 vehicles in two locations in 2011 to 25 vehicles in 6 locations in 2016. Six of the 26 vehicles are hybrids and 2,500 Brown-related members use them to travel 30,000 miles a month.
- Brown University now has two plug-in electric vehicle charging stations available for public use.

\\vhb\proj\Providence\72806.00\graphics\FIGURES\PDI Figure\FIG2-11 Delivery Points (72806).dwg



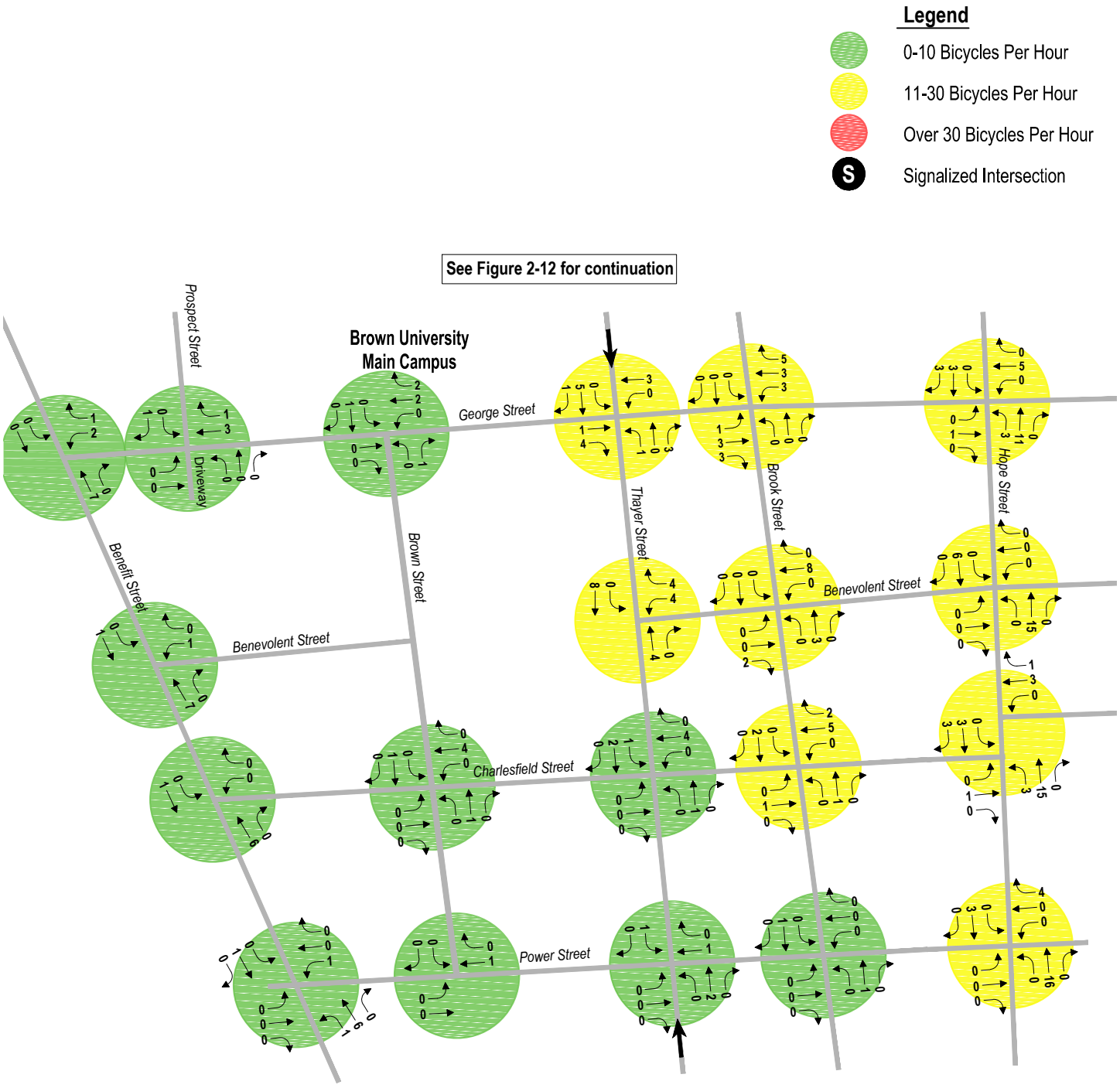
Major Campus Delivery Points
Brown University
Providence, Rhode Island

Figure 2-11



2016 Existing Morning
Peak Hour Bicycle Volumes
Brown University
Providence, Rhode Island

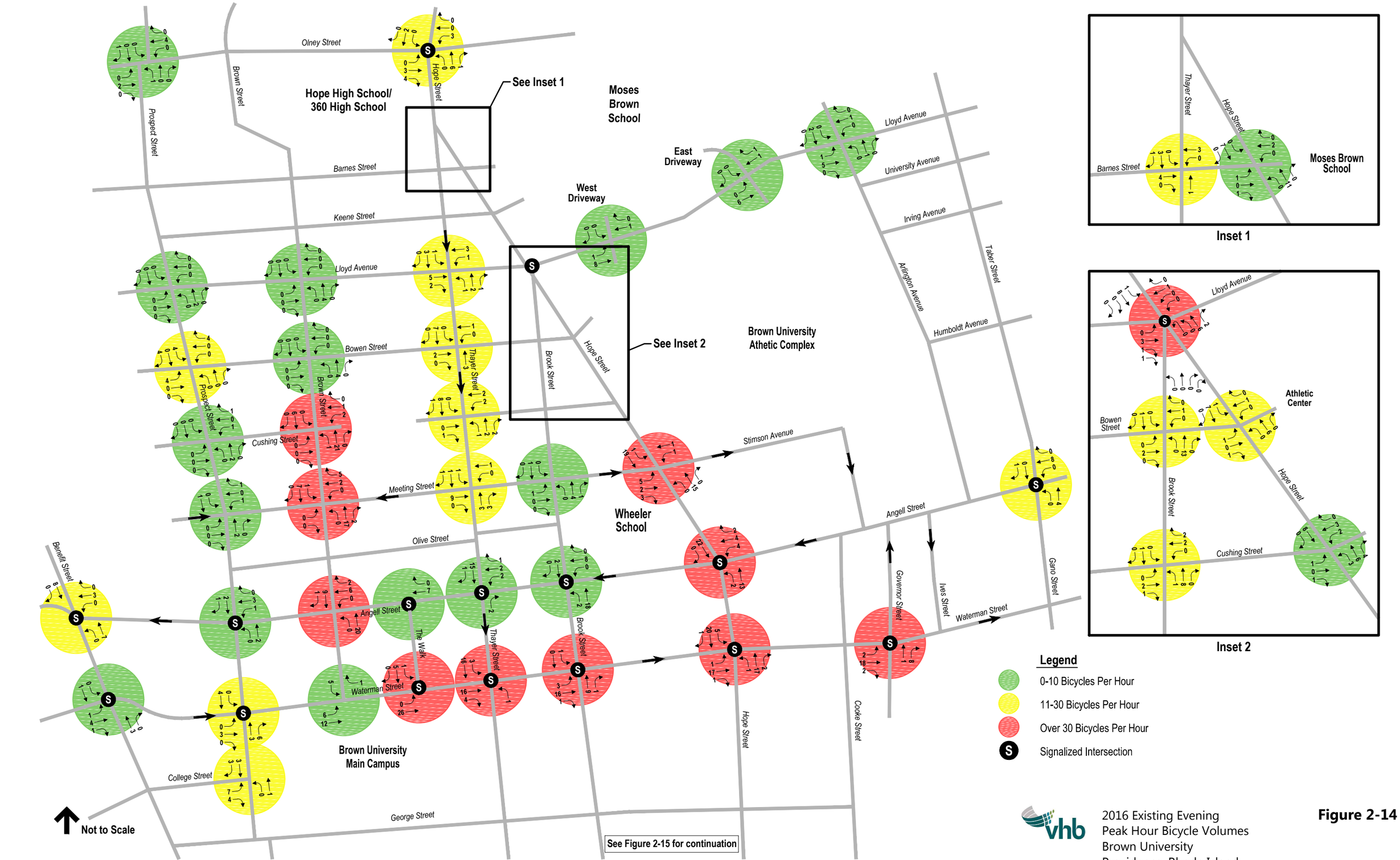
Figure 2-12



Not to Scale

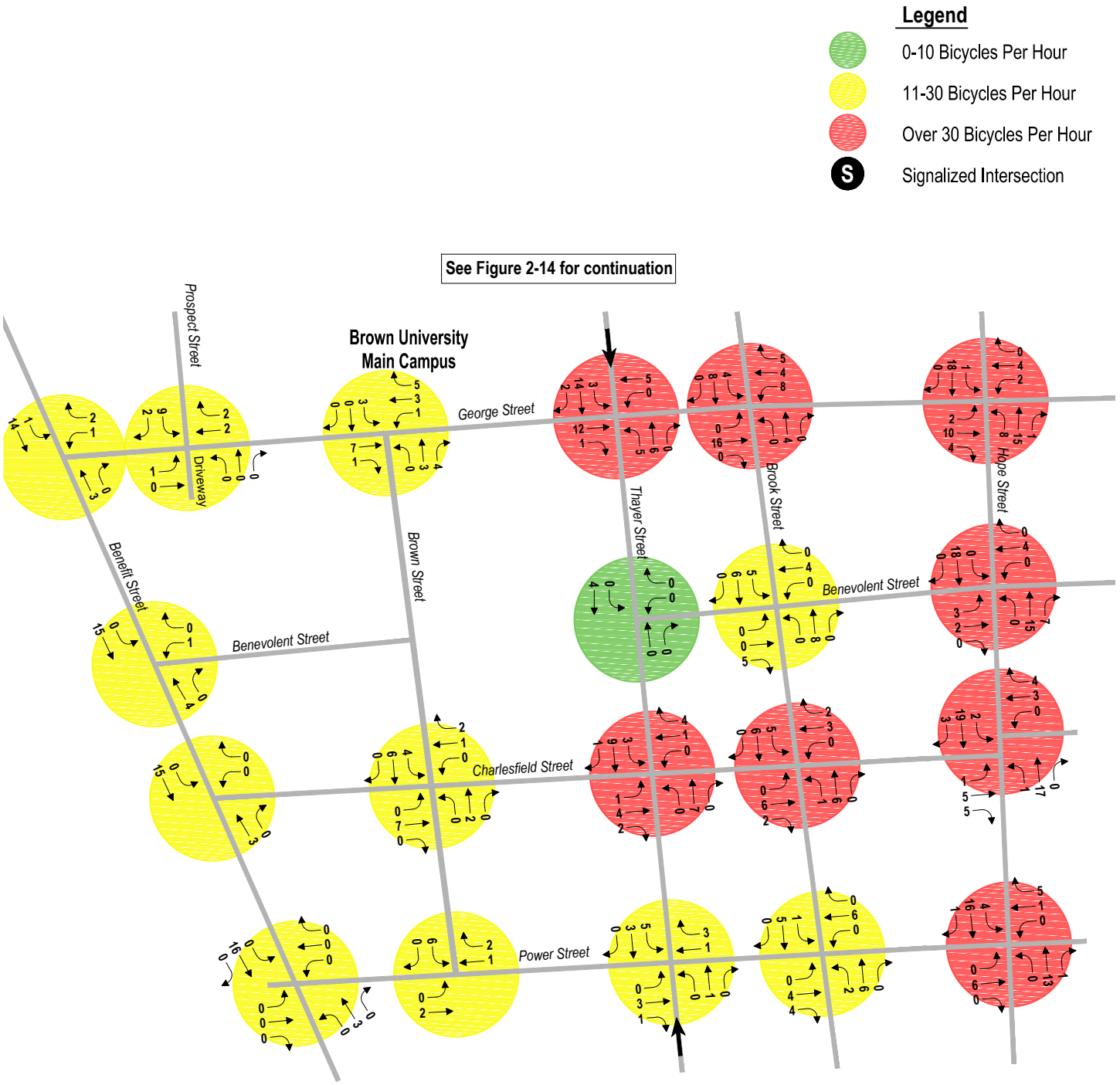
2016 Existing Morning
Peak Hour Bicycle Volumes
Brown University
Providence, Rhode Island

Figure 2-13



2016 Existing Evening
Peak Hour Bicycle Volumes
Brown University
Providence, Rhode Island

Figure 2-14



2016 Existing Evening
Peak Hour Bicycle Volumes
Brown University
Providence, Rhode Island

Figure 2-15

- Commuter flexible spending benefit offered to faculty and staff, called the Commuter Choice Assistance Program. This program allows employees to pay for train service and qualified commuter vehicle (vanpool) service on a pre-tax basis (RIPTA bus service is already free).
- Continue to adjust campus shuttle routes and headways to respond to demands.
- Continue to support the pilot bike-share program.
- Continue to increase parking fees to create a disincentive to traveling by personal automobile.
- Continued implementation of recommendations from the College Hill Parking Task Force.

3

Future Conditions

Future Analysis Years and Conditions

To assess the magnitude of change that can be expected in transportation demand in the future, transportation conditions (traffic volumes, pedestrian volumes, number of parking spaces, etc.) were projected to 2021 (5-year time horizon) and analyzed. Because of the uncertainty with longer range plans, it was determined that projections beyond a 5-year time horizon might not be accurate at this stage in the process. Two different scenarios are examined:

- **No-Build**. The No-Build scenario analyzes the transportation system serving the University campus without the Watson Institute Expansion. The No-Build scenario includes growth in traffic volumes associated with generalized regional growth as well as traffic growth due to specific projects near the campus.
- **Build**. The Build scenario accounts for any traffic shifts or new trips associated with Watson Institute Expansion are added to the No-Build traffic volumes.

No-Build Conditions

No-Build traffic conditions are projected based on planned transportation infrastructure improvements and traffic volume changes. Transportation infrastructure improvements include roadway improvements, public transit improvements, and pedestrian and bicycle enhancements. Traffic volume changes

are estimated based on two different factors, an annual growth rate and traffic growth associated with specific developments near the campus.

Infrastructure Improvement Projects

Based on coordination with City of Providence staff, there are no planned major transportation infrastructure projects that will have an impact on the study roadways in the vicinity of Brown University in the next 5 years.

Regional Traffic Growth

The 2021 No-Build traffic volumes were projected by applying a general growth rate to existing volumes and adding traffic volumes expected to be generated by specific known development projects. First, an annual growth rate was applied to the existing traffic volumes to reflect annual background traffic volume growth as a result of regional economic activity and development.

Based on a review of historical traffic data over an 11 year period (between 2005 and 2016), traffic volumes in the area generally decreased even with the growth of the University. Specifically from 2011 to 2016, the average decrease in traffic on roadways surrounding the University was 10 percent (refer to Table 2-2).

To be conservative and to be consistent with the assumptions made in the 2006 and 2011 Plan, a 0.5 percent per year annual growth rate (not including the University population growth) was used in the development the 2021 baseline traffic volumes. Coordination with the City of Providence staff confirmed that this assumption would be conservative.

Site Specific Traffic Growth

Based on coordination with the City of Providence staff, there are no proposed non-university related development projects within or adjacent to the study area that could have a notable effect on traffic/ transportation operations on the roadways serving the campus.

While there are no non-university development projects in the area, the three relevant project currently under construction that were accounted for are:

- 450 Brook Street Lot, which was recently completed, provides interim commercial and additional parking for the Thayer Street District. This project also included a landscaped perimeter zone and streetscape, and stormwater management. Potential future uses are currently being studied for this location however it is too early in the planning process to account for this site reuse in the IMP.
- The School of Engineering expansion involves a new building adjacent to the Barus & Holley complex. The building will contain classrooms, core research facilities, and high technology research laboratories. This expansion will be connected to the Barus & Holley building and will

ultimately be a resource to the entire campus. As part of the project a new green space will be created completing a chain of open spaces along the primary East/West axis of campus.

- South Street Landing will relocate over 400 staff to the Jewelry District into the upper floors of the former South Street Power Station. Brown will be sharing this location with University of Rhode Island/Rhode Island College School of Nursing.
- The John D. Rockefeller Jr Library is undergoing a multiphase revitalization effort. Phase 1 involved the renovation of the central reading room, the Sorensen Family Reading Room, and code updates. Phase 2 will convert the existing periodical room into the Sidney Frank Digital Studio, a new technology-enabled collaborative space for students and faculty. In addition to the interior renovations, significant mechanical system work, code upgrades, and renewal of the exterior are included for the 1960s building.

No-Build Traffic Volumes

The 0.5 percent annual background growth rate over the five-year planning horizon and the projected vehicular traffic reassignment due to current projects were layered onto the existing traffic networks.

This assessment is conservative because with the shift in staff to South Street Landing, there would be decreased activity to College Hill and an increase in activity to the Jewelry District. Given the aggressive TDM program implemented by the University, the vast majority of the staff shifting to College Hill are already not driving but taking transit or walking/bicycling. As a result, the demand for shuttle service to the Jewelry District is expected to increase (rather than a substantial decrease in vehicle traffic in the College Hill area).

The resulting 2021 No-Build weekday morning peak hour traffic volumes are presented in Figures 3-1, and 3-2, and the 2021 No-Build weekday evening peak hour volumes are presented in Figures 3-3 and 3-4.

No-Build Traffic Analysis

The 2021 No-Build traffic volumes were analyzed at all of the study area intersections. The results of these analyses are presented in Tables 3-1 and 3-2. As shown, the differences in calculated delay at the study area intersections between 2016 Existing and 2021 No-Build are minimal. The intersections which show degradations in the calculated levels of service are those that are near threshold values under existing traffic volumes. Although the differences in calculated delay times between Existing and No-Build conditions are minimal, as stated previously, the projected future traffic volumes used for the analyses are conservatively high. The actual differences in delays between the two conditions are expected to be less than what is shown.

Table 3-1 No-Build Signalized Intersection Capacity Analysis Summary

Location	Peak Hour	2016 Existing			2021 No Build		
		V/C[1]	Delay[2]	LOS[3]	V/C[1]	Delay[2]	LOS[3]
Angell Street/ Gano Street/Taber Avenue	Weekday Morning	0.80	20.0	C	0.82	21.5	C
	Weekday Evening	0.71	15.7	B	0.72	16.4	B
Angell Street/ Hope Street	Weekday Morning	0.68	12.7	B	0.68	12.7	B
	Weekday Evening	0.62	10.9	B	0.64	11.3	B
Angell Street/ Brook Street	Weekday Morning	0.79	19.8	B	0.81	21.0	C
	Weekday Evening	0.63	11.3	B	0.64	11.8	B
Angell Street/ Thayer Street	Weekday Morning	0.63	17.7	B	0.65	18.1	B
	Weekday Evening	0.59	20.4	C	0.61	21.0	C
Angell Street/ The Walk	Weekday Morning	0.45	2.8	A	0.47	2.9	A
	Weekday Evening	0.38	2.3	A	0.39	2.4	A
Angell Street/ Prospect Street	Weekday Morning	0.66	11.4	B	0.67	11.8	B
	Weekday Evening	0.51	7.9	A	0.52	8.4	A
Angell Street/ Benefit Street	Weekday Morning	0.44	8.3	A	0.45	8.4	A
	Weekday Evening	0.50	8.8	A	0.51	9.0	A
Waterman Street/ Benefit Street	Weekday Morning	0.36	11.4	B	0.37	11.5	B
	Weekday Evening	0.42	13.2	B	0.43	13.4	B
Waterman Street/ Prospect Street	Weekday Morning	0.47	7.8	A	0.49	8.0	A
	Weekday Evening	0.49	8.0	A	0.50	8.1	A
Waterman Street/ The Walk	Weekday Morning	0.23	4.5	A	0.23	4.6	A
	Weekday Evening	0.35	5.3	A	0.36	5.4	A
Waterman Street/ Thayer Street	Weekday Morning	0.39	9.1	A	0.40	9.2	A
	Weekday Evening	0.55	10.4	B	0.57	10.6	B
Waterman Street/ Brook Street	Weekday Morning	0.47	8.0	A	0.48	8.2	A
	Weekday Evening	0.66	12.0	B	0.67	12.4	B
Waterman Street/ Hope Street	Weekday Morning	0.64	11.4	B	0.66	12.0	B
	Weekday Evening	0.81	21.0	C	0.85	23.3	C
Waterman Street/ Governor Street	Weekday Morning	0.41	5.4	A	0.42	5.4	A
	Weekday Evening	0.62	7.9	A	0.64	8.3	A
Hope Street/ Olney Street	Weekday Morning	>1.00	46.9	D	>1.00	53.4	D
	Weekday Evening	>1.00	102.2	F	>1.00	112.8	F
Hope Street/ Lloyd Avenue/Brook Street	Weekday Morning	>1.00	>120.0	F	>1.00	>120.0	F
	Weekday Evening	>1.00	>120.0	F	>1.00	>120.0	F

Source: Synchro 9 software using the procedures in the 2000 Highway Capacity Manual. Compiled by VHB.

1 V/C = volume to capacity ratio.

2 Delay = Vehicle delay expressed in seconds per vehicle. See Note below.

3 LOS = Level of service

Note: Interruptions to traffic flow caused by pedestrians, bus blockages, delivery vehicles, parking maneuvers, and double parking vehicles were observed at times. These interruptions caused congestion along these roadways during the peak hour periods. During these times, the observed delay times at some intersections may exceed the calculated values.

Legend

S Signalized Intersection

NEG Negligible

Olney Street
Brown Street
Prospect Street
Hope Street
Barnes Street
Keene Street
Lloyd Avenue
Bowen Street
Cushing Street
Meeting Street
Stimson Avenue
Olive Street
Angell Street
Waterman Street
College Street
George Street
Benefit Street
The Walk
Thayer Street
Brook Street
Governor Street
Ives Street
Gano Street
Cooke Street
University Avenue
Irving Avenue
Taber Street
Arlington Avenue
Humboldt Avenue

Hope High School/
360 High School

Moses
Brown
School

East
Driveway

West
Driveway

Brown University
Athletic Complex

Wheeler
School

Brown University
Main Campus

See Inset 1

See Inset 2

See Figure 3-2 for continuation

Not to Scale

Inset 1

Inset 2

Athletic
Center

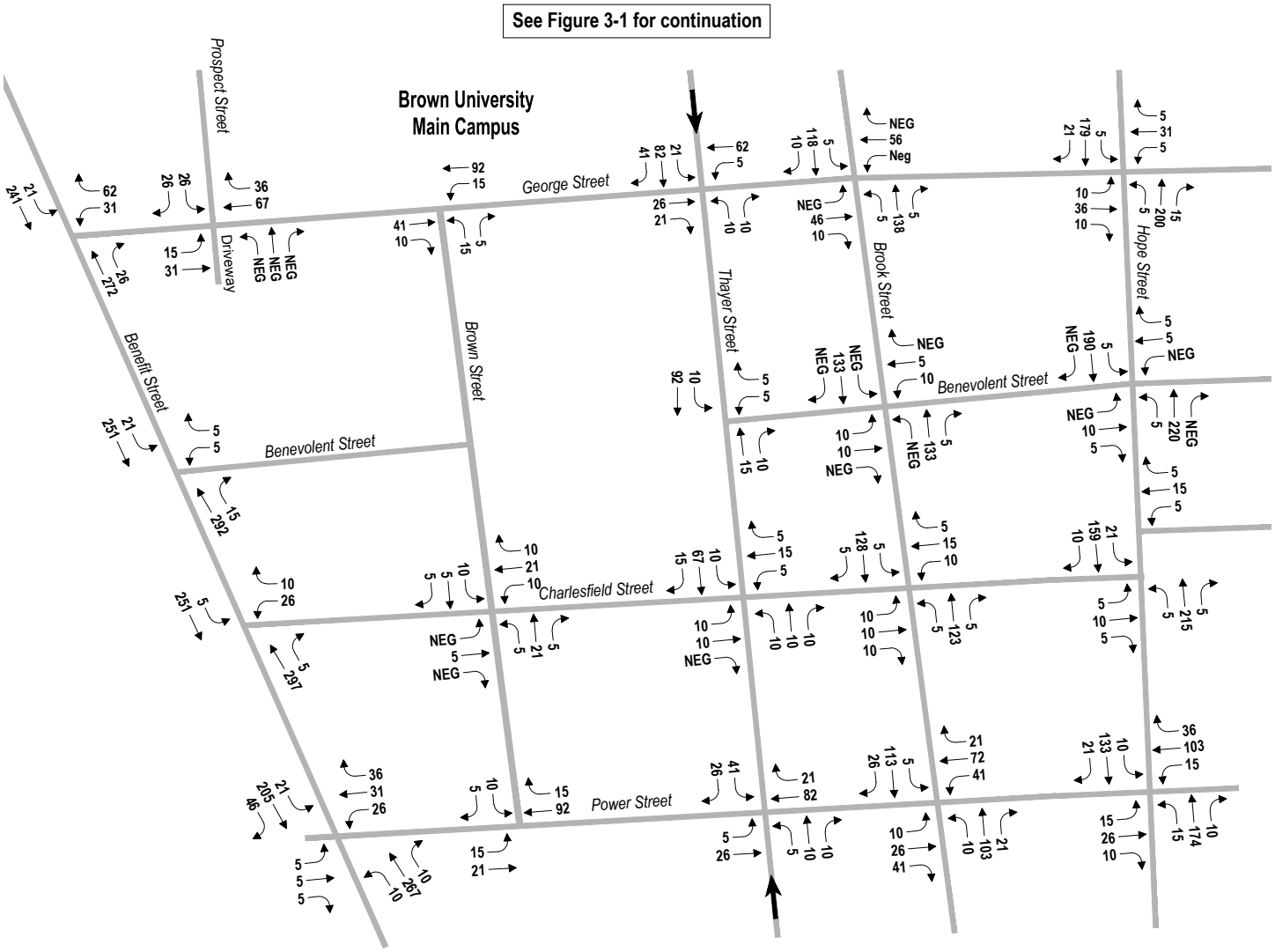
2021 No-Build Morning
Peak Hour Traffic Volumes
Brown University
Providence, Rhode Island

Figure 3-1

Legend

S — Signalized Intersection

NEG — Negligible



Not to Scale

2021 No-Build Morning
Peak Hour Traffic Volumes
Brown University
Providence, Rhode Island

Figure 3-2

Legend

S Signalized Intersection

NEG Negligible

Olney Street
Prospect Street
Brown Street
Hope Street
Barnes Street
Keene Street
Lloyd Avenue
Bowen Street
Thayer Street
Brook Street
Cushing Street
Meeting Street
Stimson Avenue
Olive Street
Angell Street
Waterman Street
College Street
George Street
Benefit Street
The Walk
Governor Street
Ives Street
Gano Street
Cooke Street
University Avenue
Irving Avenue
Arlington Avenue
Taber Street
Humboldt Avenue
East Driveway
West Driveway

Hope High School/
360 High School

Moses
Brown
School

Brown University
Athletic Complex

Wheeler
School

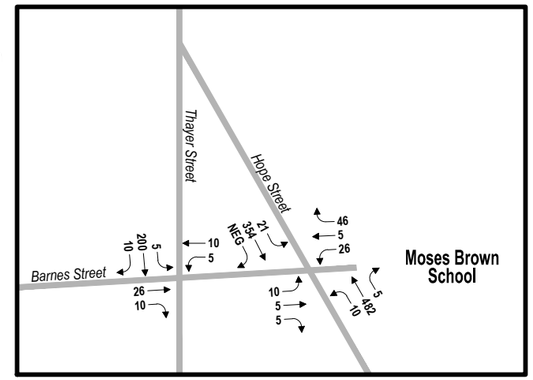
Brown University
Main Campus

See Inset 1

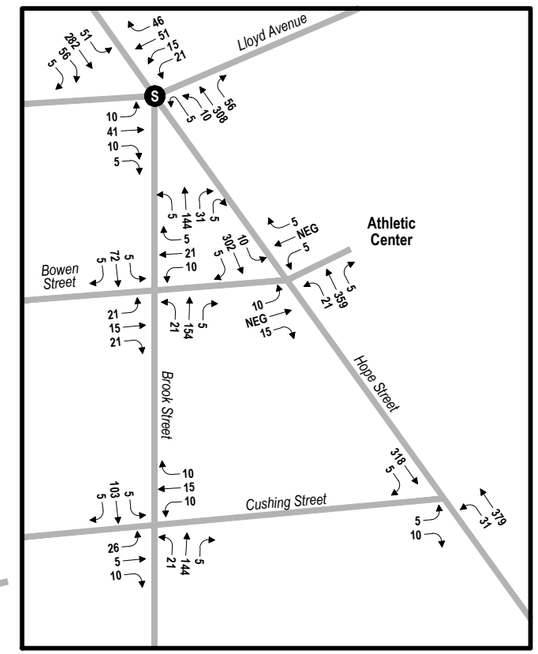
See Inset 2

See Figure 3-4 for continuation

Not to Scale



Inset 1



Inset 2

vhb

2021 No-Build Evening
Peak Hour Traffic Volumes
Brown University
Providence, Rhode Island

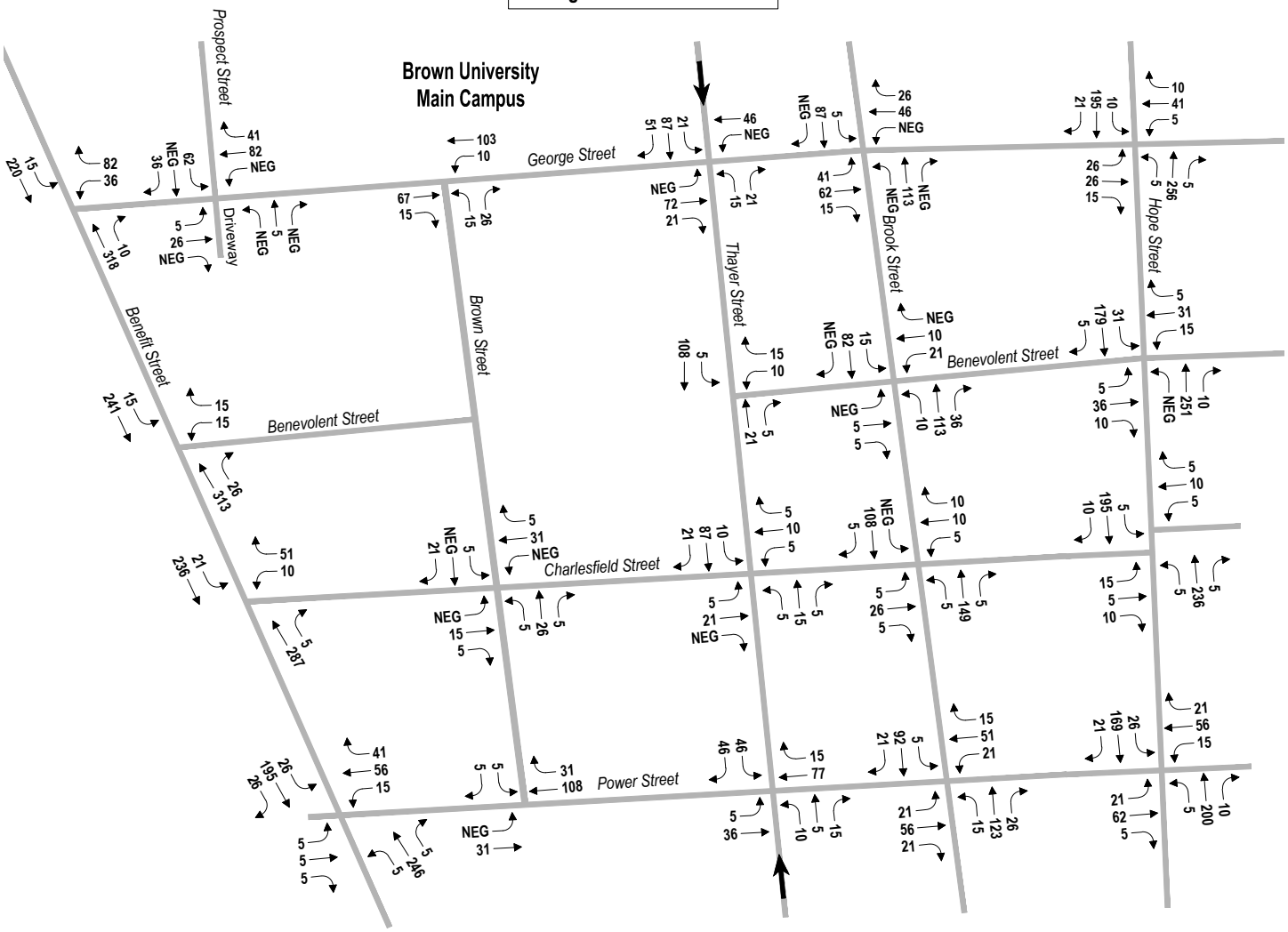
Figure 3-3

Legend

S — Signalized Intersection

NEG — Negligible

See Figure 3-3 for continuation



Not to Scale

2021 No-Build Evening
Peak Hour Traffic Volumes
Brown University
Providence, Rhode Island

Figure 3-4

Table 3-2 No-Build Unsignalized Intersection Capacity Analysis Summary

Location	Peak Hour	2016 Existing				2021 No Build			
		Critical Movement[1]	Demand[2]	Delay[3]	LOS[4]	Critical Movement	Demand	Delay	LOS
Angell Street/Brown Street	Weekday Morning	NB LT	40	24.2	C	NB LT	41	25.0	C
	Weekday Evening	NB LT	60	≥50.0	F	NB LT	61	≥50.0	F
Waterman Street/ Brown Street	Weekday Morning	SB L	25	15.9	C	SB L	26	16.1	C
	Weekday Evening	SB L	55	≥50.0	F	SB L	56	≥50.0	F
Lloyd Avenue/ Arlington Avenue	Weekday Morning	WB LTR	405	29.3	D	WB LTR	415	32.8	D
	Weekday Evening	SB LTR	225	12.9	B	SB LTR	231	13.3	B
Lloyd Avenue/Moses Brown East Drive	Weekday Morning	SB LR	25	19.1	C	SB LR	26	19.9	C
	Weekday Evening	SB LR	30	11.2	B	SB LR	31	11.4	B
Lloyd Avenue/Moses Brown West Drive	Weekday Morning	SB LR	95	14.1	B	SB LR	97	14.4	B
	Weekday Evening	Driveway closed during this peak period				Driveway closed during this peak period			
Hope Street/Barnes Street/ Moses Brown	Weekday Morning	WB LTR	130	44.7	E	WB LTR	133	50.0	E
	Weekday Evening	EB LTR	20	34.0	D	EB LTR	20	35.8	E
Hope Street/Bowen Street	Weekday Morning	WB LTR	10	18.5	C	WB LTR	10	18.9	C
	Weekday Evening	WB LTR	10	18.5	C	WB LTR	10	19.0	C
Hope Street/Cushing Street	Weekday Morning	EB LR	15	16.6	C	EB LR	15	16.9	C
	Weekday Evening	EB LR	15	25.9	D	EB LR	15	26.5	D
Hope Street/Meeting Street	Weekday Morning	EB LTR	115	36.1	E	EB LTR	118	38.8	E
	Weekday Evening	EB LTR	65	26.4	D	EB LTR	66	27.3	D
Hope Street/George Street	Weekday Morning	SB LTR	200	10.1	B	SB LTR	205	10.3	B
	Weekday Evening	NB LTR	260	10.3	B	NB LTR	266	10.4	B
Hope Street/Benevolent Street	Weekday Morning	EB LTR	15	12.1	B	EB LTR	15	12.2	B
	Weekday Evening	WB LTR	50	17.7	C	WB LTR	51	18.1	C
Hope Street/ Charlesfield Street	Weekday Morning	WB LTR	20	17.3	C	WB LTR	25	17.5	C
	Weekday Evening	EB LTR	30	28.5	D	EB LTR	30	29.0	D
Hope Street/Power Street	Weekday Morning	NB LTR	195	10.0	B	NB LTR	199	10.2	B
	Weekday Evening	SB LTR	210	10.6	B	SB LTR	216	10.8	B
Brook Street/Bowen Street	Weekday Morning	NB LTR	165	9.0	A	NB LTR	169	9.1	A
	Weekday Evening	NB LTR	175	8.6	A	NB LTR	180	8.7	A
Brook Street/Cushing Street	Weekday Morning	SB LTR	165	9.3	A	SB LTR	169	9.3	A
	Weekday Evening	NB LTR	165	8.7	A	NB LTR	170	8.8	A
Brook Street/Meeting Street	Weekday Morning	SB LTR	185	47.0	E	SB LTR	190	≥50.0	F
	Weekday Evening	NB LTR	245	18.2	C	NB LTR	252	18.6	C
Brook Street/George Street	Weekday Morning	NB LTR	145	8.2	A	SB LTR	133	8.3	A
	Weekday Evening	EB LTR	115	8.3	A	EB LTR	118	8.4	A

Table 3-2 (cont) No-Build Unsignalized Intersection Capacity Analysis Summary

Location	Peak Hour	2016 Existing				2021 No Build			
		Critical Movement[1]	Demand[2]	Delay[3]	LOS[4]	Critical Movement	Demand	Delay	LOS
Brook Street/ Benevolent Street	Weekday Morning	EB LTR	20	11.5	B	EB LTR	20	11.5	B
	Weekday Evening	WB LTR	30	13.4	B	WB LTR	31	13.5	B
Brook Street/ Charlesfield Street	Weekday Morning	WB LTR	30	15.1	C	WB LTR	30	15.2	C
	Weekday Evening	EB LTR	35	23.2	C	EB LTR	36	23.6	C
Brook Street/Power Street	Weekday Morning	NB LTR	130	9.4	A	NB LTR	134	9.5	A
	Weekday Evening	NB LTR	160	9.1	A	NB LTR	164	9.2	A
Thayer Street/Barnes Street	Weekday Morning	SB LTR	255	9.7	A	SB LTR	262	9.9	A
	Weekday Evening	SB LTR	210	8.7	A	SB LTR	215	8.8	A
Thayer Street/Lloyd Avenue	Weekday Morning	SB LTR	245	10.7	B	SB LTR	251	10.9	B
	Weekday Evening	SB LTR	215	9.2	A	SB LTR	220	9.3	A
Thayer Street/Bowen Street	Weekday Morning	WB LT	50	18.7	C	WB LT	52	19.3	C
	Weekday Evening	WB LT	45	22.2	C	WB LT	47	22.8	C
Thayer Street/Cushing Street	Weekday Morning	WB LT	25	35.1	E	WB LT	26	36.4	E
	Weekday Evening	WB LT	40	≥50.0	F	WB LT	41	≥50.0	F
Thayer Street/Meeting Street	Weekday Morning	WB LT	15	21.2	C	WB LT	15	21.5	C
	Weekday Evening	WB LT	30	≥50.0	F	WB LT	31	≥50.0	F
Thayer Street/George Street	Weekday Morning	SB LTR	140	8.3	A	SB LTR	144	8.3	A
	Weekday Evening	SB LTR	155	8.3	A	SB LTR	159	8.4	A
Thayer Street/ Benevolent Street	Weekday Morning	WB LR	10	9.6	A	WB LR	10	9.6	A
	Weekday Evening	WB LR	25	12.6	B	WB LR	25	12.6	B
Thayer Street/ Charlesfield Street	Weekday Morning	SB LTR	90	7.7	A	SB LTR	92	7.7	A
	Weekday Evening	SB LTR	115	7.8	A	SB LTR	118	7.8	A
Thayer Street/Power Street	Weekday Morning	WB TR	100	8.0	A	WB TR	103	8.1	A
	Weekday Evening	WB TR	90	7.8	A	WB TR	92	7.8	A
Brown Street/Lloyd Avenue	Weekday Morning	WB LTR	85	7.8	A	WB LTR	87	7.8	A
	Weekday Evening	NB LTR	45	7.2	A	NB LTR	46	7.2	A
Brown Street/Bowen Street	Weekday Morning	EB LTR	35	7.5	A	EB LTR	36	7.5	A
	Weekday Evening	SB LTR	55	7.4	A	SB LTR	56	7.4	A
Brown Street/Cushing Street	Weekday Morning	WB LTR	10	11.5	B	WB LTR	10	11.5	B
	Weekday Evening	WB LTR	5	14.5	B	WB LTR	5	14.6	B
Brown Street/Meeting Street	Weekday Morning	NB LT	60	7.7	A	NB LT	61	7.7	A
	Weekday Evening	SB TR	75	7.8	A	NB LT	72	7.9	A
Brown Street/George Street	Weekday Morning	NB LR	20	12.5	B	NB LR	20	12.5	B
	Weekday Evening	NB LR	40	≥50.0	F	NB LR	41	≥50.0	F
Brown Street/ Charlesfield Street	Weekday Morning	WB LTR	40	7.6	A	WB LTR	41	7.6	A
	Weekday Evening	NB LTR	35	7.1	A	NB LTR	36	7.1	A

Table 3-2 (cont) No-Build Unsignalized Intersection Capacity Analysis Summary

Location	Peak Hour	2016 Existing				2021 No Build			
		Critical Movement[1]	Demand[2]	Delay[3]	LOS[4]	Critical Movement	Demand	Delay	LOS
Brown Street/Power Street	Weekday Morning	SB LR	15	9.3	A	SB LR	15	9.3	A
	Weekday Evening	SB LR	10	9.4	A	SB LR	10	9.4	A
Prospect Street/Olney Street	Weekday Morning	NB LTR	35	≥50.0	F	NB LTR	36	≥50.0	F
	Weekday Evening	NB LTR	115	45.5	E	NB LTR	117	48.7	E
Prospect Street/Lloyd Avenue	Weekday Morning	WB LTR	85	8.3	A	WB LTR	87	8.3	A
	Weekday Evening	SB LTR	90	7.9	A	SB LTR	92	7.9	A
Prospect Street/Bowen Street	Weekday Morning	SB LTR	140	7.6	A	SB LTR	144	7.6	A
	Weekday Evening	NB LTR	90	7.6	A	SB LTR	108	7.6	A
Prospect Street/Cushing Street	Weekday Morning	SB LTR	125	8.2	A	SB LTR	128	8.2	A
	Weekday Evening	NB LTR	110	7.8	A	NB LTR	112	7.8	A
Prospect Street/Meeting Street	Weekday Morning	SB LT	125	8.2	A	SB LT	128	8.3	A
	Weekday Evening	SB LT	120	8.2	A	SB LT	123	8.2	A
Prospect Street/College Street	Weekday Morning	EB LR	90	8.5	A	EB LR	92	8.5	A
	Weekday Evening	EB LR	100	9.5	A	EB LR	205	9.6	A
Prospect Street/George Street	Weekday Morning	SB LTR	50	10.5	B	SB LTR	52	10.5	B
	Weekday Evening	SB LTR	95	14.4	B	SB LTR	98	14.6	B
Benefit Street/George Street	Weekday Morning	WB LR	90	15.0	C	WB LR	93	15.4	C
	Weekday Evening	WB LR	115	17.4	C	WB LR	118	17.9	C
Benefit Street/ Benevolent Street	Weekday Morning	WB LR	10	13.6	B	WB LR	10	13.8	B
	Weekday Evening	WB LR	30	15.4	C	WB LR	30	15.6	C
Benefit Street/ Charlesfield Street	Weekday Morning	WB LR	35	12.5	B	WB LR	36	12.7	B
	Weekday Evening	WB LR	60	11.3	B	WB LR	61	11.4	B
Benefit Street/Power Street	Weekday Morning	SB LTR	265	11.8	B	SB LTR	272	12.2	B
	Weekday Evening	NB LTR	250	10.5	B	NB LTR	256	10.7	B

Source: Synchro 9 software using the procedures in the 2000 Highway Capacity Manual. Compiled by VHB.

1 L= Left-turn movement, T= Through movement, R= Right-turn movement

2 Demand = Demand of critical movement, expressed in vehicles per hour

3 Delay = Vehicle delay expressed in seconds per vehicle (See note below)

4 LOS = Level of service

Note: Interruptions to traffic flow caused by pedestrians, bus blockages, delivery vehicles, parking maneuvers, and double parking vehicles were observed at times. These interruptions caused congestion along these roadways during the peak hour periods. During these times, the observed delay times at some intersections may exceed the calculated values

Build Conditions

The Build Condition includes transportation demand caused by the construction of the projects identified in the IMP over the next 5 years. Because of the uncertainty with longer range plans, it was determined that projections beyond a 5-year time horizon might not be accurate at this stage in the process.

The project that is seeking approval in the IMP and planned to be constructed over the next five to ten years is the Watson Institute Expansion. This project includes the renovation of 63-65 Charlesfield Street (a 11,000 gsf building), renovating 111 Thayer Street, and construction of a new 20,000 gsf building. The project would incur a 17 parking space loss.

Since the Watson Institute Expansion does not add parking, does not alter roadway circulation or access, and is relatively small in scale, there would be a negligible change in traffic, pedestrian, or bicycle patterns.

Therefore, there is essentially no difference between the No-Build and Build Condition traffic analysis. Additionally, with the traffic growth rate of 0.5 and the continued decreasing trend in traffic volume to the area, a conservative (higher) vehicular traffic project for the next 5 years has already been applied to the entire area.

The 2021 Build traffic are presented in Tables 3-3 and 3-4. As stated previously, there is no change between the No-Build and Build conditions for vehicles, pedestrians, or bicyclists patterns since the Watson Institute Expansion is relatively small in scale, does not include new parking, does not alter roadway circulation or access, and does not substantially change the concentration of students, faculty, or staff.

Table 3-3 Build Signalized Intersection Capacity Analysis Summary

Location	Peak Hour	2021 No Build			2021 Build		
		V/C[1]	Delay[2]	LOS[3]	V/C[1]	Delay[2]	LOS[3]
Angell Street/ Gano Street/Taber Avenue	Weekday Morning	0.82	21.5	C	0.82	21.5	C
	Weekday Evening	0.72	16.4	B	0.72	16.4	B
Angell Street/ Hope Street	Weekday Morning	0.68	12.7	B	0.68	12.7	B
	Weekday Evening	0.64	11.3	B	0.64	11.3	B
Angell Street/ Brook Street	Weekday Morning	0.81	21.0	C	0.81	21.0	C
	Weekday Evening	0.64	11.8	B	0.64	11.8	B
Angell Street/ Thayer Street	Weekday Morning	0.65	18.1	B	0.65	18.1	B
	Weekday Evening	0.61	21.0	C	0.61	21.0	C
Angell Street/ The Walk	Weekday Morning	0.47	2.9	A	0.47	2.9	A
	Weekday Evening	0.39	2.4	A	0.39	2.4	A
Angell Street/ Prospect Street	Weekday Morning	0.67	11.8	B	0.67	11.8	B
	Weekday Evening	0.52	8.4	A	0.52	8.4	A
Angell Street/ Benefit Street	Weekday Morning	0.45	8.4	A	0.45	8.4	A
	Weekday Evening	0.51	9.0	A	0.51	9.0	A
Waterman Street/ Benefit Street	Weekday Morning	0.37	11.5	B	0.37	11.5	B
	Weekday Evening	0.43	13.4	B	0.43	13.4	B
Waterman Street/ Prospect Street	Weekday Morning	0.49	8.0	A	0.49	8.0	A
	Weekday Evening	0.50	8.1	A	0.50	8.1	A
Waterman Street/ The Walk	Weekday Morning	0.23	4.6	A	0.23	4.6	A
	Weekday Evening	0.36	5.4	A	0.36	5.4	A
Waterman Street/ Thayer Street	Weekday Morning	0.40	9.2	A	0.40	9.2	A
	Weekday Evening	0.57	10.6	B	0.57	10.6	B
Waterman Street/ Brook Street	Weekday Morning	0.48	8.2	A	0.48	8.2	A
	Weekday Evening	0.67	12.4	B	0.67	12.4	B
Waterman Street/ Hope Street	Weekday Morning	0.66	12.0	B	0.66	12.0	B
	Weekday Evening	0.85	23.3	C	0.85	23.3	C
Waterman Street/ Governor Street	Weekday Morning	0.42	5.4	A	0.42	5.4	A
	Weekday Evening	0.64	8.3	A	0.64	8.3	A
Hope Street/ Olney Street	Weekday Morning	>1.00	53.4	D	>1.00	53.4	D
	Weekday Evening	>1.00	112.8	F	>1.00	112.8	F
Hope Street/ Lloyd Avenue/Brook Street	Weekday Morning	>1.00	>120.0	F	>1.00	>120.0	F
	Weekday Evening	>1.00	>120.0	F	>1.00	>120.0	F

Source: Synchro 9 software using the procedures in the 2000 Highway Capacity Manual. Compiled by VHB.

1 V/C = volume to capacity ratio.

2 Delay = Vehicle delay expressed in seconds per vehicle. See Note below.

3 LOS = Level of service

Note: Interruptions to traffic flow caused by pedestrians, bus blockages, delivery vehicles, parking maneuvers, and double parking vehicles were observed at times. These interruptions caused congestion along these roadways during the peak hour periods. During these times, the observed delay times at some intersections may exceed the calculated values.

Table 3-4 Build Unsignalized Intersection Capacity Analysis Summary

Location	Peak Hour	2021 No Build				2021 Build			
		Critical Movement[1]	Demand[2]	Delay[3]	LOS[4]	Critical Movement	Demand	Delay	LOS
Angell Street/Brown Street	Weekday Morning	NB LT	41	25.0	C	NB LT	41	25.0	C
	Weekday Evening	NB LT	61	≥50.0	F	NB LT	61	≥50.0	F
Waterman Street/ Brown Street	Weekday Morning	SB L	26	16.1	C	SB L	26	16.1	C
	Weekday Evening	SB L	56	≥50.0	F	SB L	56	≥50.0	F
Lloyd Avenue/ Arlington Avenue	Weekday Morning	WB LTR	415	32.8	D	WB LTR	415	32.8	D
	Weekday Evening	SB LTR	231	13.3	B	SB LTR	231	13.3	B
Lloyd Avenue/Moses Brown East Drive	Weekday Morning	SB LR	26	19.9	C	SB LR	26	19.9	C
	Weekday Evening	SB LR	31	11.4	B	SB LR	31	11.4	B
Lloyd Avenue/Moses Brown West Drive	Weekday Morning	SB LR	97	14.4	B	SB LR	97	14.4	B
	Weekday Evening	Driveway closed during this peak period				Driveway closed during this peak period			
Hope Street/Barnes Street/ Moses Brown	Weekday Morning	WB LTR	133	50.0	E	WB LTR	133	50.0	E
	Weekday Evening	EB LTR	20	35.8	E	EB LTR	20	35.8	E
Hope Street/Bowen Street	Weekday Morning	WB LTR	10	18.9	C	WB LTR	10	18.9	C
	Weekday Evening	WB LTR	10	19.0	C	WB LTR	10	19.0	C
Hope Street/Cushing Street	Weekday Morning	EB LR	15	16.9	C	EB LR	15	16.9	C
	Weekday Evening	EB LR	15	26.5	D	EB LR	15	26.5	D
Hope Street/Meeting Street	Weekday Morning	EB LTR	118	38.8	E	EB LTR	118	38.8	E
	Weekday Evening	EB LTR	66	27.3	D	EB LTR	66	27.3	D
Hope Street/George Street	Weekday Morning	SB LTR	205	10.3	B	SB LTR	205	10.3	B
	Weekday Evening	NB LTR	266	10.4	B	NB LTR	266	10.4	B
Hope Street/Benevolent Street	Weekday Morning	EB LTR	15	12.2	B	EB LTR	15	12.2	B
	Weekday Evening	WB LTR	51	18.1	C	WB LTR	51	18.1	C
Hope Street/ Charlesfield Street	Weekday Morning	WB LTR	25	17.5	C	WB LTR	25	17.5	C
	Weekday Evening	EB LTR	30	29.0	D	EB LTR	30	29.0	D
Hope Street/Power Street	Weekday Morning	NB LTR	199	10.2	B	NB LTR	199	10.2	B
	Weekday Evening	SB LTR	216	10.8	B	SB LTR	216	10.8	B
Brook Street/Bowen Street	Weekday Morning	NB LTR	169	9.1	A	NB LTR	169	9.1	A
	Weekday Evening	NB LTR	180	8.7	A	NB LTR	180	8.7	A
Brook Street/Cushing Street	Weekday Morning	SB LTR	169	9.3	A	SB LTR	169	9.3	A
	Weekday Evening	NB LTR	170	8.8	A	NB LTR	170	8.8	A
Brook Street/Meeting Street	Weekday Morning	SB LTR	190	≥50.0	F	SB LTR	190	≥50.0	F
	Weekday Evening	NB LTR	252	18.6	C	NB LTR	252	18.6	C
Brook Street/George Street	Weekday Morning	SB LTR	133	8.3	A	SB LTR	133	8.3	A
	Weekday Evening	EB LTR	118	8.4	A	EB LTR	118	8.4	A

Table 3-4 (cont) Build Unsignalized Intersection Capacity Analysis Summary

Location	Peak Hour	2021 No Build				2021 Build			
		Critical Movement[1]	Demand[2]	Delay[3]	LOS[4]	Critical Movement	Demand	Delay	LOS
Brook Street/ Benevolent Street	Weekday Morning	EB LTR	20	11.5	B	EB LTR	20	11.5	B
	Weekday Evening	WB LTR	31	13.5	B	WB LTR	31	13.5	B
Brook Street/ Charlesfield Street	Weekday Morning	WB LTR	30	15.2	C	WB LTR	30	15.2	C
	Weekday Evening	EB LTR	36	23.6	C	EB LTR	36	23.6	C
Brook Street/Power Street	Weekday Morning	NB LTR	134	9.5	A	NB LTR	134	9.5	A
	Weekday Evening	NB LTR	164	9.2	A	NB LTR	164	9.2	A
Thayer Street/Barnes Street	Weekday Morning	SB LTR	262	9.9	A	SB LTR	262	9.9	A
	Weekday Evening	SB LTR	215	8.8	A	SB LTR	215	8.8	A
Thayer Street/Lloyd Avenue	Weekday Morning	SB LTR	251	10.9	B	SB LTR	251	10.9	B
	Weekday Evening	SB LTR	220	9.3	A	SB LTR	220	9.3	A
Thayer Street/Bowen Street	Weekday Morning	WB LT	52	19.3	C	WB LT	52	19.3	C
	Weekday Evening	WB LT	47	22.8	C	WB LT	47	22.8	C
Thayer Street/Cushing Street	Weekday Morning	WB LT	26	36.4	E	WB LT	26	36.4	E
	Weekday Evening	WB LT	41	≥50.0	F	WB LT	41	≥50.0	F
Thayer Street/Meeting Street	Weekday Morning	WB LT	15	21.5	C	WB LT	15	21.5	C
	Weekday Evening	WB LT	31	≥50.0	F	WB LT	31	≥50.0	F
Thayer Street/George Street	Weekday Morning	SB LTR	144	8.3	A	SB LTR	144	8.3	A
	Weekday Evening	SB LTR	159	8.4	A	SB LTR	159	8.4	A
Thayer Street/ Benevolent Street	Weekday Morning	WB LR	10	9.6	A	WB LR	10	9.6	A
	Weekday Evening	WB LR	25	12.6	B	WB LR	25	12.6	B
Thayer Street/ Charlesfield Street	Weekday Morning	SB LTR	92	7.7	A	SB LTR	92	7.7	A
	Weekday Evening	SB LTR	118	7.8	A	SB LTR	118	7.8	A
Thayer Street/Power Street	Weekday Morning	WB TR	103	8.1	A	WB TR	103	8.1	A
	Weekday Evening	WB TR	92	7.8	A	WB TR	92	7.8	A
Brown Street/Lloyd Avenue	Weekday Morning	WB LTR	87	7.8	A	WB LTR	87	7.8	A
	Weekday Evening	NB LTR	46	7.2	A	NB LTR	46	7.2	A
Brown Street/Bowen Street	Weekday Morning	EB LTR	36	7.5	A	EB LTR	36	7.5	A
	Weekday Evening	SB LTR	56	7.4	A	SB LTR	56	7.4	A
Brown Street/Cushing Street	Weekday Morning	WB LTR	10	11.5	B	WB LTR	10	11.5	B
	Weekday Evening	WB LTR	5	14.6	B	WB LTR	5	14.6	B
Brown Street/Meeting Street	Weekday Morning	NB LT	61	7.7	A	NB LT	61	7.7	A
	Weekday Evening	NB LT	72	7.9	A	NB LT	72	7.9	A
Brown Street/George Street	Weekday Morning	NB LR	20	12.5	B	NB LR	20	12.5	B
	Weekday Evening	NB LR	41	≥50.0	F	NB LR	41	≥50.0	F
Brown Street/ Charlesfield Street	Weekday Morning	WB LTR	41	7.6	A	WB LTR	41	7.6	A
	Weekday Evening	NB LTR	36	7.1	A	NB LTR	36	7.1	A

Table 3-4 (cont) Build Unsignalized Intersection Capacity Analysis Summary

Location	Peak Hour	2021 No Build				2021 Build			
		Critical Movement[1]	Demand[2]	Delay[3]	LOS[4]	Critical Movement	Demand	Delay	LOS
Brown Street/Power Street	Weekday Morning	SB LR	15	9.3	A	SB LR	15	9.3	A
	Weekday Evening	SB LR	10	9.4	A	SB LR	10	9.4	A
Prospect Street/Olney Street	Weekday Morning	NB LTR	36	≥50.0	F	NB LTR	36	≥50.0	F
	Weekday Evening	NB LTR	117	48.7	E	NB LTR	117	48.7	E
Prospect Street/Lloyd Avenue	Weekday Morning	WB LTR	87	8.3	A	WB LTR	87	8.3	A
	Weekday Evening	SB LTR	92	7.9	A	SB LTR	92	7.9	A
Prospect Street/Bowen Street	Weekday Morning	SB LTR	144	7.6	A	SB LTR	144	7.6	A
	Weekday Evening	NB LTR	108	7.6	A	SB LTR	108	7.6	A
Prospect Street/Cushing Street	Weekday Morning	SB LTR	128	8.2	A	SB LTR	128	8.2	A
	Weekday Evening	NB LTR	112	7.8	A	NB LTR	112	7.8	A
Prospect Street/Meeting Street	Weekday Morning	SB LT	128	8.3	A	SB LT	128	8.3	A
	Weekday Evening	SB LT	123	8.2	A	SB LT	123	8.2	A
Prospect Street/College Street	Weekday Morning	EB LR	92	8.5	A	EB LR	92	8.5	A
	Weekday Evening	EB LR	205	9.6	A	EB LR	205	9.6	A
Prospect Street/George Street	Weekday Morning	SB LTR	52	10.5	B	SB LTR	52	10.5	B
	Weekday Evening	SB LTR	98	14.6	B	SB LTR	98	14.6	B
Benefit Street/George Street	Weekday Morning	WB LR	93	15.4	C	WB LR	93	15.4	C
	Weekday Evening	WB LR	118	17.9	C	WB LR	118	17.9	C
Benefit Street/ Benevolent Street	Weekday Morning	WB LR	10	13.8	B	WB LR	10	13.8	B
	Weekday Evening	WB LR	30	15.6	C	WB LR	30	15.6	C
Benefit Street/ Charlesfield Street	Weekday Morning	WB LR	36	12.7	B	WB LR	36	12.7	B
	Weekday Evening	WB LR	61	11.4	B	WB LR	61	11.4	B
Benefit Street/Power Street	Weekday Morning	SB LTR	272	12.2	B	SB LTR	272	12.2	B
	Weekday Evening	NB LTR	256	10.7	B	NB LTR	256	10.7	B

Source: Synchro 9 software using the procedures in the 2000 Highway Capacity Manual. Compiled by VHB.

1 L= Left-turn movement, T= Through movement, R= Right-turn movement

2 Demand = Demand of critical movement, expressed in vehicles per hour

3 Delay = Vehicle delay expressed in seconds per vehicle (See note below)

4 LOS = Level of service

Note: Interruptions to traffic flow caused by pedestrians, bus blockages, delivery vehicles, parking maneuvers, and double parking vehicles were observed at times. These interruptions caused congestion along these roadways during the peak hour periods. During these times, the observed delay times at some intersections may exceed the calculated values.

4

Improvement Measures

The cornerstone of the University's overall transportation program is its Transportation Demand Management (TDM) program and its public realm investments to sidewalks and crosswalks.

Enhancements to the Transportation Demand Management Program

Brown's strategic investments in automobile trip reduction measures, combined with incentives that promote the use of alternative modes of transportation, have yielded a superior return-on-investment. As noted in chapter 2, Brown University continues to provide an array of successful TDM programs in response to the needs of the students, faculty, and staff and in concert with the urban environment of the campus. Brown commits to the following TDM program investments:

- The Brown University shuttle service from the main campus to the Jewelry District and Rhode Island Hospital has seen a significant increase in ridership from 2011 to 2016. Over this period, ridership has increased by 75 percent due, in part, to the OnCall Shuttle Service that began in 2013 and provides transportation to and from a Brown campus building to a rider's registered off-campus residence from 5:00 P.M. to 3:00 A.M. Ridership is expected to continue to increase with the shift in staff to the South Street Landing site and Brown will incrementally implement shuttle service enhancements to meet the added demands to the South Street Landing site. Brown completed a detailed shuttle study in February 2016 and is in the process of

evaluating the recommendations made as part of that effort to enhance service to South Street Landing.

- RIPTA U-Pass program allows current students, faculty and staff to ride any RIPTA bus or trolley anytime, anywhere in the state at no charge. Brown's investment in the UPASS program continues to support the transportation initiatives benefiting the Brown community. The program provides more than 30,000 rides per month. Brown will continue to support this program.
- The Zipcar program has expanded from 15 vehicles in two locations in 2011 to 25 vehicles in 6 locations in 2016. Six of the 26 vehicles are hybrids and 2,500 Brown-related members use them to travel 30,000 miles a month.
- Brown University has two plug-in electric vehicle charging stations available for public use and will add new stations as demand warrants.
- Evaluate and expand the pilot bike-share program.
- Increase parking fees to create a disincentive to traveling by personal automobile.
- Continued implementation of recommendations from the College Hill Parking Task Force as appropriate.

Infrastructure Improvements

Although there are no traffic, pedestrian, or bicycle impacts are associated with the Watson Institute Expansion, Brown is committed to continue to improve the overall operations and pedestrian environment throughout the campus.

As in the past, Brown will continue to partner with the City of Providence to invest in public realm streetscape and pedestrian improvements on city streets including sidewalk replacement, accessible curb cuts, new street trees, and crosswalks at various locations in the campus. The University has been involved with the painting of over 100 crosswalks with enhanced signing for pedestrians throughout the campus.

The University will work with the City of Providence Department of Public Works and Division of Traffic Engineering to identify and implement additional measures to further enhance the overall pedestrian environment around the Brown University campus. These measures would complement the capacity enhancement and pedestrian improvement measures that have already been implemented around the campus, and they can be tailored to meet specific needs of the individual locations where such improvements are necessary.

5

Short-Term Construction Impacts

The Watson Institute Expansion is expected to have minimal construction impacts due to the fact that it is a relatively small scale expansion on a site that currently contains surface parking and can easily be fenced off and self-contained during construction.

It is not expected that roadway or sidewalk closures would be needed, except for brief periods when materials are being delivered to the site or when construction debris is being removed from the site.

The University will continue to apply the following construction management practices for the project:

- **Parking for Construction Workers** – The University requires its contractors to make arrangements for the transportation of workers to the job site. Consistent with past practices and University policy, parking for construction workers working on major projects on College Hill are contractually prohibited from parking on the streets. Limited off-street parking is occasionally permitted within the confines of the specific job site. On site secure storage is made available for worker's tools and supplies, eliminating the need to transport them to and from the job site on a daily basis.
- **Construction Vehicle Traffic Management/Truck Routes** – Construction vehicle traffic is controlled in accordance with applicable City regulations and procedures. Construction management plans will be developed and reviewed by the City of Providence Department of Traffic Engineering and the Department of Public Works.

The University works with its contractors to minimize noise and other disturbances associated with construction traffic and construction vehicles are routed to avoid residential neighborhoods. As in past projects, it is expected that construction traffic will use major arterial roadways such as Angell Street, Waterman Street, Gano Street, and Hope Street for access to the construction sites.

Construction traffic and deliveries will be timed to minimize impact to traffic on area streets by scheduling deliveries outside of the peak hour periods to the extent practical.

- **Pedestrian Access/Site Security** – Generally, all construction activities will be limited to the project site to minimize impacts on University operations and the public. Protective fencing and barriers will be provided as needed on each project to segregate construction activity from walkways and roadways. Appropriate lighting, temporary sidewalks, and crosswalks will be installed to ensure pedestrian safety.