Final Report

Transportation Component

Institutional Master Plan
Brown University

Prepared for Brown University
Providence, Rhode Island

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Introduction and Executive Summary

Introduction

As part of the master planning process, Brown University has retained Vanasse Hangen Brustlin (VHB), Inc. to consider the transportation implications of the plan. This document comprises the Transportation Component of the Brown University Institutional Master Plan. This document summarizes the transportation needs of the university and describes the Master Plan's implications for the transportation system serving the University.

The following chapters present an analysis of the transportation system serving Brown University today, a projection of how this system would operate in the future without master plan development, and an assessment of the effect of the Master Plan development on this system. Although an assessment of the master plan development indicates that the program is not expected to have any major impacts on the transportation system serving the University, Brown recognizes that the campus is a major generator of transportation demand within the City of Providence. To help moderate the demand the University is placing upon the transportation system, Brown has defined a transportation improvement program including minor infrastructure improvements and a transportation demand management program.

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Study Methodology

This study was conducted to assess existing transportation conditions in the study area. The following tasks were key components of the study methodology:

- Inventory of the surrounding roadway infrastructure,
- Inventory of existing parking facilities,
- Inventory of public transportation and shuttle services,
- Observations of traffic, pedestrian, and bicycle flows,
- Collection of daily and peak period traffic and pedestrian counts,
- Identification of planned transportation improvement projects,

- Review of Brown University's current Transportation Demand Management (TDM) strategies,
- Review of other projects in the area surrounding Brown University that may affect future transportation system operation,
- Evaluation of the Master Plan's impact on the operation of the transportation system,
- Development of a transportation improvement program intended to reduce the University's impact on the surrounding community, and
- Identification of anticipated short-term construction impacts associated with the Master Plan development program.

Executive Summary

The Transportation Component of the Institutional Master Plan provides a comprehensive review of the transportation system serving Brown University and provides an analysis of the projected impact of the proposed Master Plan projects on this system. The following section provides a brief summary of the transportation analysis and results.

Existing Conditions

The transportation analysis contained in this report focuses on a study area generally bounded by Lloyd Avenue to the north, Waterman Street to the south, Arlington Avenue to the east and Prospect Street to the west. Daily and peak hour traffic volumes were collected for the major roadway corridors and at 37 intersections within the study area. These traffic data were used to evaluate the quality of the traffic operations within the study area. The 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 than the operations analysis suggests. Field observations revealed lengthy queues and long delays for some of the approaches to the intersections. 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 caused by non-university related factors.

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 Thayer Street commercial related activity during the morning peak hour period. Pedestrian volumes along Thayer Street and Brown Street and at the primary street crossings along Angell Street, Waterman Street, and George Street were very high.

Additional Observations

There are thirteen (13) signalized intersections along Angell Street and Waterman Street between Gano Street and Benefit Street. Due to the relatively close spacing of the intersections, many of the traffic signals were originally designed and programmed to run coordinated with each other. However, based on a field review in September 2005, many of the intersections were not running coordinated with the adjacent traffic signals. As a result, the progression of vehicles through the corridor was poor and the queue lengths at some intersections were observed to extend through the adjacent intersections.

In addition, all of the traffic signals within the study area are non-actuated and operate on fixed time intervals 24 hours a day. Consequently, the traffic signals cycle through the various phases to pre-established threshold values regardless of actual vehicle or pedestrian demand on the approaches to the intersections. As a result, there are unnecessary delays to both vehicles and pedestrians throughout the day.

Additional disruptions to traffic flow were noted along Angell Street, Waterman Street, and Thayer Street. At the unsignalized intersections of Brown Street with Angell Street and with Waterman Street, pedestrians crossing the roadways interfered with flow of traffic, which resulted in areas of congestion during peak periods. Along Thayer Street between Cushing Street and Waterman Street, several factors caused 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 all

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Future Conditions

The changes in transportation demand associated with the proposed Master Plan projects were estimated based on the slight faculty/staffing growth, slight graduate student enrollment growth, reassignment of parking, and building program.

The proposed development program presented in the Institutional Master Plan will have limited impacts on the transportation system serving Brown University. Automobile traffic to and from the campus will be impacted in two different ways. First, the Plan for Academic Enrichment, which will result in minor increases in faculty, staff, and graduate students, will result in more vehicles arriving to the campus. Second, the reassignment of existing parking areas and the increase in leased parking spaces off-campus will result in altered travel paths at some intersections near the campus.

The more significant change to the campus transportation network will be the increase in pedestrian activity related to the opening of the Life Sciences Building currently under construction, the development of The Walk, and the construction of the Sidney E. Frank Hall, the Creative Arts Center, and the Jonathan Nelson Fitness Center.

The Master Plan building program results in few minor changes in level of service. In most cases, the intersections which show degradations in the calculated levels of service are those that are near threshold values or near capacity under No-Build traffic volumes.

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Improvement Measures

Although the development associated with the Master Plan does not generate significant transportation demand, the University has developed a transportation improvement program. This improvement program addresses the specific impacts of the Master Plan development program, improves the University's management of its transportation facilities, and strives to reduce its impact on the operation of the transportation system serving the campus.

Transportation Demand Management

While Brown University has been providing many TDM services, the University will continue to look at ways to further encourage public transportation. At a minimum, this will include modifications to the existing parking policies to allow for experimentation with public transportation without losing a parking permit and improved outreach to University employees about the RIPTA pass program and other TDM measures.

Roadway Infrastructure Improvements

The traffic impacts associated with the proposed Master Plan development program are relatively minor. However, improvements are recommended at various locations impacted directly by the proposed changes on campus and at the gateway intersections which provide poor levels of service under future projected No-Build and Build volumes. Improvements have been proposed for each of the areas listed below:

- **Gateway intersections –** Traffic signal timing adjustments
  - Angell Street at Benefit Street
  - Waterman Street at Benefit Street
  - Hope Street at Olney Street
- **Angell Street and Waterman Street corridors –** Traffic signal coordination
- **The Walk pedestrian crossings –** Signalized crossings at Angell Street and Waterman Street, hardwire interconnected with traffic signals at Thayer Street, and improved visibility of crosswalks.
- **Cushing Street pedestrian crossings –** Improved visibility of crosswalks and potential 4-way stop control at intersection of Cushing Street and Brook Street.

The proposed signal timing modifications and any required equipment upgrades at the intersections would need to be coordinated with the City of Providence Department of Traffic Engineering.

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Existing Conditions

Introduction

As the first step in the development of the transportation component of Brown University's Institutional Master Plan, Vanasse Hangen Brustlin Inc. (VHB) has reviewed the existing transportation conditions and identified the critical access and circulation issues that need to be addressed as part of the long-term plan for the campus. This chapter quantifies existing traffic, parking, pedestrian, and public transportation conditions on and around the campus.

The first section of this chapter describes the University's surroundings and the transportation study focus area. The following 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 access

The final two sections of this chapter 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 impact on the transportation system serving the University and its neighbors.

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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 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 1,500 students is 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.
- Rhode Island School of Design (RISD), a private institution of higher learning with total enrollment of approximately 2,200 students, is located to the west of the Brown University campus primarily in the area north of College Street and south of Meeting Street.

The neighboring institutions have a direct impact on transportation operations within the northern portion of the Brown University campus. Brown University and its neighbors depend on a transportation system that is comprised of several different modes including automobiles, public transportation, bicycles, and walking.

Because the majority of the roadways in the southern section of the Brown University campus act as campus streets primarily serving Brown University, and because the projects included in the Institutional Master Plan for the next 5-10 years are located within the northern portion of the campus, the transportation study area focussed on the northern sector of the campus and surrounding area.

The project study area is generally bounded by Lloyd Avenue to the north, Waterman Street to the south, Arlington Avenue to the east and Prospect Street to the west, as shown in Figure 2-1. Additional intersections outside of the general study area were included to identify existing traffic patterns to/from the Brown 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 university projects.

In total, this study includes the following thirty-seven (37) intersections that have been identified based on discussions with Brown University and the City of Providence Department of Planning and Development:

1. Angell Street/Gano Street (signalized)
2. Angell Street/Governor Street
3. Angell Street/Hope Street (signalized)
4. Angell Street/Brook Street (signalized)
5. Angell Street/Thayer Street (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/Thayer Street (signalized)

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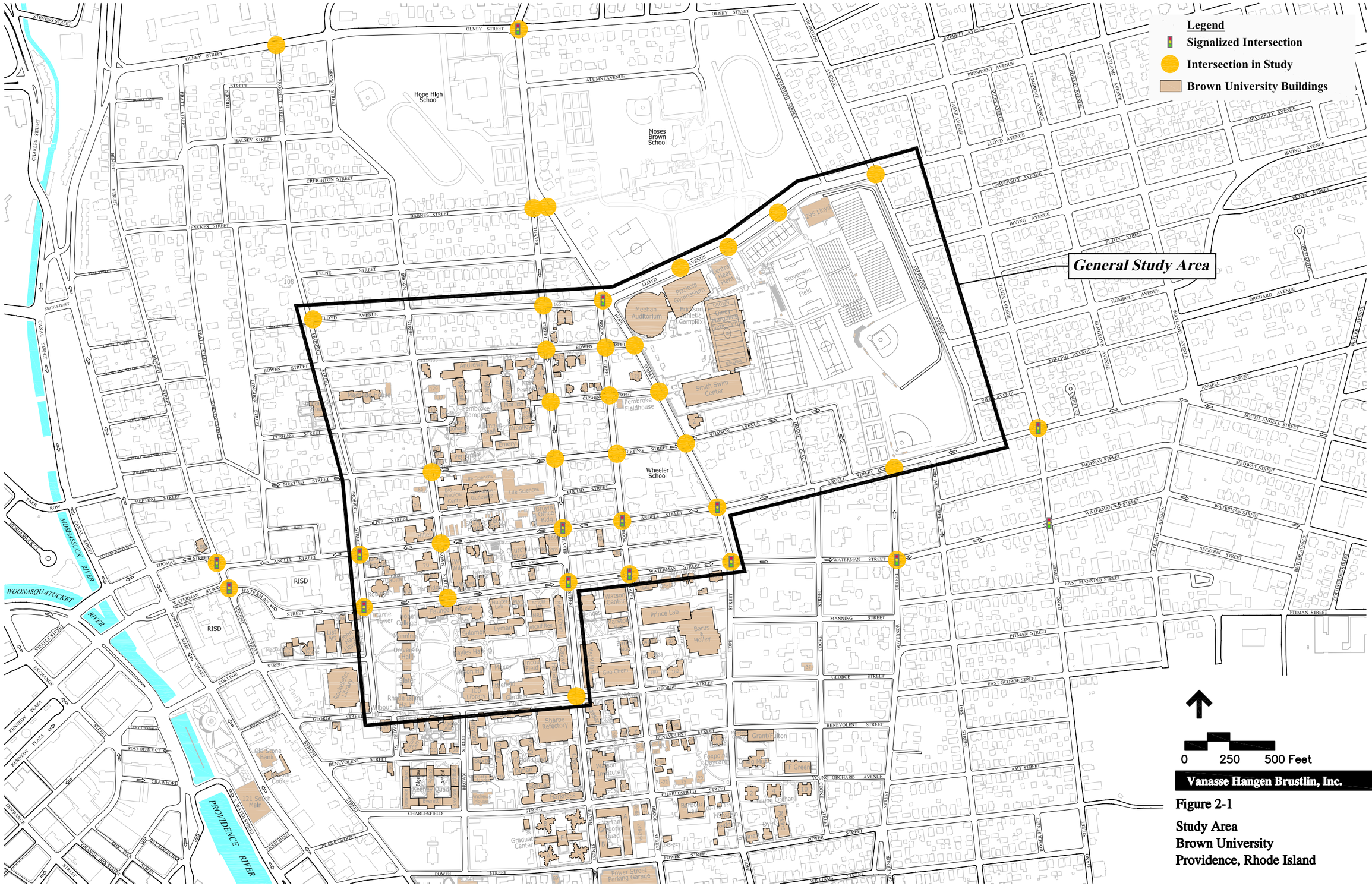

Figure 2-1

Study Area
Brown University
Providence, Rhode Island

13. Waterman Street/Brook Street (signalized)
14. Waterman Street/Hope Street (signalized)
15. Waterman Street/Governor Street (signalized)
16. Lloyd Avenue/Arlington Avenue
17. Lloyd Avenue/Moses Brown East Drive
18. Lloyd Avenue/Brown University Parking Areas Nos. 89 & 90
19. Lloyd Avenue/Moses Brown Main Entrance
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. Brook Street/Bowen Street
27. Brook Street/Cushing Street
28. Brook Street/Meeting Street
29. Thayer Street/Barnes Street
30. Thayer Street/Lloyd Avenue
31. Thayer Street/Bowen Street
32. Thayer Street/Cushing Street
33. Thayer Street/Meeting Street
34. Thayer Street/George Street
35. Brown Street/Meeting Street
36. Prospect Street/Olney Street
37. Prospect Street/Lloyd Avenue

These study area intersections were evaluated in detail using 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.

Vehicular Access and Roadway Conditions

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

Vehicular Access

Brown 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 vehicular access to the campus.

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Roadways

The primary roadways providing access to the Brown 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 Brown University, Angell Street is approximately 25' wide with parking prohibited along the south side and two-hour parking generally allowed along the north side. Due to the on-street parking and limited pavement width, Angell Street operates as one west-bound 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.

Traffic signals exist at the Angell Street intersections with Gano Street, Hope Street, Brook Street, Thayer Street, 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 Brown 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 east-bound travel lane through the study area during most times of the day. On the eastbound approach to Hope Street, Waterman Street frequently operates as two travel lanes (a left-turn only lane and a shared through/right-turn lane) during the peak hour periods

Traffic signals exist at the Waterman Street intersections with Benefit Street, Prospect Street, 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 intersection with George Street is 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 and George 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 Bowen Street and George 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, and Meeting 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.

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Observed Conditions

VHB observed traffic conditions along the various roadways and intersections within the study area. Specific highlights of the traffic observations are presented below.

Traffic Signal Operations

As shown in Figure 2-1, there are thirteen (13) signalized intersections along Angell Street and Waterman Street between Gano Street and Benefit Street. Due to the

relatively close spacing of the intersections, many of the traffic signals were originally designed and programmed to run coordinated with each other. However, based on a field review in September 2005, the Angell Street intersections with Gano Street, Thayer Street, and Benefit Street/Thomas Street, as well as the Waterman Street intersections with Benefit Street (during the evening peak hour only), Brook Street, and Governor Street (during the morning peak hour only) were not running coordinated with the adjacent traffic signals. As a result, the progression of vehicles through the corridor was poor and the queue lengths at some intersections were observed to extend through the adjacent intersections.

In addition, all of the traffic signals within the study area are non-actuated and operate on fixed time intervals 24 hours a day. Consequently, the traffic signals cycle through the various phases to pre-established threshold values regardless of actual vehicle or pedestrian demand on the approaches to the intersections. As a result, there are unnecessary delays to both vehicles and pedestrians throughout the day.

Moses Brown School Operations

The Moses Brown School has three entrances within the study area. The main entrance is located on Lloyd Avenue approximately 450 feet east of Hope Street. A second entrance is located on Lloyd Avenue approximately 600 feet east of the main entrance, and a third entrance is located on Hope Street across from Barnes Street. The majority of the school bus drop-off and pick-up activity occurs on Lloyd Avenue at the main entrance, as most school buses do not enter the Moses Brown property. Some school bus activity was observed at the Hope Street entrance to Moses Brown School. 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 main entrance with the help of a crossing guard. 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. During the afternoon peak hour period, the gate at the Moses Brown main entrance was closed.

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 school buses drop off and pick up students along Angell Street. 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 guard is positioned during the school arrival and departure periods.

Parents dropping off students in the morning sometimes double-park on Angell Street, which restricts the flow of through traffic along Angell Street. In addition, the queue of vehicles for morning student drop-offs on Meeting Street often extends to Brook Street between 7:45 AM and 7:55 AM and impacts the flow of traffic on Brook Street. The disruptions in traffic flow during the morning peak period caused by Wheeler School activities were observed to last approximately 20 minutes, and they generally subsided by 8:05 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 2:40 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. 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 approximately 30 minutes, and they generally subsided by 3:15 PM.

Additional Observations

Additional observations made by VHB traffic engineers during the data collection efforts include:

- During the traffic data collection and observations conducted, Olive Street between Thayer Street and Brown Street was closed, and the available on-street parking along Meeting Street was reduced due to the construction of the Brown University Life Sciences Building.
- 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.
- Many of the pedestrian traffic signals throughout the study were damaged or not working properly. At the intersection of Hope Street and Lloyd Avenue, the pedestrian signals for the eastern Lloyd Avenue crossing were not working, and they did not appear to be wired or programmed correctly in the traffic signal cabinet and controller.
- Several vehicles on the roadway network were observed to be circulating around the blocks looking for on-street parking.

- The large number of pedestrians, parking maneuvers, and buses related to the Hope 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.
- Congestion within Downtown Providence often spills back to South Main Street at Steeple Street/Thomas Street during the peak hour periods. This congestion further restricts the flow of traffic along Angell Street at the intersection with Benefit Street.
- During the morning peak hour period, the Waterman Avenue vehicle queue from the intersection with Benefit Street extended beyond South Main Street, which impacted the operation the upstream traffic signals. The queue was the result of the large number of pedestrians crossing against the signals and the steep slope on the Waterman Avenue approach to Benefit Street.

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Traffic Volumes

An extensive transportation data collection program was conducted in September 2005 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 also conducted between 2:00 PM and 4:00 PM 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.

In addition, traffic counts from previous studies were collected and reviewed. This included the following:

- ATR counts collected for 96 consecutive hours along Waterman Street west of Gano Street in May 2002 (from a previous VHB study)
- Turning movement counts collected in September 2004 between 7:00 AM and 9:00 AM and between 2:00 PM and 6:00 PM at the intersections of Brook Street with Cushing Street, Brook Street with Meeting Street, and Meeting Street with Thayer Street (from a previous VHB study)
- Weekday morning and weekday evening turning movement count volumes collected in October 1999 at the intersections of Hope Street with Lloyd Avenue/Brook Street, Hope Street with Alumni Avenue, Hope Street with Olney Street, and Lloyd Avenue with Moses Brown Main Entrance (from "Moses Brown School Proposed Improvements Traffic Assessment", Caputo and Wick Ltd., December 1999, Revised April 2000)

- Turning movement counts collected in April 2000 between 6:00 AM and 8:00 AM and between 12:00 PM and 6:00 PM at the intersection of Hope Street with Lloyd Avenue/Brook Street (from "Traffic Impact Analysis for the Relocation of the Facilities Management Building", Bryant Associates, Inc., May 1, 2000, Revised November 2002)

The study area's overall morning peak hour was determined to occur between 7:45 AM and 8:45 AM, and the study area's overall evening peak hour was determined to occur between 5:00 PM and 6:00 PM. The peak hour along Lloyd Avenue east of Hope Street occurred between 7:30 AM and 8:30 AM and between 2:30 PM and 3:30 PM due to the activity related to the Moses Brown School.

The existing distribution of traffic entering/exiting the study area is shown in Figure 2-2. As shown, approximately 71% of the traffic accesses the study area along the arterial roadways of Angell Street, Waterman Street, and Hope Street.

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 for urban facilities, traffic on urban facilities in the month of September is higher than the average month. Counts collected in the latter half of September are considered appropriate for establishing base transportation conditions for urban facilities directly impacted by colleges/universities. Therefore, RIDOT seasonal adjustment factors were not applied to the traffic counts collected in September 2005. The existing weekday morning and weekday evening peak hour traffic volumes are presented in Figures 2-3, and 2-4, respectively.

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
Angell Street (east of Hope Street)	9,400	890	9.5	100% WB	760	8.1	100% WB
Waterman Street (east of Benefit Street)	5,610	350	6.2	100% EB	435	7.8	100% EB
Waterman Street[4] (east of Governor Street)	9,320	400	4.3	100% EB	755	8.1	100% EB
Hope Street (north of Angell Street)	9,960	695	7.0	55% NB	870	8.7	57% NB
Hope Street[4] (south of Angell Street)	7,990	535	6.7	66% SB	695	8.7	62% SB
Brook Street (north of Angell Street)	6,680	425	6.4	68% NB	505	7.6	68% NB
Thayer Street (south of Meeting Street)	6,660	435	6.5	100% SB	410	6.2	100% SB
Brown Street (south of Meeting Street)	2,610	170	6.5	57% SB	190	7.3	58% NB
Prospect Street (south of Meeting Street)	3,410	290	8.5	59% SB	290	8.5	51% SB
Olney Street[4] (west of Hope Street)	8,115	760	9.4	55% EB	690	8.5	65% EB
Lloyd Avenue (east of Hope Street)	4,640	485	10.5	55% WB	420	9.1	51% EB
Lloyd Avenue (west of Thayer Street)	1,640	180	11.0	58% WB	140	8.5	52% EB
Bowen Street[4] (west of Brook Street)	1,530	125	8.2	55% EB	130	8.5	63% WB
Cushing Street[4] (west of Brook Street)	1,410	85	6.0	57% WB	120	8.5	62% WB
Meeting Street[4] (west of Brook Street)	940	45	4.9	60% EB	80	8.5	59% EB
George Street[4] (west of Brook Street)	1,880	155	8.2	64% WB	160	8.5	53% EB

Source: Compiled by VHB from traffic 2005 automatic traffic recorder (ATR) counts conducted by Transportation Data Corporation (TDC) in September 2005.

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

4 Estimated based on peak hour volumes

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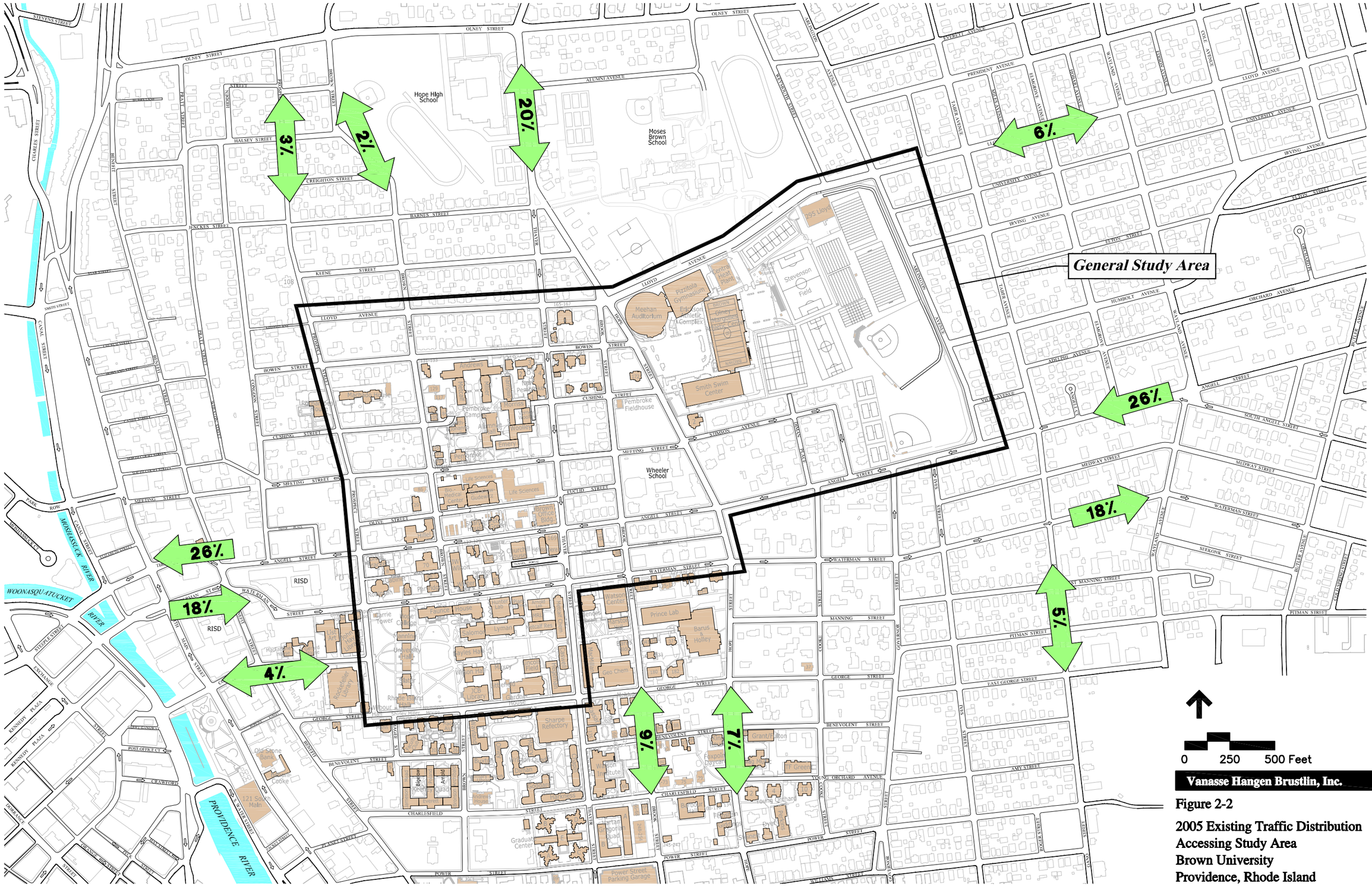

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Figure 2-2

2005 Existing Traffic Distribution Accessing Study Area Brown University Providence, Rhode Island

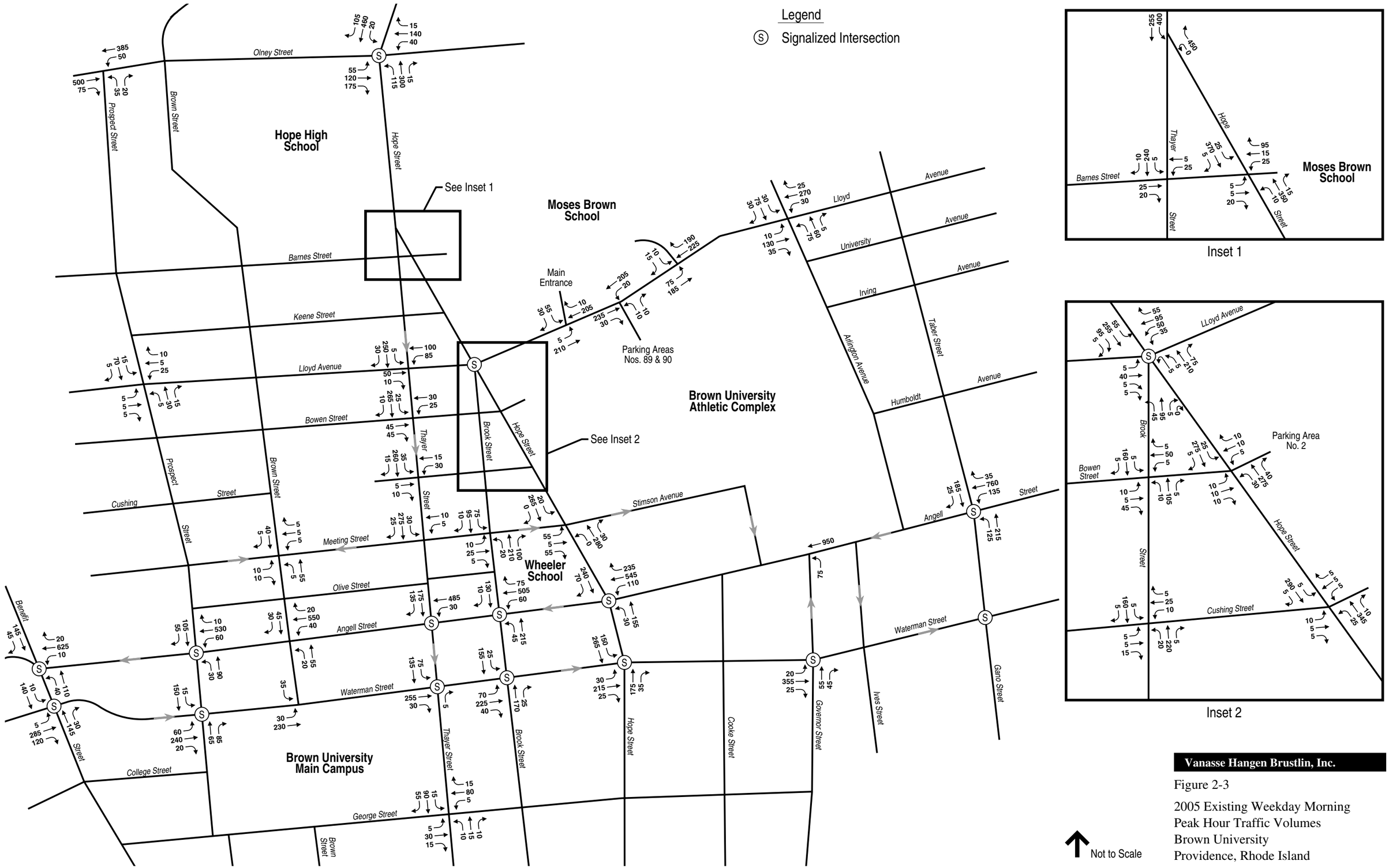

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Figure 2-3

2005 Existing Weekday Morning Peak Hour Traffic Volumes
Brown University
Providence, Rhode Island

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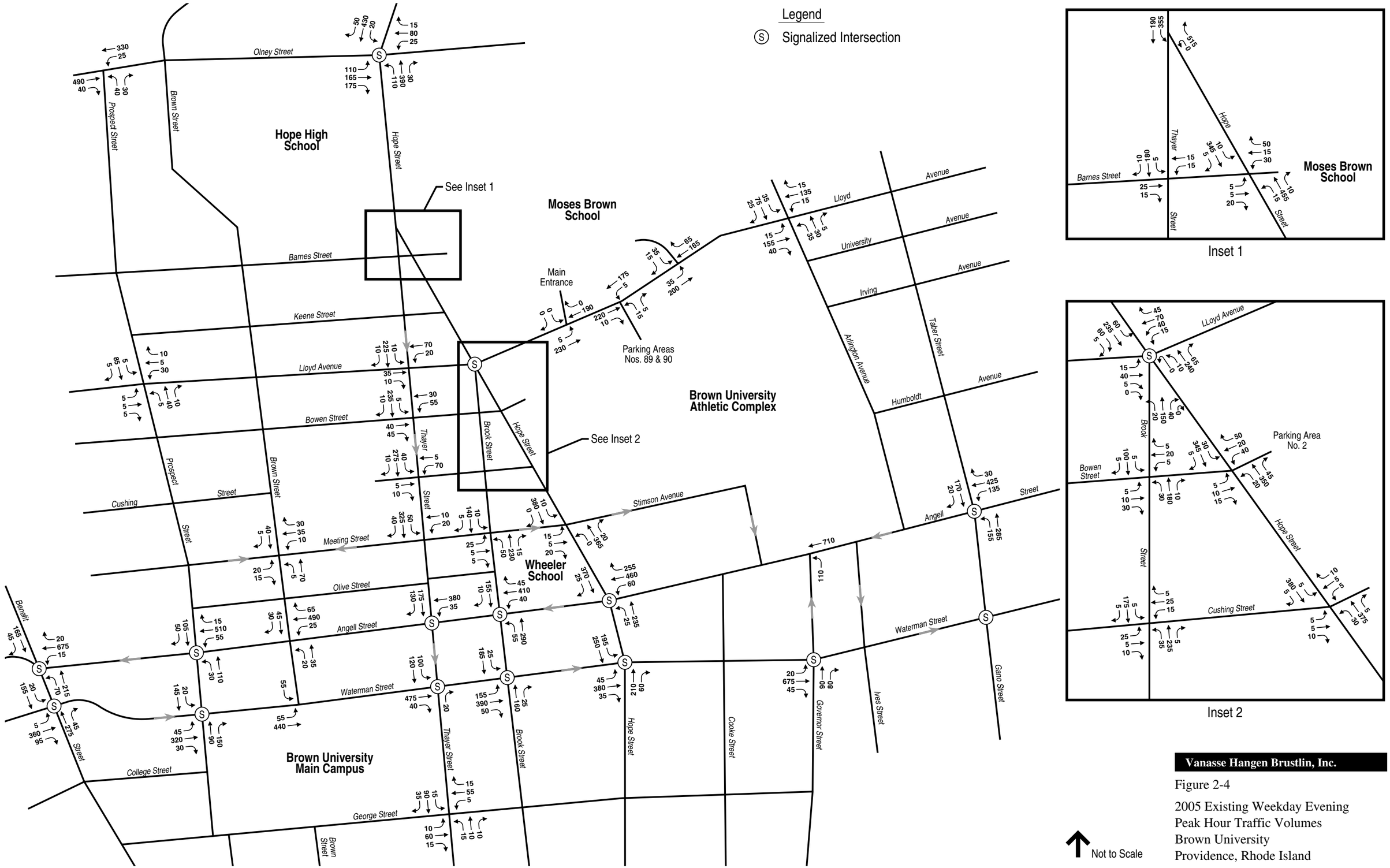

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Figure 2-4

2005 Existing Weekday Evening Peak Hour Traffic Volumes
Brown University
Providence, Rhode Island

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Traffic Operations Analysis

Measuring existing traffic volumes quantifies traffic flow within the study area. To assess quality of flow, intersection capacity analyses were conducted with respect to 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 as described below

Level-Of-Service Criteria

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, freedom to maneuver, and safety. 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 most often the left turn out of the side street.

Signalized Intersections

Capacity analyses were conducted at the fourteen signalized intersections included in this study. The traffic signal timings used for the analysis were based on actual field measurements or extracted traffic signal controller data obtained by VHB during the weekday morning and weekday evening peak hour periods in September 2005. A summary of the signalized intersection capacity analyses results for existing conditions is presented in Table 2-2.

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.

Due to the fact that the capacity analysis does not totally take into account disruptions to traffic flow between intersections, 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 and future conditions.

As shown in Table 2-2, the results of the capacity analyses indicate that all of the signalized intersections within the study area, with the exception of the intersection of Angell Street and Benefit Street, operate at acceptable calculated level of service (LOS) D or better during the weekday morning and weekday evening peak hour periods.

However, based on field observations, many of the intersections appear to operate at poorer levels of service than the operations analysis suggests. Field observations revealed lengthy queues and long delays for some of the approaches to the intersections. 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. This traffic condition frequently occurs at the intersections along Angell Street and Waterman Street between Hope Street and Thayer Street and along Gano Street.

The intersection of Angell Street and Benefit Street operates at a deficient calculated level of service (LOS E) during both peak hour periods due to the poor timings of the traffic signal, and the lack of coordination with the traffic signal at the intersection of Waterman Street and Benefit Street.

Table 2-2
Existing Conditions Signalized Intersection Capacity Analysis Summary

Location	Peak Hour	2005 Existing V/C[1]	2005 Existing Delay[2]	2005 Existing LOS[3]
Angell Street/ Gano Street	Weekday Morning	0.72	21.8	C
	Weekday Evening	0.62	17.1	B
Angell Street/ Hope Street	Weekday Morning	0.79	20.6	C
	Weekday Evening	0.75	18.7	B
Angell Street/ Brook Street	Weekday Morning	0.78	30.1	C
	Weekday Evening	0.68	16.2	B
Angell Street/ Thayer Street	Weekday Morning	0.71	20.6	C
	Weekday Evening	0.63	17.1	B
Angell Street/ Prospect Street	Weekday Morning	0.55	15.6	B
	Weekday Evening	0.53	15.4	B
Angell Street/ Benefit Street	Weekday Morning	0.73	69.3	E
	Weekday Evening	0.84	65.9	E
Waterman Street/ Benefit Street	Weekday Morning	0.54	44.2	D
	Weekday Evening	0.63	18.8	B
Waterman Street/ Prospect Street	Weekday Morning	0.36	17.1	B
	Weekday Evening	0.43	14.4	B
Waterman Street/ Thayer Street	Weekday Morning	0.38	14.4	B
	Weekday Evening	0.62	22.8	C
Waterman Street/ Brook Street	Weekday Morning	0.43	12.7	B
	Weekday Evening	0.68	18.9	B
Waterman Street/ Hope Street	Weekday Morning	0.60	13.2	B
	Weekday Evening	0.77	17.1	B
Waterman Street/ Governor Street	Weekday Morning	0.22	9.7	A
	Weekday Evening	0.38	14.0	B
Hope Street/ Lloyd Avenue/Brook Street	Weekday Morning	0.73	34.7	C
	Weekday Evening	0.72	32.4	C
Hope Street/ Olney Street	Weekday Morning	0.89	41.7	D
	Weekday Evening	0.91	29.7	C

Source: Synchro 6 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 on the study area roadways between intersections. These interruptions caused congestion along these roadways during the peak hour periods. As a result, the observed delay times at some intersections exceeded the calculated values.

Unsignalized Intersections

Capacity analyses were also conducted at the twenty-three unsignalized intersections included in this study. A summary of the unsignalized intersection capacity analysis results for existing conditions is presented in Table 2-3.

As stated in the signalized intersections analysis section, the capacity analysis software analyzes the operation at the intersections only and does not totally 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.

During the weekday morning peak hour period, the intersection of Angell Street and Brown Street operates at a deficient calculated level of service (LOS E) due to traffic volumes along Angell Street.

During the weekday evening peak hour period, three other intersections operate at deficient levels of service:

- Hope Street at Barnes Street/Moses Brown Drive (LOS E)
- Brook Street at Cushing Street (LOS E)
- Thayer Street at Meeting Street (LOS F)

The delays experienced at the intersection of Hope Street and Barnes Street/Moses Brown School are due to the traffic volumes along Hope Street and the traffic exiting Moses Brown School over a concentrated peak period. The delays experienced at 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.

Table 2-3
Existing Conditions Unsignalized Intersection Capacity Analysis Summary

		2005 Existing			
Location	Peak Hour	Critical Movement[1]	Demand[2]	Delay[3]	LOS[4]
Angell Street/	Weekday Morning	NB L	75	14.5	B
Governor Street	Weekday Evening	NB L	110	12.6	B
Angell Street/	Weekday Morning	NB TR	75	46.0	E
Brown Street	Weekday Evening	NB TR	55	32.0	D
Waterman Street/	Weekday Morning	SB L	35	11.5	B
Brown Street	Weekday Evening	SB L	55	30.3	D
Lloyd Avenue/	Weekday Morning	WB LTR	325	22.7	C
Arlington Avenue	Weekday Evening	EB LTR	210	10.4	B
Lloyd Avenue/	Weekday Morning	SB LR	25	17.2	C
Moses Brown East Drive	Weekday Evening	SB LR	50	14.2	B
Lloyd Avenue/	Weekday Morning	NB LR	20	13.8	B
Parking Areas Nos. 89 & 90	Weekday Evening	NB LR	20	13.4	B
Lloyd Avenue/	Weekday Morning	SB LR	85	20.6	C
Moses Brown Main Entrance	Weekday Evening	SB LR	1	11.9	B
Hope Street/	Weekday Morning	EB LTR	115	27.9	D
Meeting Street	Weekday Evening	EB LTR	40	17.5	C
Hope Street/	Weekday Morning	WB LTR	15	19.2	C
Cushing Street	Weekday Evening	WB LTR	20	20.5	C
Hope Street/	Weekday Morning	EB LTR	30	18.2	C
Bowen Street	Weekday Evening	WB TR	50	25.0	C
Hope Street/	Weekday Morning	WB LTR	135	26.2	D
Barnes Street/Moses Brown	Weekday Evening	WB LTR	95	39.3	E
Brook Street/	Weekday Morning	EB LTR	40	26.2	D
Meeting Street	Weekday Evening	EB LTR	35	18.1	C
Brook Street/	Weekday Morning	WB LTR	40	15.4	B
Cushing Street	Weekday Evening	WB LTR	40	18.9	C
Brook Street/	Weekday Morning	WB LTR	60	12.9	B
Bowen Street	Weekday Evening	WB LTR	30	14.9	B
Thayer Street/	Weekday Morning	WB LT	30	13.4	B
Barnes Street	Weekday Evening	EB TR	40	16.1	C
Thayer Street/	Weekday Morning	WB LT	185	23.3	C
Lloyd Avenue	Weekday Evening	WB LT	90	15.3	C
Thayer Street/	Weekday Morning	WB LT	55	19.0	C
Bowen Street	Weekday Evening	WB LT	85	21.0	C
Thayer Street/	Weekday Morning	WB LT	45	23.0	C
Cushing Street	Weekday Evening	WB LT	75	35.6	E
Thayer Street/	Weekday Morning	WB LT	15	20.2	C
Meeting Street	Weekday Evening	WB LT	30	>100	F
Thayer Street/	Weekday Morning	SB LTR	160	8.5	A
George Street	Weekday Evening	SB LTR	140	8.3	A
Brown Street/	Weekday Morning	NB LTR	60	7.5	A
Meeting Street	Weekday Evening	NB LTR	75	7.9	A

Table 2-3 (Continued)
Existing Conditions Unsignalized Intersection Capacity Analysis Summary

Location	Peak Hour	2005 Existing Critical Movement[1]	Demand[2]	Delay[3]	LOS[4]
Prospect Street/ Olney Street	Weekday Morning	NB LR	55	24.6	C
	Weekday Evening	NB LR	70	21.5	C
Prospect Street/ Lloyd Avenue	Weekday Morning	SB LTR	90	7.7	A
	Weekday Evening	SB LTR	95	7.8	A

Source: Synchro 6 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 on the study area roadways between intersections. These interruptions caused congestion along these roadways during the peak hour periods. As a result, the observed delay times at some intersections exceeded the calculated values.

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Parking

A parking inventory, utilization, and supply/demand study was conducted for the Brown University Campus by Howard/Stein-Hudson Associates, Inc. (HSH) as documented in the "Brown University Parking Demand Analysis", May 2002. As part of the Howard/Stein-Hudson Associates study, an inventory of Brown University off-street parking supply and existing on-street parking supply surrounding the university was conducted. The information included in the study has been updated by Brown University to reflect changes since the completion in the study. The following summarizes the results.

On-street Parking

The existing on-street parking supply surrounding Brown University is presented in Figure 2-5. According to the 2002 Howard/Stein-Hudson Associates Inc. study, there are approximately 1,700 on-street parking spaces available within the Brown University Institutional Zone generally bounded by Benefit Street/Prospect Street to the west, Bowen Street/Lloyd Avenue to the north, Hope Street, Cooke Street to the east, and Power Street, John Street to the south. Based on the HSH study, approximately 32 percent (545 spaces) are unrestricted, 18 percent (305 spaces) are signed as no parking between 8:00 AM and 10:00 AM, 34 percent (585 spaces) are designated as 2-hour parking spaces, and the remaining 16 percent range from 15-minute to 3 hour parking or have varying additional restrictions. There is a limited amount of metered parking along sections of Prospect Street, Angell Street, and Waterman Street.

Utilization of the on-street parking was been observed by HSH, and reported in the "Brown University Parking Demand Analysis". According to the study, *"virtually all of the on-street parking supply was filled to capacity. Parking spaces with the restriction of*

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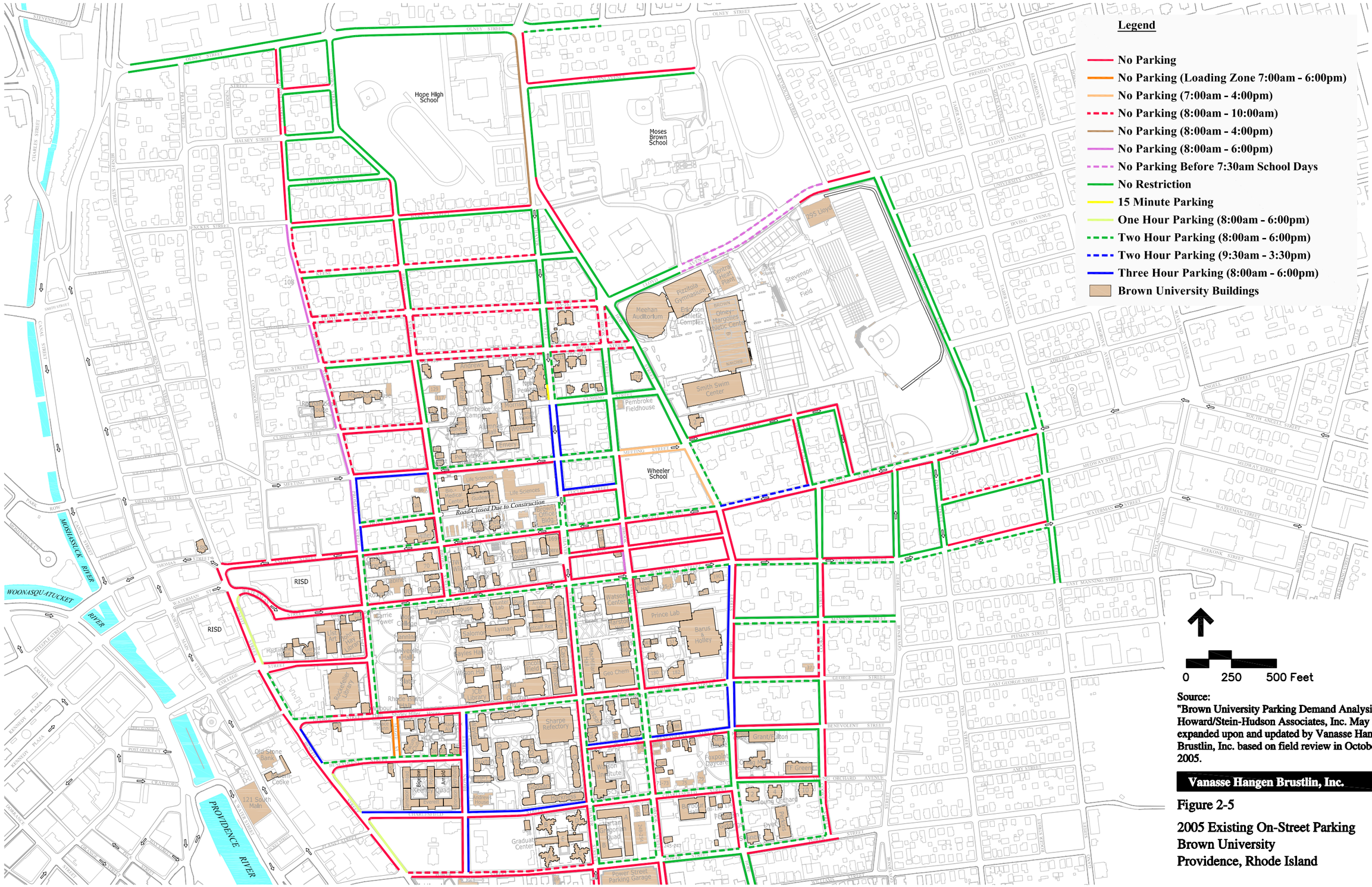

Source:
"Brown University Parking Demand Analysis", Howard/Stein-Hudson Associates, Inc. May 2002 expanded upon and updated by Vanasse Hangen Brustlin, Inc. based on field review in October 2005.

Vanasse Hangen Brustlin, Inc.

Figure 2-5

2005 Existing On-Street Parking
Brown University
Providence, Rhode Island

'No Parking between 8:00 AM and 10:00 AM' were occupied by 10:00 AM. Observations suggest that just prior to 10:00 AM, faculty and staff move their vehicles to a space with the 'No-Parking between 8:00 and 10:00 AM' designation, since after 10:00 AM these spaces become free spaces with no time limits." The HSH study also indicated that vehicles were parked in "No Parking" areas and there was limited parking enforcement on the streets surrounding the Brown University campus.

Observations conducted by VHB confirmed the observations identified in the HSH study. Enforcement of the "No Parking Before 7:30 AM School Days" restriction along Lloyd Avenue in front of Moses Brown was observed by VHB on multiple days.

Brown University Off-Street Parking

Brown University's current off-street parking supply within, or in close proximity to, the main campus area consists of approximately 90 parking areas including one structured parking garage, as summarized in Table 2-4. These lots range in size from 1 space to approximately 400 spaces and total 2,566 parking spaces. The Brown University off-street parking areas within the study area are shown in Figure 2-6.

Based on the City of Providence zoning requirements, the required number of parking spaces for Brown University is 3,305 spaces. However, 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 shortage, the revised required number of off-street parking spaces is 2,374 spaces. As shown in Table 2-4, Brown University currently controls 2,566 parking spaces for a surplus of 192 spaces. The City of Providence parking requirements for Brown University are summarized in Table 2-5.

All parking on campus requires a parking permit from the Brown University Parking Office and is regulated by University security. The costs of parking permits vary by type (i.e. faculty, student, day, etc.) and range from $105 per year for a recreation parking permit to park near the Athletic Center, to $950 for a resident employee parking permit. An all-day parking permit for employees, students (excluding freshmen and sophomores) and affiliates is $340 per year. 24-hour parking permits are $465 per academic year for undergraduates, $340 for resident graduate or medical students, and $155 for the summer months only.

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Legend

- Brown University Lot Numbers
- Brown University Buildings

0 250 500 Feet

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Figure 2-6

2005 Existing Off-Street Parking
Brown University
Providence, Rhode Island

Table 2-4
Brown University Off-Street Parking Facilities

Lot #	Location	Current Use	Total Spaces
1	Athletic Center (Swim Center)	Faculty/Staff	22
2	Athletic Center (OMAC)	Faculty/Staff	260
3	Brook & Bowen Streets	Student	12
4	New Pembroke, Bowen & Thayer St.	Faculty/Staff	2
5	Champlin Hall	Faculty/Staff	17
6	New Pembroke Alcove	Faculty/Staff	3
7	Andrews Hall	Student	9
8	Woolley Hall	Faculty/Staff	4
9	Emery Hall	Faculty/Staff	13
10	West Cushing Street	Faculty/Staff	21
11	Brook & Bowen Sts (formerly 60 Olive St)	Faculty/Staff	41
12	Brown Office Building, West Drive	Faculty/Staff	5
13	Churchill East	Faculty/Staff	10
14	Churchill West	Faculty/Staff	13
15	90 Waterman Street	Faculty/Staff	18
16	Fones Alley, Environmental Studies	Faculty/Staff	6
17	Fones Alley, J Walter Wilson	Faculty/Staff	29
18	Olive Street (Peter Green House)	Other	6
19	Brown & Olive Streets	Other	47
20	Hemisphere Building	Faculty/Staff	3
21	Fones Alley, 70 Waterman	Faculty/Staff	8
22	Fones Alley, Robinson West	Faculty/Staff	1
23	Fones Alley, Robinson East	Faculty/Staff	8
24	10 Park Lane (126 spaces, not included in count)	Faculty/Staff	0
25	Ladd Observatory	Other	3
26	25 George Street	Faculty/Staff	5
27	67 George Street	Faculty/Staff	5
28	Marston Boathouse	Other	15
30	Hospital-Based Faculty, JW Wilson	Faculty/Staff	8
32	Environmental Studies	Faculty/Staff	3
40	333 Brook Street	Faculty/Staff	2
41	190 Hope Street	Faculty/Staff	23
42	Prince Engineering Lab, Hope Street	Faculty/Staff	18
43	Barus & Holley, George Street	Faculty/Staff	67
44	Minden Hall	Faculty/Staff	42
45	Applied Math	Faculty/Staff	11
46	341 Brook Street	Faculty/Staff	3
47	37 Manning Street	Faculty/Staff	5
48	Lincoln Field	Faculty/Staff	5
50	36 Prospect Street ("Prospect House")	Faculty/Staff	3
51	54 College Street	Faculty/Staff	8
52	Rockefeller Library, College Street	Faculty/Staff	34
53	Rockefeller Library, Loading Dock	Faculty/Staff	4
54	Benevolent Street, East Campus	Faculty/Staff/Student	21
55	Young Orchard Ave	Student	20
56	Perkins Hall, Power & Hope Streets	Student	11
	Subtotal Number of Off-Street Parking Spaces		874

Table 2-4 (Continued)
Brown University Off-Street Parking Facilities

Lot #	Location	Current Use	Total Spaces
57	75 Charlesfield, King House, & Daycare Center	Faculty/Staff/Student	64
58	Barbour Hall, Charlesfield Street	Student	58
59	Giddings Hall, Power Street	Faculty/Staff	12
60	130 Hope Street	Faculty/Staff	2
61	163 George Street	Faculty/Staff	3
62	155 George Street	Faculty/Staff	3
63	159 George Street	Faculty/Staff	2
64	61 Charlesfield Street	Faculty/Staff/Student	17
65	Benevolent & Thayer Streets	Faculty/Staff	17
66	88 Benevolent Street	Faculty/Staff	6
67	Power-Brook St	Faculty/Staff	6
68	Power Street Garage	Faculty/Staff/Student	397
69	50 John Street	Faculty/Staff	5
70	5 Benevolent Street	Faculty/Staff	1
71	Andrews Infirmary	Faculty/Staff	24
74	Faculty Club	Faculty/Staff	3
75	Keeney Quad, Benevolent Street	Faculty/Staff	6
76	Horace Mann, George Street	Faculty/Staff	34
77	74-80 Benevolent Street	Faculty/Staff	12
77	84 & 86 Benevolent Street	Faculty/Staff	13
77	281-283 Brook Street	Faculty/Staff	6
77	70-72 Charles Field Street	Faculty/Staff	9
77	20 Olive Street	Faculty/Staff	13
77	86 Waterman	Faculty/Staff	8
77	129 Waterman Street	Faculty/Staff	6
77	21 Various Additional Rental Facilities (5 or less spaces each location)	Faculty/Staff	59
78	Hoppin House, 383 Benefit Street	Faculty/Staff	36
80	110 Elm Street	Faculty/Staff	87
81	70 Ship Steet	Faculty/Staff	125
82	Old Stone Bank/Benoni Cooke House	Faculty/Staff	12
83	3 Davol Square	Faculty/Staff	55
84	121 South Main Street	Faculty/Staff	87
86	2 Stimson Street	Faculty/Staff	4
87	Athletic Center (Swim Center - South Side)	Student	38
88	Brown Stadium, Elmgrove Ave	Other	160
89	Athletic Center (Heating Plant)	Faculty/Staff	33
90	Athletic Center (1 Lloyd Ave)	Faculty/Staff/Student	133
92	133 Waterman Street	Faculty/Staff	3
93	84 Prospect Street	Faculty/Staff	12
94	131 Waterman Street	Faculty/Staff	6
95	Taft Avenue Daycare Center	Faculty/Staff	4
101	Nightingale Brown House (J. N. Brown Center)	Faculty/Staff	8
102	2 Lloyd Ave	Other	14
104	280 Richmond Street	Faculty/Staff	89
	Total Off-Street Parking Spaces		2,566

Source: Brown University September 2005 Parking Lot Inventory. Current use based on Brown University Parking Map May 2005.

Table 2-5
City of Providence Parking Requirements for Brown University

Use	People	Required Ratio[1]	Required Number of Parking Spaces (FY05)
Employees	3,609	1:3	1,203
On-Campus Students	4,825	1:8	603
Off-Campus Students	2,997	1:2	1,499
		Total Spaces Required	3,305
		Current Inventory (See Table 2-4)	2,566
		Surplus/Deficit	-739
		Grandfathered Shortage	931
		Net Surplus/Deficit	+192

Source: Brown University
[1] As required for the use based on City of Providence zoning requirements.

Public Transportation

Brown University is served by the Rhode Island Public Transit Authority (RIPTA) and various safeRIDE shuttle services, as shown in Figure 2-7. Five 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 Intermodal 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 an existing bus tunnel from Thayer Street to South Main Street.

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Bus Service

There are six existing RIPTA bus routes that currently serve the Brown University Campus area:

- Route 35 Rumford
- Route 40 Butler/Elmgrove
- Route 42 Hope Street
- Route 49 Camp Street
- Route 78 Beverage Hill Avenue
- Route 92 Providence Link Trolley Green Line

A brief description of each of the routes is included below.

Route 35 Rumford

Route 35 operates on 50-minute headways during the weekday morning peak hour, and between 35 and 65 minute headways during the weekday evening peak hour period. The route begins in Pawtucket at the Rhode Island State Line near the South

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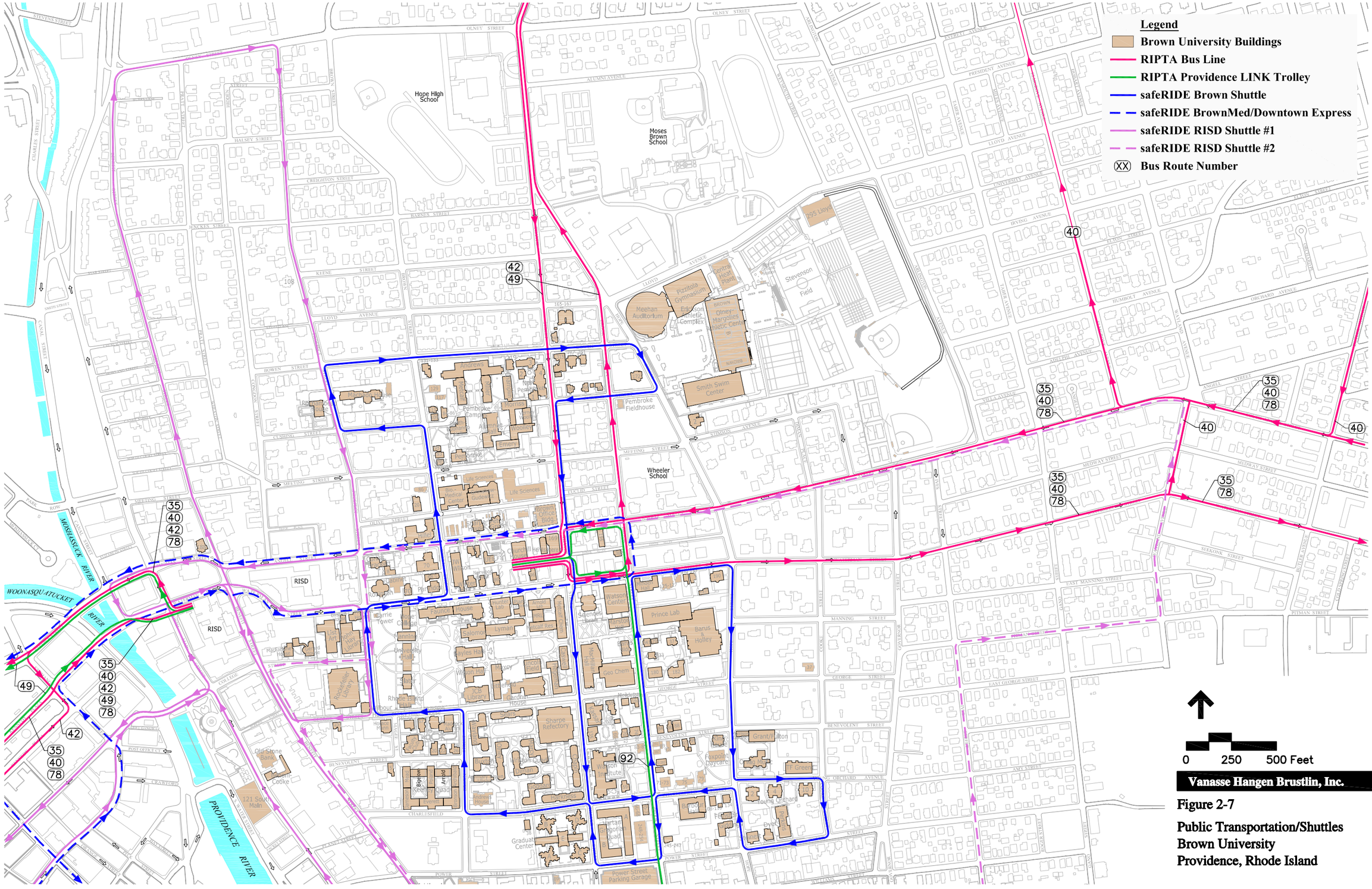

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Figure 2-7

Public Transportation/Shuttles
Brown University
Providence, Rhode Island

Attleboro, Massachusetts MBTA station and runs along Newport Avenue, Wilson Avenue, Roger Williams Avenue, and North Broadway to Taunton Avenue/ Waterman Avenue (Six Corners) in East Providence. From there, the route continues along Waterman Avenue and Massasoit Avenue, over the Henderson Bridge, and along Angell Street to Thayer Street and the bus tunnel through to Kennedy Plaza.

Route 40 Butler/Elmgrove

Route 40 operates on approximately 25-minute headways during the weekday morning and weekday evening peak hour periods. The route runs from Butler Hospital or Elmgrove Avenue and continues along Blackstone Boulevard, Butler Avenue, South Angell Street, and Angell Street to the Thayer Street bus tunnel through to Kennedy Plaza.

Route 42 Hope Street

Route 42 operates on 20-minute headways during the weekday morning and weekday evening peak hour periods. Route 42 is a continuation of Route 77 that begins at the intersection of Thurber Street and Benefit Street in Pawtucket and runs along Benefit Street, Broadway, Main Street and Roosevelt Avenue. Route 42 runs from Main Street in Pawtucket along Roosevelt Avenue, Jenks Way, Pleasant Street, Grace Street, George Street, and East Avenue to Hope Street. From there, the route continues down Hope Street to Thayer Street and the bus tunnel through to Kennedy Plaza. After Kennedy Plaza, the Route continues as Route 1, and provides service to Rhode Island Hospital, and Ann & Hope Outlet in Warwick, Rhode Island. With the continuations to either Route 77 or Route 1, Route 42 provides for one seat rides between Pawtucket, Warwick, or Rhode Island Hospital to Brown University.

Route 49 Camp Street

Route 49 operates on approximately 45-minute headways during the weekday morning and weekday evening peak hour periods. The route runs from Shaw's Plaza in Providence along North Main Street and Rochambeau Avenue to Camp Street. From there, the route continues along Camp Street, Doyle Avenue, and Hope Street to Thayer Street and the bus tunnel through to Kennedy Plaza.

Route 78 Beverage Hill Avenue

Route 78 runs approximately every hour throughout the day. The route begins on Roosevelt Avenue in Pawtucket , and runs along Main Street, School Street or Prospect Street to Beverage Hill Avenue. From there it continues to Newport Avenue and along Ferris Avenue, Bishop Avenue, Newman Avenue, Pawtucket Avenue and Waterman Avenue to Taunton Avenue (Six Corners) in East Providence. From there, the route continues along Waterman Avenue and Massasoit Avenue, over the Henderson Bridge, and along Angell Street to Thayer Street and the bus tunnel through to Kennedy Plaza.

Route 92 Providence LINK Trolley Green Line

Route 92, which is served by the Green Line of the Providence LINK Trolley runs every 20 minutes Monday through Friday from 6:30 AM to 9:00 PM, Saturday from 8:00 AM to 6:30 PM, and Sunday from 11:00 AM to 6:30 PM. The "East Side Route" of the trolley runs from Wickenden Street in the Fox Point section of Providence to Brook Street to the Thayer Street bus tunnel by way of Angell Street and Waterman Street. The route continues to Kennedy Plaza, where connections can be made to other RIPTA bus lines or the trolley Gold Line, which services the Capitol Hill and South Side districts of Providence. The trolley Green Line also provides access from Kennedy Plaza to the Federal Hill area of Providence. The fare for the Providence LINK Trolley is $1.50 per person per ride.

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safeRIDE Shuttle Service

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. There are five existing safeRIDE shuttles that provide service to the Brown University campus:

- BrownMed/Downcity Express
- Brown Shuttle
- RISD Shuttle #1
- RISD Shuttle #2
- safeRIDE onCall

Based on information provided by Brown University, they typically have over 4,000 safeRIDE shuttle rides per week.

safeRIDE BrownMed / Downcity Express

The safeRIDE BrownMed/Downcity Express operates on 15-minute headways between 8:00 PM and 6:00 PM. The shuttle, which provides access from Brown University to Downtown Providence and the Jewelry District/Rhode Island Hospital area of Providence, travels along segments of Waterman Street, Brook Street, Angell Street, Thomas Street, Steeple Street, Exchange Terrace, Dorrance Street, Eddy Street to Rhode Island Hospital, Point Street, Hopin Street, South Street, Hospital Street, Ship Street, Richmond Street, Weybosset Street, Exchange Street, and College Street. There are five shuttle stops for the safeRIDE BrownMed/Downcity Express shuttle within the main campus of Brown University.

safeRIDE Brown Shuttle

The safeRIDE Brown Shuttle operates on 5-minute headways between 7:00 PM and 4:00 AM during Eastern Daylight Time and between 5:00 PM and 3:00 AM during Eastern Standard Time. The shuttle travels throughout the Brown University campus along segments of Charlesfield Street, Brook Street, Power Street, Thayer Street,

Brown Street, George Street, Prospect Street, Waterman Street, Cushing Street, Bowen Street, Hope Street, Young Orchard Street, Cooke Street, and Power Street. The safeRIDE Brown Shuttle stops at thirteen designated locations along the route.

safeRIDE RISD Shuttle #1

The safeRIDE RISD Shuttle #1 operates on 20-minute headways between 5:00 PM and 3:00 AM (7:00 PM to 3:00 AM during Eastern Daylight Time) and 30-minute headways between 3:00 AM and 4:00 AM. The shuttle, which provides access from Brown University and RISD to Downtown Providence, travels along segments of Waterman Street, Prospect Street, George Street, Benefit Street, Olney Street, Angell Street, Steeple Street, Canal Street, South Main Street, Westminster Street, Dorrance Street, Washington Street, Empire Street, and Weybosset Street. There are eight shuttle stops for the safeRIDE RISD Shuttle #1 within close proximity of the Brown University Campus.

safeRIDE RISD Shuttle #2

The safeRIDE RISD Shuttle #2 operates on 15-minute headways between 5:00 PM and 3:00 AM (7:00 PM to 3:00 AM during Eastern Daylight Time) and 30-minute headways between 3:00 AM and 4:00 AM. The shuttle circles around the southern half of the Brown University campus along Benefit Street, Wickenden Street, Ives Street, Pitman Street, Wayland Avenue, Angell Street, Prospect Street, and College Street. There are ten shuttle stops for the safeRIDE RISD Shuttle #2 within close proximity of the Brown University Campus.

safeRIDE onCall

The safeRIDE onCall service provides transportation from a Brown or RISD campus building to a rider's registered off-campus residence within the onCall coverage area, or vice versa. The service is available to all Brown and RISD students, faculty, and staff who live off-campus within the onCall coverage area and who do not live directly on one of the safeRIDE shuttle routes. The onCall service is available between 5:00 PM and 3:00 AM (7:00 PM to 3:00 AM during Eastern Daylight Time) with registration done by telephone. The onCall service area is the area enclosed by Point Street, Wickenden Street, Gano Street, Pitman Street, Butler Avenue, Grotto Avenue, Blackstone Boulevard, Chase Avenue, North Main Street, and Interstate Route 95.

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 September 2005.

■

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 2-8 and 2-9 present the peak hour pedestrian flows during the commuting peak periods.

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 Thayer Street commercial related activity during the morning peak hour period. The highest pedestrian volumes in the area during the morning and evening peak hour periods were observed along Thayer Street and Brown Street, although 150 pedestrians during the morning peak period and 115 pedestrians during the evening peak period crossed Hope Street at Cushing Street in the area of the Brown University Athletic Complex.

During the afternoon peak hour period, over 500 pedestrians crossed Angell Street at Brown Street, and 1,150 pedestrians crossed Angell Street at Thayer Street. During the same period, 450 pedestrians crossed Waterman Street at Brown Street, and 925 pedestrians crossed Waterman Street at Thayer Street. The difference in volume between the two intersections crossing Thayer Street is due in part to the bus tunnel/bus stop located on Thayer Street between Angell Street and Waterman Street.

In the designated crosswalks accessing the Brown University historic central campus area during the weekday evening period, 450 pedestrians crossed Waterman Street, 240 crossed Prospect Street, 515 crossed George Street and 260 crossed Thayer Street.

During the peak periods for the Moses Brown School, 30 pedestrians during the morning and 25 pedestrians during the weekday evening were observed crossing Lloyd Avenue between Hope Street and Arlington Avenue. Of those pedestrians, 15 were students during each time period, and they all crossed Lloyd Avenue at the main entrance to Moses Brown with the help of a crossing guard to access school buses parked on Lloyd Avenue eastbound.

■

Bicycle Activity

Bicycling is a popular mode of travel in Providence's East Side and the Brown University campus. Bicycle usage was observed throughout the campus with the most activity occurring along Thayer Street and Hope Street. Bicycle racks are located at 107 outdoor locations on the Brown University campus with a total rack capacity of over 500 bicycles. Bicycle parking locations around the study area and the primary bicycle routes based on observations and discussions with the City of Providence Department of Planning and Development are shown in Figure 2-10.

71832 PedCrossing.dwg

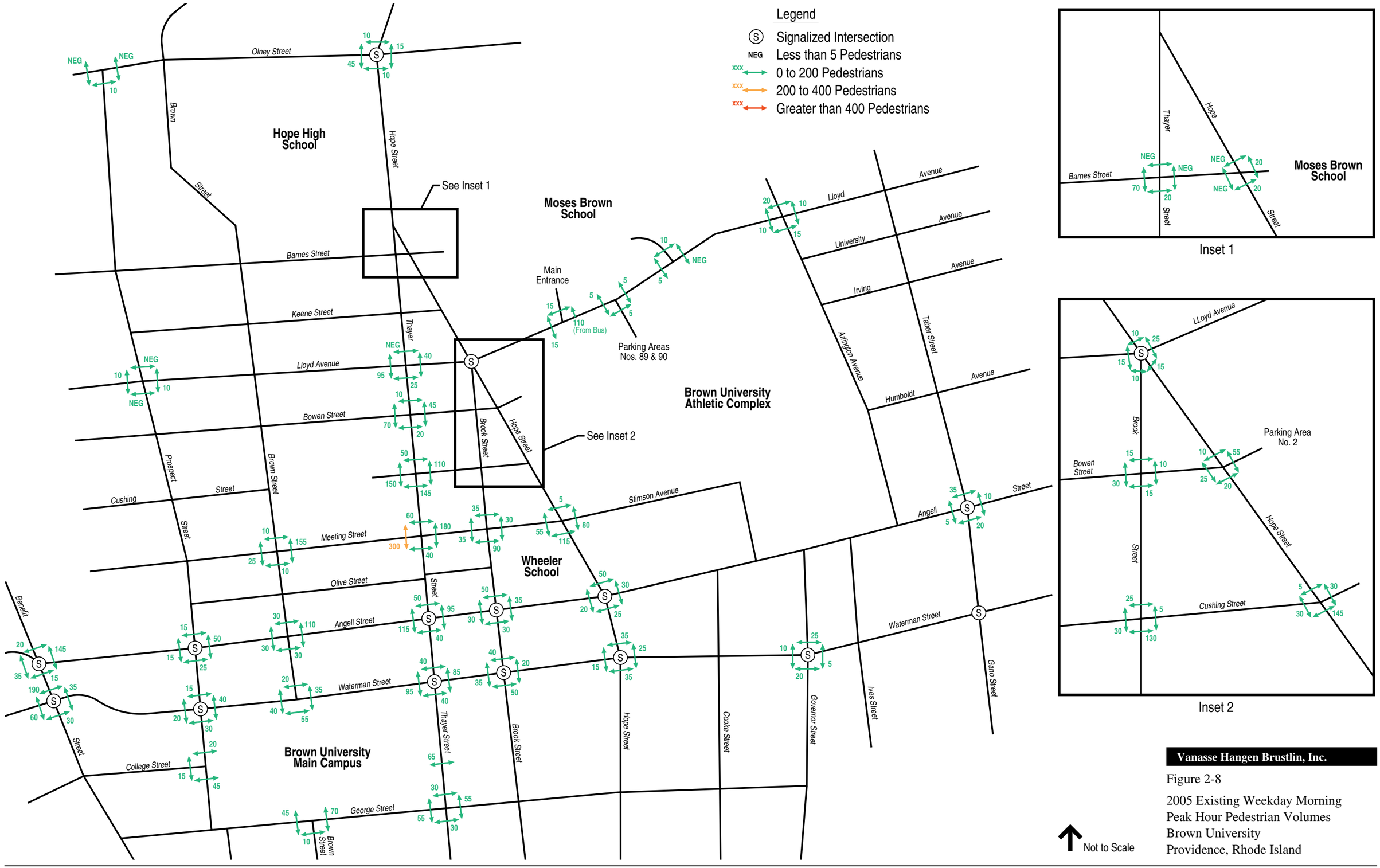

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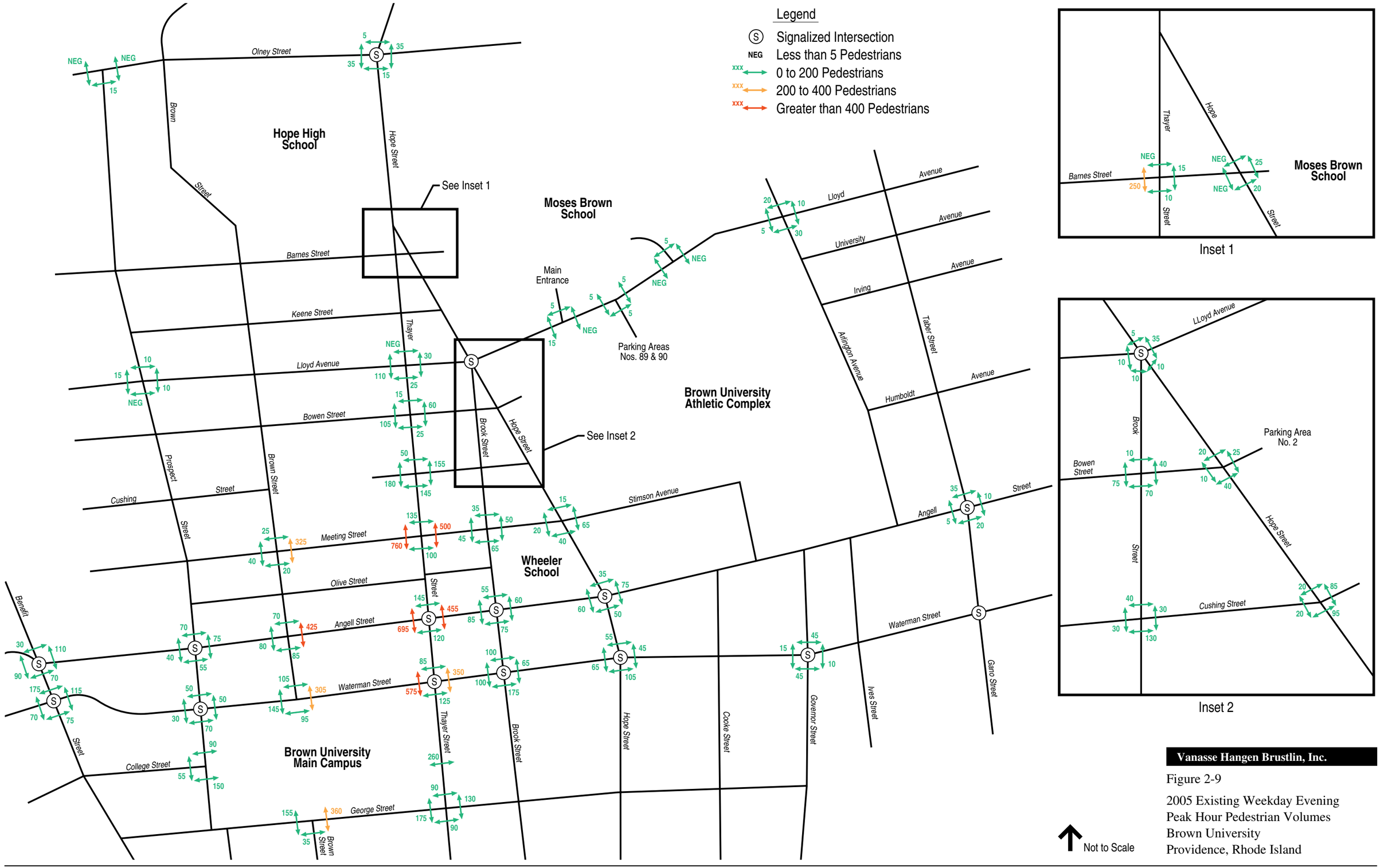
Figure 2-8

2005 Existing Weekday Morning Peak Hour Pedestrian Volumes
Brown University
Providence, Rhode Island

71832 PedCrossing.dwg



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Not to Scale

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Figure 2-9

2005 Existing Weekday Evening Peak Hour Pedestrian Volumes
Brown University
Providence, Rhode Island

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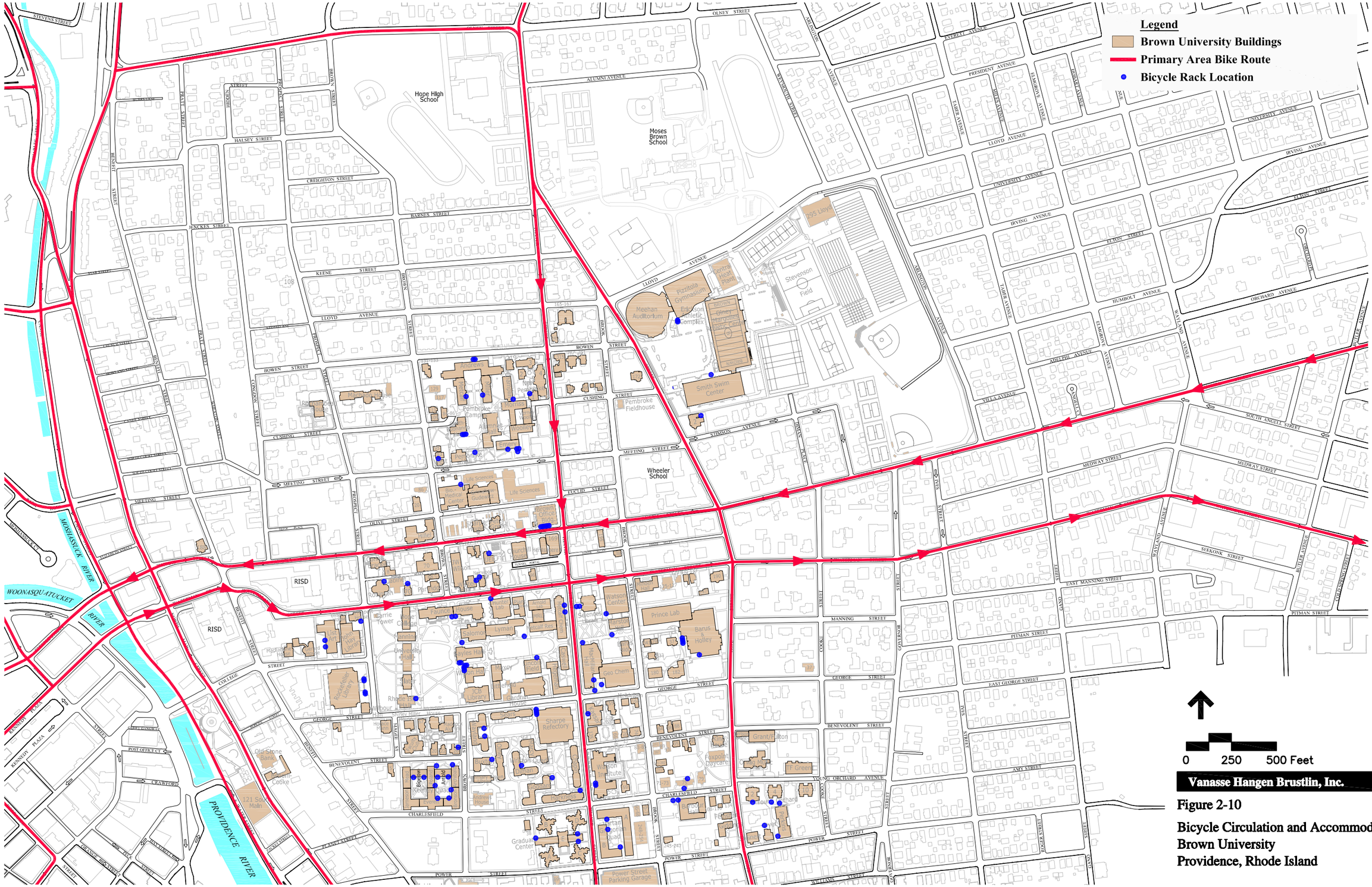

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Figure 2-10

Bicycle Circulation and Accommodations
Brown University
Providence, Rhode Island

Loading, Service, and Emergency Access

According to the Brown University Materials Handling Study by SEA Consultants Inc., there are currently eight major delivery points on the Brown University campus:

- Brown Office Building (via Olive Street)
- Faunce House (via Waterman Avenue)
- Sciences Library/Watson Center (via Waterman Avenue)
- Rockefeller Library (via George Street)
- Sharpe Refectory (via Thayer Street)
- Verney Whoolley (via Thayer Street)
- Prince Lab/Barus & Holley (via Hope Street)
- Facility Services 295 Lloyd Avenue (via Lloyd Avenue)

The locations of the major delivery points are shown in Figure 2-11.

All campus mail is distributed through a centralized facility in the Faunce House, where a U.S. Post Office (Brown Station) is located. 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 Programs

Brown University provides a number of 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 are designed to encourage alternatives to driving and parking at the campus. The following section describes the management program.

RIPTA Pass Program

As described in the Public Transportation section, Brown University is served by four RIPTA bus lines and the Providence LINK trolley in addition to various shuttles. Brown University currently pays 50% of the cost of RIPTA monthly passes or up to two RIPTIK booklets of ten fares per month to those with a valid Brown University identification. Subsidized RIPTA monthly passes or RIPTIKS can be purchase at the brown Bookstore or through the Operations Manager in Development located at 110 Elm Street in the Jewelry District.

j:\71832.00\graphics\figures\71832 deliverypoints.dwg

Legend

- Brown University Buildings
- (1) Brown Office Building
- (2) Faunce House
- (3) Sciences Library/Watson Center
- (4) Rockefeller Library
- (5) Sharpe Refectory
- (6) Verney Whoolley
- (7) Prince Lab/Barus & Holley
- (8) Facility Services (295 Lloyd Ave.)

0 250 500 Feet

Source:
"Brown University Progress Report Meeting Materials Management Plan Tasks 1 and 2 Review Meeting August 19, 2005" Presentation by SEA Consultants, Inc.

Vanasse Hangen Brustlin, Inc.

Figure 2-11

Major Campus Delivery Points
Brown University
Providence, Rhode Island

The RIPTA pass program has resulted in steady increases in ridership. Based on information provided by Brown University, the program has resulted in 3,000 RIPTIK purchases and 1,500 monthly RIPTA pass purchases per year.

■

Guaranteed Ride Home

Brown University has established a Guaranteed Ride Home program in conjunction with RIPTA to encourage the use of carpooling or public transportation to commute to and from the university. Under the program, a guaranteed ride home is provided by a taxi. Brown employee carpools registered with RIPTA express travel may use the RIPTA guaranteed ride home twice a year. Bus riders that live within a 50 mile radius of Brown University and purchased a monthly pass or one book of RIPTIKS through the Brown Bookstore are eligible for the Guaranteed Ride Home program for that month. The origin of the Guaranteed Ride Home must originate from a Brown address, and the ride can be used to handle a personal emergency between 8:00 AM and 4:45 PM. The ride can also be used to travel home after regular work hours if the rider is required to work late, does not live within the safeRIDE onCall area, and the regular RIPTA bus has stopped running.

■

ZipCar

Brown University has started an arrangement with ZipCar in 2005 to allow for students to join for a cost of $30.00 per year plus $8.00 per hour of use, which includes insurance, maintenance, and 25 free miles per rental. Two ZipCar vehicles are available for use 24 hours a day, seven days of the week to Brown University ID holders. Registered members can reserve the vehicles in advance online or by phone. The cars use an electronic key system and a keypad which can be encoded by ZipCar so that no attendant is required for the vehicles and only an approved renter with a reservation can access the vehicles during the time they reserved it for. ZipCar can capture the Brown ID numbers and report them back to the university with the rental length so that usage patterns can be analyzed and the program can be fine tuned if needed. If the demand for the vehicles increases, Brown University will request additional vehicles from ZipCar to further reduce the parking demand on campus. Based on information provided by Brown University, ZipCar usage has been approximately 2,000 hours per month

■

Other Transportation Demand Management Techniques

To further reduce the campus traffic and parking demands, Brown University has implemented additional TDM measures over the past few years including:

- The elimination of sophomore parking (in addition to freshmen)
- The increase in parking rates for students and employees
- The establishment of a visitor parking lot
- Rental agreements with Enterprise Rental to provide students discounted rates

- Incentives for carpooling including reduces rates and priority parking space selection
- The use of off-campus lots for parking construction worker vehicles for all major projects.

3

Future Conditions

Future Analysis Years and Conditions

Transportation conditions on and near Brown University's campus will change in the future. To assess the magnitude of that change, transportation conditions (traffic volumes, pedestrian volumes, number of parking spaces, etc.) were projected to 2010 and analyzed. Because of the uncertainty with longer range plans due to the potential for university expansion into new areas opened up from the relocation of Interstate Route 195, only the 2010 future year condition was analyzed. Two different scenarios are examined:

- **No-Build**. The No-Build scenario analyzes the transportation system serving the Brown University campus without any of the changed proposed in the Brown University Master Plan. 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 Brown campus.
- **Build**. The Build conditions present the building program and related changes to parking associated with Brown's Master Plan. The traffic shifts and new trips associates with the projects contained within the Master Plan are added to the No-Build traffic volumes.

The transportation analyses for each of these conditions are presented in detail in this chapter.

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.

■

Transportation Infrastructure Improvements

Two planned transportation infrastructure improvement projects that will have an impact on the study area roadways were identified based on discussions with the City of Providence Department of Planning & Development and the Rhode Island Department of Transportation. The projects, which are not expected to have a significant impact on the existing Brown University campus and surrounding infrastructure, are described below.

Roadways

Although not in the study area, the RIDOT Relocation of Interstate Route 195 project will have a significant impact on regional traffic flow along the interstate highway system and access to the City of providence. The existing congestion in the area of the Interstate Route 95/Interstate Route 195 split is expected to be reduced with the completion of the project. The reduction in vehicle delays as well as the new access points from I-195/I-95 into the City of Providence will likely result in a reduction in through traffic along Angell Street and Waterman Street. Both of these arterial roadways through the Brown University campus connect East Providence to Downtown Providence and serve as diversion routes from I-195 during periods of peak congestion. The new highway is expected to be open by 2010 with the network of city streets and demolition of the existing highway completed by 2013.

Pedestrian and Bicycle Enhancements

The City of Providence Bicycle Network implementation project will enhance bicycle awareness within the city through signing of multiple on-road bicycle routes. The designated routes will connect Downtown Providence to neighboring cities and towns and connect key access roadways throughout Providence. Within the study area Hope Street, Angell Street, Waterman Street, and Lloyd Avenue east of Hope Street are currently proposed to be signed as bicycle routes as part of the Citywide Bicycle Network. The new signs are expected to be installed by spring 2006.

■

Regional Traffic Growth

2010 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 historical traffic data, between 2000 and 2005 traffic volumes in the area increased by an average of approximately 0.8 percent per year. During the same time period, Brown University faculty, staff, and student levels increased by approximately 0.67 percent per year. To provide for a conservatively high estimate of background growth without

additional Brown University growth, a 0.5 percent per year annual growth rate was applied to develop the 2010 baseline traffic volumes

■

Site Specific Traffic Growth

Through discussions with the City of Providence Department of Planning & Development, three proposed development projects within or adjacent to the study area were identified. These projects are described below. Only the East Side Commons residential project was identified as having an impact on traffic volumes within the study area. Traffic related to the other projects is expected to be included in the general regional traffic background growth rate.

East Side Commons

The East Side Commons (formerly Riverview Plaza) residential development consists of 85 high-end condominium units along Gano Street with a right-turn in driveway on Gano Street and a full access driveway on East George Street. An estimate of the traffic to be generated by the proposed development, which is currently under construction, was based on the "Riverview Place Residential Providence, Rhode Island Traffic Impact Assessment" dated August 5, 2002 prepared by Schoor Depalma. The projected traffic volumes associated the East Side Commons development are included in the 2010 No-Build traffic volumes.

RISD Chace Center

The RISD Chace Center will be located on North Main Street facing downtown Providence. The Chace Center is expected to become a new hub for RISD students to meet, socialize, have a cup of coffee, and review artwork. The project is not expected to have a significant impact on traffic operations within the study area.

The Wheeler School

The Wheeler School is planning renovations at their campus. The extent of the renovations is unknown; however, the project is not expected to have a significant impact on traffic operations within the study area.

■

No-Build Traffic Volumes

The 0.5 percent background growth rate over the five-year planning horizon and the projected traffic volumes for the East Side Commons residential development were added to the 2005 Existing traffic volume networks to create the projected 2010 No-Build traffic volumes. The 2010 No-Build weekday morning and weekday evening peak hour traffic volumes are presented in Figures 3-1, and 3-2, respectively.

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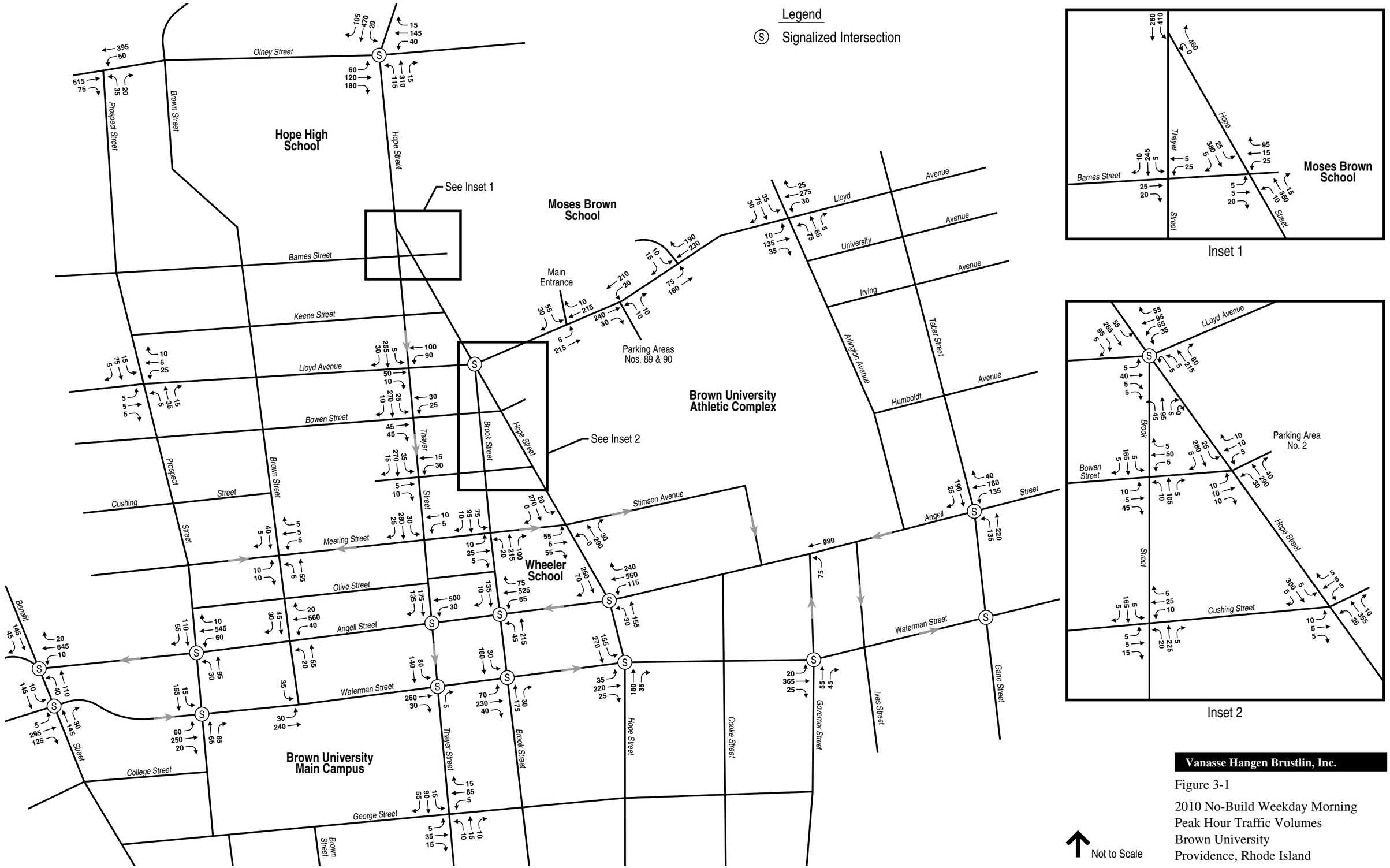

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Vanasse Hangen Brustlin, Inc.

Figure 3-1

2010 No-Build Weekday Morning Peak Hour Traffic Volumes
Brown University
Providence, Rhode Island

Not to Scale

71832 Traffic Volumes.dwg

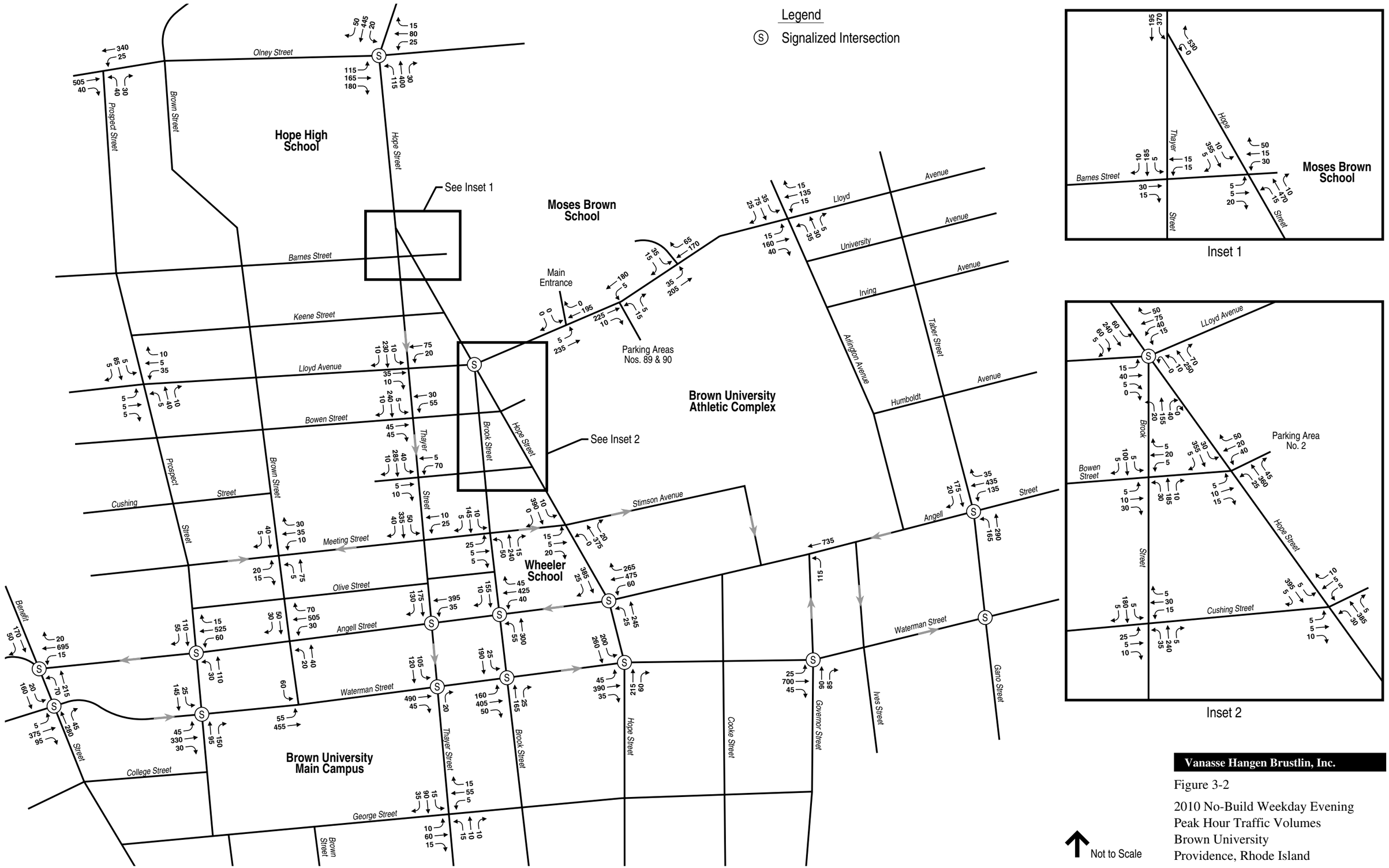

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Figure 3-2

2010 No-Build Weekday Evening Peak Hour Traffic Volumes
Brown University
Providence, Rhode Island

■

No-Build Traffic Analysis

The 2010 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 2005 Existing and 2010 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.

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

		2005 Existing			2010 No-Build		
Location	Peak Hour	V/C[1]	Delay[2]	LOS[3]	V/C	Delay	LOS
Angell Street/ Gano Street	Weekday Morning	0.72	21.8	C	0.76	25.5	C
	Weekday Evening	0.62	17.1	B	0.64	17.6	B
Angell Street/ Hope Street	Weekday Morning	0.79	20.6	C	0.82	22.0	C
	Weekday Evening	0.75	18.7	B	0.77	19.5	B
Angell Street/ Brook Street	Weekday Morning	0.78	30.1	C	0.80	36.6	D
	Weekday Evening	0.68	16.2	B	0.70	16.7	B
Angell Street/ Thayer Street	Weekday Morning	0.71	20.6	C	0.73	21.7	C
	Weekday Evening	0.63	17.1	B	0.65	17.4	B
Angell Street/ Prospect Street	Weekday Morning	0.55	15.6	B	0.57	16.0	B
	Weekday Evening	0.53	15.4	B	0.54	15.8	B
Angell Street/ Benefit Street	Weekday Morning	0.73	69.3	E	0.75	79.2	E
	Weekday Evening	0.84	65.9	E	0.86	73.6	E
Waterman Street/ Benefit Street	Weekday Morning	0.54	44.2	D	0.56	51.3	D
	Weekday Evening	0.63	18.8	B	0.64	19.4	B
Waterman Street/ Prospect Street	Weekday Morning	0.36	17.1	B	0.37	17.3	B
	Weekday Evening	0.43	14.4	B	0.44	14.6	B
Waterman Street/ Thayer Street	Weekday Morning	0.38	14.4	B	0.39	14.8	B
	Weekday Evening	0.62	22.8	C	0.64	23.4	C
Waterman Street/ Brook Street	Weekday Morning	0.43	12.7	B	0.44	13.0	B
	Weekday Evening	0.68	18.9	B	0.70	20.2	C
Waterman Street/ Hope Street	Weekday Morning	0.60	13.2	B	0.61	13.3	B
	Weekday Evening	0.77	17.1	B	0.80	18.3	B
Waterman Street/ Governor Street	Weekday Morning	0.22	9.7	A	0.23	9.7	A
	Weekday Evening	0.38	14.0	B	0.40	14.1	B
Hope Street/ Lloyd Avenue/Brook Street	Weekday Morning	0.73	34.7	C	0.75	37.0	D
	Weekday Evening	0.72	32.4	C	0.74	33.7	C
Hope Street/ Olney Street	Weekday Morning	0.89	41.7	D	0.92	45.3	D
	Weekday Evening	0.91	29.7	C	0.95	34.2	C

Source: Synchro 6 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 on the study area roadways between intersections. These interruptions caused congestion along these roadways during the peak hour periods. As a result, the observed delay times at some intersections exceeded the calculated values.

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

		2005 Existing				2010 No-Build			
Location	Peak Hour	Critical Movement[1]	Demand[2]	Delay[3]	LOS[4]	Critical Movement	Demand	Delay	LOS
Angell Street/	Weekday Morning	NB L	75	14.5	B	NB L	75	14.3	B
Governor Street	Weekday Evening	NB L	110	12.6	B	NB L	115	12.9	B
Angell Street/	Weekday Morning	NB TR	75	46.0	E	NB TR	75	50.2	F
Brown Street	Weekday Evening	NB TR	55	32.0	D	NB TR	60	36.9	E
Waterman Street/	Weekday Morning	SB L	35	11.5	B	SB L	35	11.6	B
Brown Street	Weekday Evening	SB L	55	30.3	D	SB L	60	32.8	D
Lloyd Avenue/	Weekday Morning	WB LTR	325	22.7	C	WB LTR	330	24.7	C
Arlington Avenue	Weekday Evening	EB LTR	210	10.4	B	EB LTR	215	10.6	B
Lloyd Avenue/	Weekday Morning	SB LR	25	17.2	C	SB LR	25	17.5	C
Moses Brown East Drive	Weekday Evening	SB LR	50	14.2	B	SB LR	50	14.4	B
Lloyd Avenue/	Weekday Morning	NB LR	20	13.8	B	NB LR	20	13.9	B
Parking Areas Nos. 89 & 90	Weekday Evening	NB LR	20	13.4	B	NB LR	20	13.7	B
Lloyd Avenue/	Weekday Morning	SB LR	85	20.6	C	SB LR	85	21.4	C
Moses Brown Main Entrance	Weekday Evening	SB LR	1	11.9	B	SB LR	1	12.1	B
Hope Street/	Weekday Morning	EB LTR	115	27.9	D	EB LTR	115	29.0	D
Meeting Street	Weekday Evening	EB LTR	40	17.5	C	EB LTR	40	18.0	C
Hope Street/	Weekday Morning	WB LTR	15	19.2	C	WB LTR	15	19.7	C
Cushing Street	Weekday Evening	WB LTR	20	20.5	C	WB LTR	20	21.1	C
Hope Street/	Weekday Morning	EB LTR	30	18.2	C	EB LTR	30	18.7	C
Bowen Street	Weekday Evening	WB TR	110	31.3	D	WB TR	110	33.9	D
Hope Street/	Weekday Morning	WB LTR	135	26.2	D	WB LTR	135	27.6	D
Barnes Street/Moses Brown	Weekday Evening	WB LTR	95	39.3	E	WB LTR	95	42.8	E
Brook Street/	Weekday Morning	EB LTR	40	26.2	D	EB LTR	40	26.5	D
Meeting Street	Weekday Evening	EB LTR	35	18.1	C	EB LTR	35	18.6	C
Brook Street/	Weekday Morning	WB LTR	40	15.4	B	WB LTR	40	15.7	C
Cushing Street	Weekday Evening	WB LTR	45	18.9	C	WB LTR	50	19.2	C
Brook Street/	Weekday Morning	WB LTR	60	12.9	B	WB LTR	60	13.0	B
Bowen Street	Weekday Evening	WB LTR	30	14.9	B	WB LTR	30	15.0	B
Thayer Street/	Weekday Morning	WB LT	30	13.4	B	WB LT	30	13.5	B
Barnes Street	Weekday Evening	EB TR	40	16.1	C	EB TR	45	16.7	C
Thayer Street/	Weekday Morning	WB LT	185	23.3	C	WB LT	190	24.3	C
Lloyd Avenue	Weekday Evening	WB LT	90	15.3	C	WB LT	95	15.6	C
Thayer Street/	Weekday Morning	WB LT	55	19.0	C	WB LT	55	19.1	C
Bowen Street	Weekday Evening	WB LT	85	21.0	C	WB LT	90	21.7	C
Thayer Street/	Weekday Morning	WB LT	45	23.0	C	WB LT	45	23.5	C
Cushing Street	Weekday Evening	WB LT	75	35.6	E	WB LT	75	36.6	E
Thayer Street/	Weekday Morning	WB LT	15	20.2	C	WB LT	15	20.3	C
Meeting Street	Weekday Evening	WB LT	30	>100	F	WB LT	35	>100	F
Thayer Street/	Weekday Morning	SB LTR	160	8.5	A	SB LTR	160	8.6	A
George Street	Weekday Evening	SB LTR	140	8.3	A	SB LTR	140	8.3	A
Brown Street/	Weekday Morning	NB LTR	60	7.5	A	NB LTR	60	7.5	A
Meeting Street	Weekday Evening	NB LTR	75	7.9	A	NB LTR	80	7.9	A

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

		2005 Existing				2010 No-Build			
Location	Peak Hour	Critical Movement[1]	Demand[2]	Delay[3]	LOS[4]	Critical Movement	Demand	Delay	LOS
Prospect Street/ Olney Street	Weekday Morning	NB LR	55	24.6	C	NB LR	55	25.6	D
	Weekday Evening	NB LR	70	21.5	C	NB LR	70	22.4	C
Prospect Street/ Lloyd Avenue	Weekday Morning	SB LTR	90	7.7	A	SB LTR	95	7.7	A
	Weekday Evening	SB LTR	95	7.8	A	SB LTR	95	7.8	A

Source: Synchro 6 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 on the study area roadways between intersections. These interruptions caused congestion along these roadways during the peak hour periods. As a result, the observed delay times at some intersections exceeded the calculated values.

■

No-Build Parking, Pedestrian, Bicycle, and Transit Conditions

No significant changes are associated with the parking, pedestrian, bicycle, and transit conditions within or adjacent to the campus in the No-Build conditions. How the various modes of transportation will be affected by the proposed Master Plan projects is described in later sections of this chapter. Without the Master Plan projects, the No-Build conditions for each of these modes will be similar to those under Existing conditions.

Build Conditions

The Build Conditions represent a future condition that includes the development associated with the Brown University Master Plan. Because of the uncertainty with longer range plans due to the potential for university expansion into new areas opened up from the relocation of Interstate Route 195, only the 2010 Build scenario is investigated. The building program contained within the Brown University Master Plan is summarized below.

■

Master Plan Development Program

The Brown University Master Plan development program is described in detail within the Institutional Master Plan. The projects and programs listed in the Institutional Master Plan over the next 5-10 years include 1.5 miles of improved public streetscapes, significant campus utilities renewal, adaptive reuse of over 250,000 square feet of historic campus buildings, and the construction of over 125,000 square feet of new buildings.

2010 Building Program

By the year 2010, the University plans to construct the following projects:

- **Sidney E. Frank Hall** is planned as a new 4-story building approximately 45,000 square feet located adjacent to the Brown Office Building on the block between Olive Street and Angell Street. This new academic building will provide public function spaces including a large auditorium and classrooms on the ground floor and the Department of Cognitive and Linguistic Sciences and the administrative offices of the Brain Science Program will be housed on the upper floors.
- **The Walk** is a new network of green space and pedestrian paths that will provide connections from Lincoln Field in the central campus to the Life Sciences Building and the Pembroke Campus. As part of The Walk, improvements are proposed at pedestrian crossings of Meeting Street, Olive Street, Angell Street, and Waterman Street. The improvements will be designed to encourage and direct pedestrian movements to the crossings, and increase the visibility of the pedestrian crossings. As part of the plan, it is proposed that Olive Street between Brown Street and Thayer Street, which is currently closed for the construction of the Life Sciences Building, be abandoned and permanently closed as a public thoroughfare. Under the plan, Olive Street would become a service road for loading purposes to the Brown Office Building and other existing buildings along Olive Street, the Life Science Building, and the new Sidney E. Frank Hall.
- A **Creative Arts Center** is planned as a new building approximately 30,000 square feet along Waterman Avenue west of The Walk. The building will house spaces that will serve as multidisciplinary space for the areas, including studis, galleries, and a café.
- **Jonathan Nelson Fitness Center** is proposed east of Hope Street in a portion of existing Brown University parking lot #2. The Fitness Center will contain approximately 50,000 square feet of basketball courts, classrooms, offices, weight areas, fitness rooms, locker rooms, and a juice bar. The project will include a new landscaped green that will connect the entrances to all of the facilities in the Complex – Meehan Auditorium, Pizzitola Gymnasium, and Swim Center.

In addition to the projects listed above, the University is also planning a Utility Systems Renewal and Upgrade project to upgrade existing utilities from the Central Heat Plan to various points throughout the campus.

■

Trip Generation and Mode Split

Trip generation projections reflecting the proposed Master Plan development program have been developed based on projected changes in student enrollment and the number of employees at the university. They were not based on the application of trip generation rates to the building square footage. Over the planning horizon for the Master Plan, only minor changes in enrollment and staffing are expected at Brown University. Trip generation projections for the future 2010 scenario were combined with changes in distribution due to proposed projects. The specific

methodology used to project future trip generation for Brown University's campus is described below.

Student Enrollment, Faculty, and Staffing Levels

Total student enrollment (graduate and undergraduate) at Brown University in 2005 is approximately 7,800. During the five-year planning horizon, no significant change is anticipated in the number of undergraduate students at Brown, and the number of graduate students is expected to increase by a total of 150 students. During the same five-year period, the number of faculty is projected to increase by approximately 40, and the number of staff is projected to increase by between 80 and 100. The projected increases in faculty, staff, and graduate students at Brown University result in a total growth rate of approximately 2.5 percent over the five-year period, or an average of 0.5 percent per year. To provide for a conservatively high estimate of Brown University growth, a 0.5 percent per year annual growth rate was applied to all of the movements at the study area intersections to develop the 2010 baseline Build traffic volumes

Traffic Shifts Due to Reassignment of Parking

The proposed building program contained within the Master Plan does not have a significant impact on the vehicle trip generation characteristics of the University. The building program does, however, reduce the number of parking spaces on campus. Some existing student parking spaces will be reassigned to faculty/staff and some existing student parking will be relocated to locations off of the main campus. This will result in the redistribution of traffic within the campus transportation network, as faculty/staff vehicle trips have different characteristics from student vehicle trips.

The building program for the Jonathan Nelson Fitness Center will likely result in a loss of 260 faculty/staff parking spaces that currently exist in Brown parking lot #2. In addition, the construction of the Sidney E. Frank Hall, The Walk, and the Creative Arts Center will result in a loss of 136 faculty/staff parking spaces from various existing parking lots between Olive Street and Waterman Street. Many of the faculty/staff trips associated with these parking areas will be moved to the Power Street Parking Garage, where the existing student parking will be moved off of the main campus area.

Impact Analysis

The proposed development program presented in the Institutional Master Plan will have limited impacts on the transportation system serving Brown University. The specific impacts associated with different modes of accessing the campus are described in the following sections.

■

Automobile/Pedestrian

This section describes the impact of the Master Plan projects on traffic operations at key locations and on the campus parking supply.

Vehicular and Pedestrian Traffic

Automobile traffic to and from the campus will be impacted in two different ways. First, the Plan for Academic Enrichment, which will result in minor increases in faculty, staff, and graduate students, will result in more vehicles arriving to the campus. Second, the reassignment of existing parking areas and the increase in leased parking spaces off-campus will result in altered travel paths at some intersections near the campus.

The more significant change to the campus transportation network will be the increase in pedestrian activity related to the opening of the Life Sciences Building currently under construction, the development of The Walk, and the construction of the Sidney E. Frank Hall, the Creative Arts Center, and the Jonathan Nelson Fitness Center.

The impact of these factors on traffic operations are described in detail below.

Build Condition Traffic Volumes

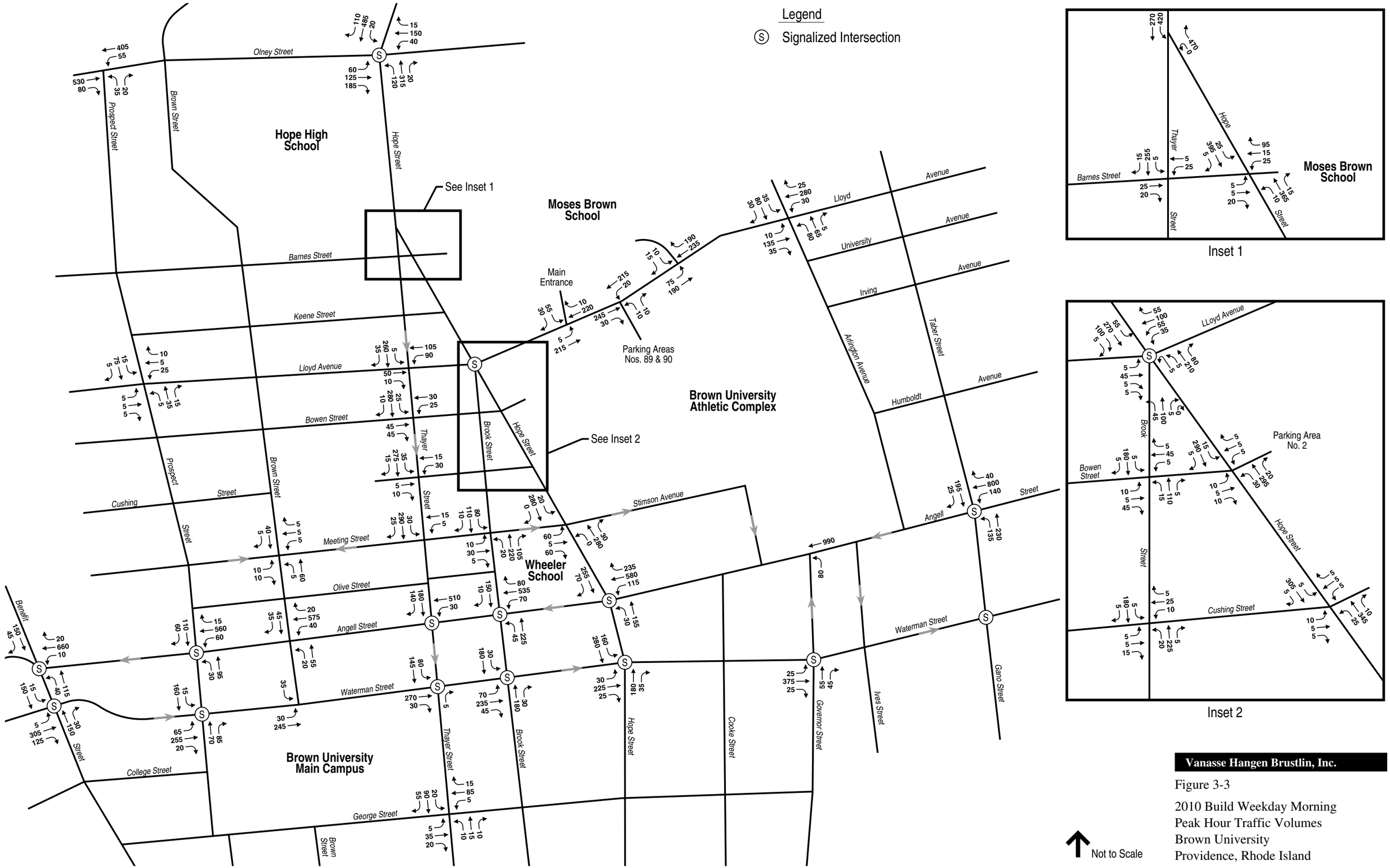
The trip generation estimates for the University for 2010 were applied to the roadway network based on the existing distribution of trips described in Chapter 2 and the traffic shifts due to the building program and shifts in parking. The changes are generally minor. The 2010 Build weekday morning and weekday evening peak hour traffic volumes are presented in Figures 3-3, and 3-4, respectively.

Build Condition Pedestrian Volumes

The opening of the Life Sciences Building currently under construction, the development of The Walk, and the construction of the Sidney E. Frank Hall and the Creative Arts Center will result in an increase in pedestrian activity in The Walk area between the Central Campus and the Pembroke Campus. Many Brown University pedestrians that currently walk along Brown Street or Thayer Street are expected to use The Walk as they travel between campus locations. For analyses purposes, it was assumed that the pedestrian activity in the area would increase by as much as 25 percent compared with existing conditions

The proposed Jonathan Nelson Fitness Center is expected to become a draw on campus and will result in an increase in pedestrian traffic to the Brown University Athletic Complex area from points throughout the campus. Cushing Street will serve as the major pedestrian connection from The Walk and the Pembroke Campus to the proposed fitness center.

71832 Traffic Volumes.dwg

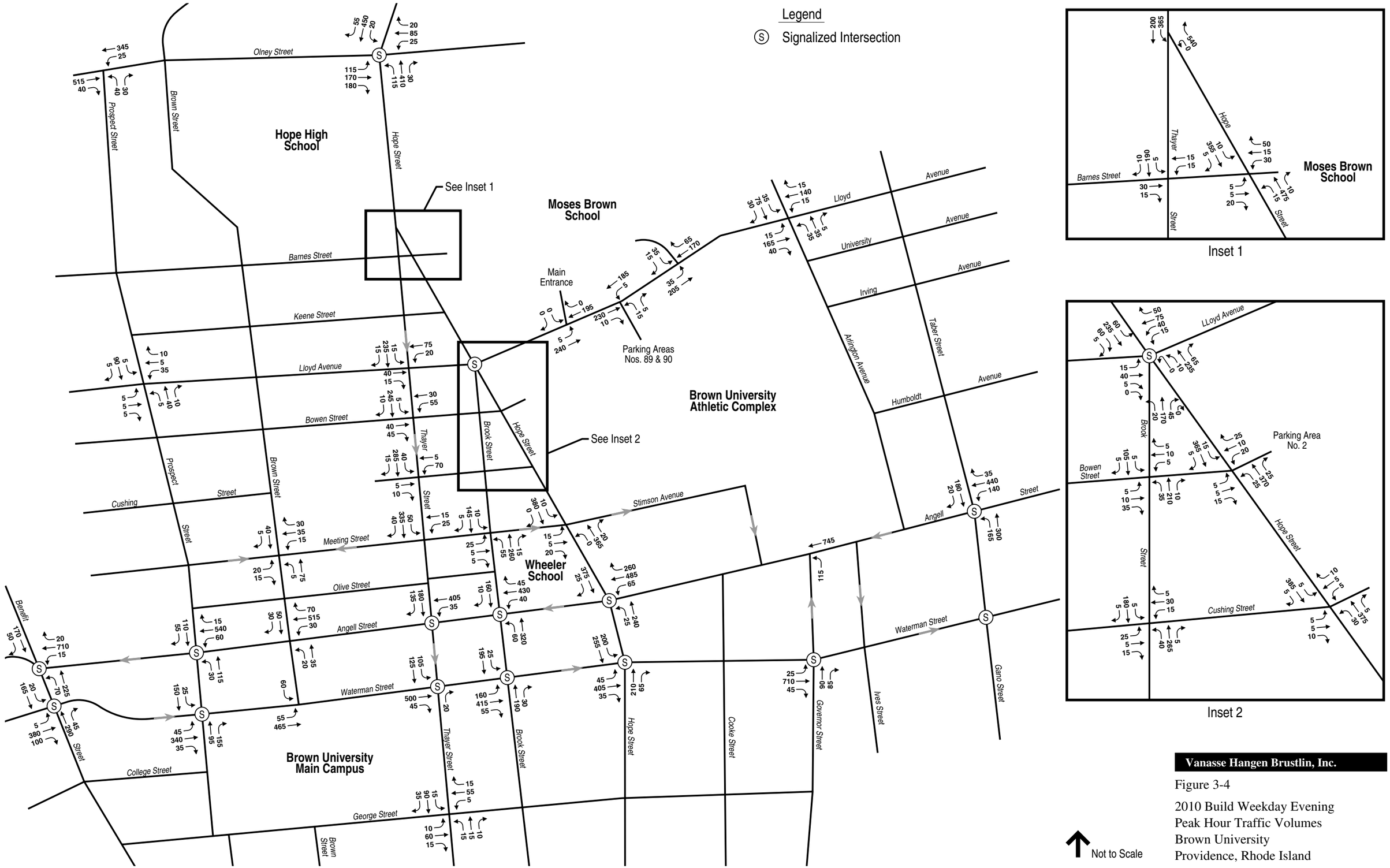


Vanasse Hangen Brustlin, Inc.

Figure 3-3

2010 Build Weekday Morning Peak Hour Traffic Volumes
Brown University
Providence, Rhode Island

71832 Traffic Volumes.dwg



Inset 1

Inset 2

Vanasse Hangen Brustlin, Inc.

Figure 3-4

2010 Build Weekday Evening Peak Hour Traffic Volumes
Brown University
Providence, Rhode Island

The projected number of person-trips to the proposed Jonathan Nelson Fitness Center was calculated based on the Institute of Transportation Engineers (ITE) Trip Generation Manual.[1] ITE Trip rates for land use code 492 (Health/Fitness Club) were applied to the proposed building to estimate the number of person trips projected to be generated during the weekday morning and weekday evening peak hour periods. To provide for a conservative estimate in the number of pedestrian trips to the proposed fitness center, the ITE data was increased by 25 percent to reflect higher than average usage expected at Brown University. A summary of the projected people trips generated by the proposed Jonathan Nelson Fitness Center is presented in Table 3-3.

Table 3-3
Jonathan Nelson Fitness Center Person-Trip Generation Summary

Peak Period	Movement	ITE Generated Vehicle Trips[1]	ITE Based Person-Trips[2]	Adjusted Person-Trips[3]
Weekday Morning	Enter	25	30	40
	Exit	35	42	50
	Total	60	72	90
Weekday Evening	Enter	105	125	155
	Exit	100	120	150
	Total	205	245	305

Source: Trip Generation, Seventh Edition, Institute of Transportation Engineers; Washington, D.C. (2003). Compiled by VHB.

1 Based on ITE Land Use Code (LUC) 492 (Health/Fitness Club)

2 Assumed average occupancy rate of 1.2 people per vehicle

3 ITE projections increased by 25% for University

As shown, the Jonathan Nelson Fitness Center is expected to generate between 100 and 300 new people trips during the weekday morning and weekday evening peak hour periods for the adjacent roadway network.

The projected increase in pedestrian activity related to the opening of the Life Sciences Building, the development of The Walk, and the construction of the Sidney E. Frank Hall, the Creative Arts Center, and the Jonathan Nelson Fitness Center was added to the 2005 Existing pedestrian traffic volumes at the study area intersections to create the 2010 Build pedestrian volumes. The 2010 Build weekday morning and weekday evening pedestrian volumes are presented in Figures 3-5, and 3-6, respectively.

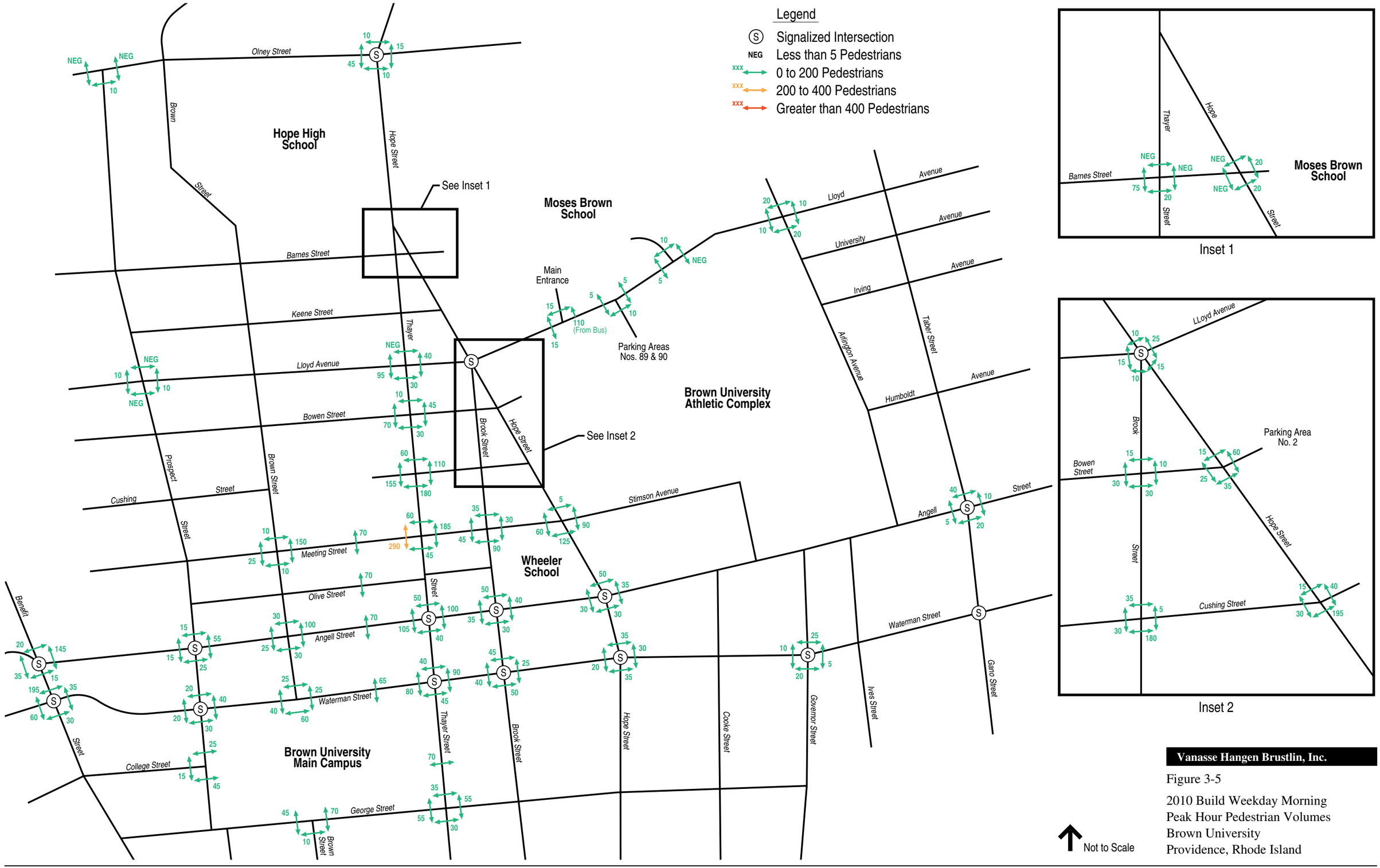
Build Condition Traffic Analysis

The 2005 Build conditions traffic volumes were analyzed at all of the study area intersections. The results of this analysis are summarized in Tables 3-4 and 3-5.

The Master Plan building program results in few minor changes in level of service. The intersections which show degradations in the calculated levels of service are those that are near threshold values or near capacity under No-Build traffic volumes.

[1] Trip Generation, Seventh Edition; Institute of Transportation Engineers; Washington, D.C. (2003).

71832 PedCrossing.dwg



Inset 1

Inset 2

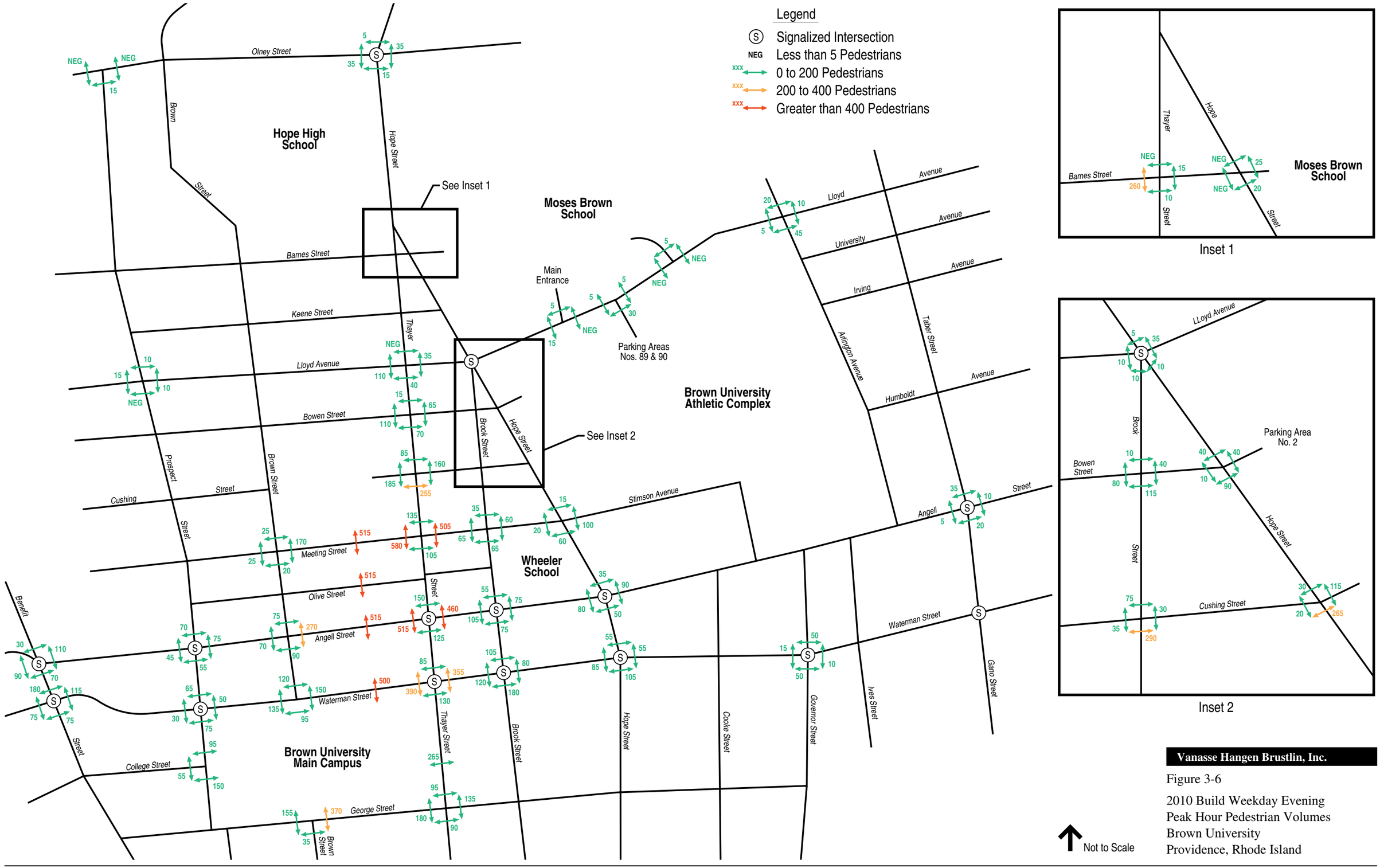
Not to Scale

Vanasse Hangen Brustlin, Inc.

Figure 3-5

2010 Build Weekday Morning Peak Hour Pedestrian Volumes
Brown University
Providence, Rhode Island

71832 PedCrossing.dwg



Vanasse Hangen Brustlin, Inc.

Figure 3-6

2010 Build Weekday Evening Peak Hour Pedestrian Volumes
Brown University
Providence, Rhode Island

Table 3-4
Build Signalized Intersection Capacity Analysis Summary

		2010 No-Build			2010 Build		
Location	Peak Hour	V/C[1]	Delay[2]	LOS[3]	V/C	Delay	LOS
Angell Street/ Gano Street	Weekday Morning	0.76	25.5	C	0.79	27.5	C
	Weekday Evening	0.64	17.6	B	0.65	17.8	B
Angell Street/ Hope Street	Weekday Morning	0.82	22.0	C	0.84	23.6	C
	Weekday Evening	0.77	19.5	B	0.78	20.1	C
Angell Street/ Brook Street	Weekday Morning	0.80	36.6	D	0.83	42.6	D
	Weekday Evening	0.70	16.7	B	0.70	16.7	B
Angell Street/ Thayer Street	Weekday Morning	0.73	21.7	C	0.74	22.8	C
	Weekday Evening	0.65	17.4	B	0.66	17.7	B
Angell Street/ Prospect Street	Weekday Morning	0.57	16.0	B	0.59	16.6	B
	Weekday Evening	0.54	15.8	B	0.56	16.1	B
Angell Street/ Benefit Street	Weekday Morning	0.75	79.2	E	0.77	86.2	F
	Weekday Evening	0.86	73.6	E	0.88	79.5	E
Waterman Street/ Benefit Street	Weekday Morning	0.56	51.3	D	0.57	56.4	E
	Weekday Evening	0.64	19.4	B	0.66	19.9	B
Waterman Street/ Prospect Street	Weekday Morning	0.37	17.3	B	0.38	17.3	B
	Weekday Evening	0.44	14.6	B	0.46	15.0	B
Waterman Street/ Thayer Street	Weekday Morning	0.39	14.8	B	0.40	15.1	B
	Weekday Evening	0.64	23.4	C	0.65	18.2	B
Waterman Street/ Brook Street	Weekday Morning	0.44	13.0	B	0.47	13.4	B
	Weekday Evening	0.70	20.2	C	0.72	21.7	C
Waterman Street/ Hope Street	Weekday Morning	0.61	13.3	B	0.63	13.9	B
	Weekday Evening	0.80	18.3	B	0.82	19.1	B
Waterman Street/ Governor Street	Weekday Morning	0.23	9.7	A	0.23	9.7	A
	Weekday Evening	0.40	14.1	B	0.40	14.2	B
Hope Street/ Lloyd Avenue/Brook Street	Weekday Morning	0.75	37.0	D	0.76	38.6	D
	Weekday Evening	0.74	33.7	C	0.75	33.0	C
Hope Street/ Olney Street	Weekday Morning	0.92	45.3	D	0.97	56.5	E
	Weekday Evening	0.95	34.2	C	0.97	36.7	D

Source: Synchro 6 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 on the study area roadways between intersections. These interruptions caused congestion along these roadways during the peak hour periods. As a result, the observed delay times at some intersections exceeded the calculated values.

Table 3-5
Build Unsignalized Intersection Capacity Analysis Summary

		2010 No-Build				2010 Build			
Location	Peak Hour	Critical Movement[1]	Demand[2]	Delay[3]	LOS[4]	Critical Movement	Demand	Delay	LOS
Angell Street/	Weekday Morning	NB L	75	14.3	B	NB L	80	14.5	B
Governor Street	Weekday Evening	NB L	115	12.9	B	NB L	115	13.0	B
Angell Street/	Weekday Morning	NB TR	75	50.2	F	NB TR	75	57.7	F
Brown Street	Weekday Evening	NB TR	60	36.9	E	NB TR	60	32.4	D
Waterman Street/	Weekday Morning	SB L	35	11.6	B	SB L	35	11.6	B
Brown Street	Weekday Evening	SB L	60	32.8	D	SB L	60	26.3	D
Lloyd Avenue/	Weekday Morning	WB LTR	330	24.7	C	WB LTR	335	26.6	D
Arlington Avenue	Weekday Evening	EB LTR	215	10.6	B	EB LTR	220	10.8	B
Lloyd Avenue/	Weekday Morning	SB LR	25	17.5	C	SB LR	25	17.7	C
Moses Brown East Drive	Weekday Evening	SB LR	50	14.4	B	SB LR	50	14.4	B
Lloyd Avenue/	Weekday Morning	NB LR	20	13.9	B	NB LR	20	14.2	B
Parking Areas Nos. 89 & 90	Weekday Evening	NB LR	20	13.7	B	NB LR	20	14.3	B
Lloyd Avenue/	Weekday Morning	SB LR	85	21.4	C	SB LR	85	21.7	C
Moses Brown Main Entrance	Weekday Evening	SB LR	1	12.1	B	SB LR	1	12.1	B
Hope Street/	Weekday Morning	EB LTR	115	29.0	D	EB LTR	125	33.4	D
Meeting Street	Weekday Evening	EB LTR	40	18.0	C	EB LTR	40	17.8	C
Hope Street/	Weekday Morning	WB LTR	15	19.7	C	WB LTR	15	21.3	C
Cushing Street	Weekday Evening	WB LTR	20	21.1	C	WB LTR	20	31.2	D
Hope Street/	Weekday Morning	EB LTR	30	18.7	C	EB LTR	15	17.9	C
Bowen Street	Weekday Evening	WB TR	110	33.9	D	WB TR	55	25.2	D
Hope Street/	Weekday Morning	WB LTR	135	27.6	D	WB LTR	135	28.8	D
Barnes Street/Moses Brown	Weekday Evening	WB LTR	95	42.8	E	WB LTR	95	43.7	E
Brook Street/	Weekday Morning	EB LTR	40	26.5	D	EB LTR	45	32.2	D
Meeting Street	Weekday Evening	EB LTR	35	18.6	C	EB LTR	35	21.1	C
Brook Street/	Weekday Morning	WB LTR	40	15.7	C	WB LTR	40	16.5	C
Cushing Street	Weekday Evening	WB LTR	50	19.2	C	WB LTR	50	25.8	D
Brook Street/	Weekday Morning	WB LTR	60	13.0	B	WB LTR	55	13.3	B
Bowen Street	Weekday Evening	WB LTR	30	15.0	B	WB LTR	20	15.9	C
Thayer Street/	Weekday Morning	WB LT	30	13.5	B	WB LT	30	13.8	B
Barnes Street	Weekday Evening	EB TR	45	16.7	C	EB TR	45	17.2	C
Thayer Street/	Weekday Morning	WB LT	190	24.3	C	WB LT	196	25.7	D
Lloyd Avenue	Weekday Evening	WB LT	95	15.6	C	WB LT	95	16.5	C
Thayer Street/	Weekday Morning	WB LT	55	19.1	C	WB LT	55	19.7	C
Bowen Street	Weekday Evening	WB LT	90	21.7	C	WB LT	85	23.7	C
Thayer Street/	Weekday Morning	WB LT	45	23.5	C	WB LT	45	24.9	C
Cushing Street	Weekday Evening	WB LT	75	36.6	E	WB LT	75	50.8	F
Thayer Street/	Weekday Morning	WB LT	15	20.3	C	WB LT	20	21.4	C
Meeting Street	Weekday Evening	WB LT	35	>100	F	WB LT	40	>100	F
Thayer Street/	Weekday Morning	SB LTR	160	8.6	A	SB LTR	165	8.7	A
George Street	Weekday Evening	SB LTR	140	8.3	A	SB LTR	140	8.3	A
Brown Street/	Weekday Morning	NB LTR	60	7.5	A	NB LTR	65	7.5	A
Meeting Street	Weekday Evening	NB LTR	80	7.9	A	NB LTR	80	7.9	A

Table 3-5 (Continued)
Build Unsignalized Intersection Capacity Analysis Summary

		2010 No-Build				2010 Build			
Location	Peak Hour	Critical Movement[1]	Demand[2]	Delay[3]	LOS[4]	Critical Movement	Demand	Delay	LOS
Prospect Street/ Olney Street	Weekday Morning	NB LR	55	25.6	D	NB LR	55	27.4	D
	Weekday Evening	NB LR	70	22.4	C	NB LR	70	22.9	C
Prospect Street/ Lloyd Avenue	Weekday Morning	SB LTR	95	7.7	A	SB LTR	95	7.7	A
	Weekday Evening	SB LTR	95	7.8	A	SB LTR	100	7.8	A

Source: Synchro 6 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 on the study area roadways between intersections. These interruptions caused congestion along these roadways during the peak hour periods. As a result, the observed delay times at some intersections exceeded the calculated values.

As indicated in Chapter 2 – Existing Conditions, 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.

Due to the fact that the capacity analysis does not totally take into account disruptions to traffic flow between intersections, 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 and future conditions.

As shown in Table 3-4, the results of the 2010 Build condition capacity analyses indicate that all of the signalized intersections within the study area, with the exception of the intersections of Angell Street at Benefit Street, Waterman Street at Benefit Street, and Hope Street at Olney Street, are projected to continue to operate at acceptable calculated levels of service (LOS) D or better during the weekday morning and weekday evening peak hour periods. However, without any modifications to the existing traffic signals, approaches along some of the intersections will continue to experience lengthy queues and long delays due to poor traffic signal timings at closely spaced intersections and additional disruptions to traffic flow discussed previously.

Under 2010 Build conditions, the calculated levels of service at the intersections of Angell Street at Benefit Street and Waterman Street at Benefit Street are projected to degrade to LOS F and LOS E, respectively during the weekday morning peak hour period. The intersection of Hope Street at Olney Street is projected to degrade from LOS D to LOS E during the weekday morning peak hour and LOS C to LOS D during the weekday evening peak hour period. The deficient calculated levels of service are due to poor traffic signal timings, and the lack of coordination between the two locations on Benefit Street.

The only notable changes in LOS between No-Build and Build conditions at the unsignalized intersections are at the three intersections along Cushing Street between Brook Street and Hope Street. All three of the intersections are projected to degrade by one level of service during the weekday evening peak hour period due to the projected increase in pedestrian traffic. The remaining unsignalized intersections which show degradations in the calculated levels of service are those that are near threshold values under No-Build traffic volumes.

Olive Street Abandonment

Under the proposed plan for The Walk, Olive Street, which had been closed for the construction of the Life Sciences Building, will become a service road for loading purposes with a midblock pedestrian connection along The Walk between the Life Sciences Building and the Sidney E. Frank Hall. The abandoned Olive Street will provide service access to existing buildings along Olive Street including the Brown University Office Building and the Life Sciences Building, as well as the Sidney E. Frank Hall. In addition, the closure of Olive Street will eliminate the pedestrian/ vehicle conflicts associated with the existing loading operations along the roadway as identified in the preliminary findings of the SEA Consultants Inc. Materials Handling Study.

Olive Street, which has a curb-to-curb width of 22 feet, is the narrowest roadway within the study focus area on the northern portion of the Brown University Campus. In addition, it is the only east-west roadway in the northern sector of the Brown campus that does not provide for a connection for vehicles or pedestrians all the way from Prospect Street to Hope Street. Olive Street only runs from Prospect Street to Thayer Street. The only other east-west roadway in the area that does not provide for a vehicular connection between Prospect Street and Hope Street is Cushing Street, which does connect to pedestrian walkways through the Pembroke Campus.

Due to the limited roadway width and lack of through connections to the city street network, and due to the existing pedestrian/vehicle conflicts along Olive Street during loading and service operations, the proposed abandonment and permanent closure of Olive Street will not have a negative impact on traffic conditions around the Brown University campus.

Parking

The projects included in the Brown University Master Plan will result in a total loss of 396 off-street parking spaces. The vehicles displaced by the construction projects will be reassigned into various parking lots under Brown control. As discussed in Chapter 2 – Existing Conditions, Brown University currently has a surplus of 192 parking spaces based on the City of Providence zoning requirements. Many of the faculty/staff trips associated with the impacted parking areas will be moved to the Power Street Parking Garage, where the existing student parking will be moved off of the main campus area.

Based on the City of Providence zoning requirements, the projected growth in faculty/staff and commuting graduate students at Brown University would require as many as 121 additional parking spaces on campus. To accommodate the projected growth, Brown University plans to lease additional parking spaces in an area off of College Hill to meet the City of Providence requirements for parking.

■

Public Transportation

The number of public transportation trips to the Brown University College Hill campus is expected to increase in future years as the subsidized RIPTA pass program continues to grow and additional University growth occurs away from College Hill. The creation of additional parking areas off-campus is also expected to increase ridership on the various University shuttles.

■

Loading and Service

Brown University plans to move forward with a new materials handling plan, which is the outcome of the Materials Handling Study by SEA Consultants Inc. The proposed plan is to move away from sidewalk based pick-ups and deliveries to a more consolidated strategy. The plan is intended to reduce the visibility of trash and materials coming into the University and reduce the truck traffic associated with transport of these materials. By consolidating these activities to specific loading docks at the BioMed Center, the Life Sciences Building, a shared dock at Sidney E. Frank Hall and the Brown Office Building, and the Creative Arts Center, the University will be able to more efficiently manage the truck traffic and the flow of these materials. Olive Street and Fones Alley west of the Bus Tunnel would remain passable for fire trucks, other emergency vehicles, and occasional large delivery trucks, but would be designed as predominantly pedestrian spaces.

4

Improvement Measures

Brown University recognizes that it is a significant generator of transportation activity in terms of vehicle traffic and pedestrian activity with the East Side of the City of Providence. Although the development associated with the Master Plan does not generate significant transportation demand, the University has developed a transportation improvement program. This improvement program addresses the specific impacts of the Master Plan development program, improves the University's management of its transportation facilities, and strives to reduce its impact on the operation of the transportation system serving the campus. The improvement measures are described in detail in this chapter.

Transportation Demand Management Program

Brown University provides several transportation demand management (TDM) programs and strategies to its employees and students. Several of these programs were outlined in Chapter 2, Existing Conditions. All of the existing TDM measures have shown steady increases in participation, indicating that each is having a positive effect on traffic and parking demand. The existing activities of the University are listed below for review. The University's new TDM initiatives are presented following this review.

Current TDM Programs

The University's TDM programs are designed to reduce traffic impacts by encouraging alternatives to driving and parking at the campus. Brown University currently provides several TDM services to its faculty, staff, and students including the following:

- **On-Site Sale of Subsidized RIPTA passes.** Brown University currently pays 50% of the cost of RIPTA monthly passes or up to two RIPTIK booklets of ten fares per month to those with a valid Brown University identification. Subsidized RIPTA monthly passes or RIPTIKS can be purchase at the brown Bookstore or through the Operations Manager in Development located at 110 Elm Street in the Jewelry District.
- **Guaranteed Ride Home.** Brown University has established a Guaranteed Ride Home program in conjunction with RIPTA to encourage the use of carpooling or

public transportation to commute to and from the university. Under the program, a guaranteed ride home is provided by a taxi. Brown employee carpools registered with RIPTA express travel may use the RIPTA guaranteed ride home twice a year. Bus riders that live within a 50 mile radius of Brown University and purchased a monthly pass or one book of RIPTIKS through the Brown Bookstore are eligible for the Guaranteed Ride Home program for that month. The origin of the Guaranteed Ride Home must originate from a Brown address, and the ride can be used to handle a personal emergency between 8:00 AM and 4:45 PM. The ride can also be used to travel home after regular work hours if the rider is required to work late, does not live within the safeRIDE onCall area, and the regular RIPTA bus has stopped running.

- **ZipCar.** Brown University has started an arrangement with ZipCar in 2005 to allow for students to join for a cost of $30.00 per year plus $8.00 per hour of use, which includes insurance, maintenance, and 25 free miles per rental. Two ZipCar vehicles are available for use 24 hours a day, seven days of the week to Brown University ID holders. Registered members can reserve the vehicles in advance online or by phone. The cars use an electronic key system and a keypad which can be encoded by ZipCar so that no attendant is required for the vehicles and only an approved renter with a reservation can access the vehicles during the time they reserved it for. ZipCar can capture the Brown ID numbers and report them back to the university with the rental length so that usage patterns can be analyzed and the program can be fine tuned if needed.
- **Additional Transportation Demand Management Techniques** currently in place at Brown University include:
    - The elimination of sophomore parking (in addition to freshmen)
    - The increase in parking rates for students and employees
    - The establishment of a visitor parking lot
    - Rental agreements with Enterprise Rental to provide students discounted rates
    - Incentives for carpooling including reduces rates and priority parking space selection
    - The use of off-campus lots for parking construction worker vehicles for all major projects.

■

Additional Future TDM Measures

All of the existing TDM programs identified above will be continued over the next five years with expanded service and additional capacity added to the downtown shuttle. While Brown University has been providing many TDM services, the University will continue to look at ways to further encourage public transportation. At a minimum, this will include modifications to the existing parking policies to allow for experimentation with public transportation without losing a parking permit and improved outreach to University employees about the RIPTA pass program and other TDM measures.

Roadway Infrastructure Improvements

The traffic impacts associated with the proposed Master Plan development program are relatively minor. However, improvements are recommended at various locations impacted directly by the proposed changes on campus and at the gateway intersections which provide poor levels of service under future projected No-Build and Build volumes. Potential improvements are described in the following sections.

■

Gateway Intersections

Three of the existing intersections that are gateways to the Brown University Campus area operate with existing deficiencies and will operate at poor levels of service under projected No-Build and Build traffic volumes:

- Angell Street at Benefit Street
- Waterman Street at Benefit Street
- Hope Street at Olney Street

Potential improvements to all three of these intersections are described below. A comparison of levels of service at the intersections under the Existing, No-Build, Build, and Build with proposed improvements scenarios are presented in Table 4-1.

The proposed signal timing modifications at the intersections would need to be coordinated with the City of Providence Department of Traffic Engineering. If the existing traffic signal controllers at certain intersections cannot accommodate the proposed time-of-day timings, the controllers would need to be replaced.

Angell Street at Benefit Street

The intersection of Angell Street at Benefit Street currently operates at a deficient calculated level of service (LOS E) during the weekday morning and weekday evening peak hour periods. This is due to the poor timings of the traffic signal and lack of coordination with the traffic signal at the intersection of Waterman Street and Benefit Street. Due to the close distance between the two intersections and lack of coordination, the vehicle queues between the intersections restrict the flow of traffic at both locations. With revised traffic signal timings, the intersection would improve to a calculated LOS B during the weekday morning peak hour and LOS C during the weekday evening peak hour, and the calculated queue lengths would be substantially reduced.

Waterman Street at Benefit Street

The intersection of Waterman Street at Benefit Street currently operates at a calculated LOS D during the weekday morning and LOS B during the weekday

evening peak hour period. However, based on field observations, the intersection operates at poorer levels of service than the analysis suggests. This is due to the queuing of vehicles along Benefit Street between the Waterman Street and Angell Street signals resulting from the poor timings and lack of coordination of the traffic signals. With revised traffic signal timings, the intersection would improve to a calculated LOS B during peak hour periods, and the calculated queue lengths would be substantially reduced.

Hope Street at Olney Street

The intersection of Hope Street at Olney Street currently operates at a calculated LOS D during the weekday morning and LOS C during the weekday evening peak hour period. However, the Hope Street northbound movement is over capacity and operates at LOS F with the existing timings at the traffic signal. With the minor increases in traffic under the future Build conditions, the intersection is projected to operate at a calculated LOS E during the weekday morning and LOS D during the weekday evening without any modifications to the traffic signal timings. With revised traffic signal timings, the intersection would improve to LOS C during both peak hour periods under 2010 Build traffic volumes.

Table 4-1
Mitigation Impact Signalized Intersection Capacity Analysis Summary

		2005 Existing			2010 No-Build			2010 Build			2010 Build With Traffic Signal Timing Changes		
Location	Peak	V/C[1]	Delay[2]	LOS[3]	V/C	Delay	LOS	V/C	Delay	LOS	V/C	Delay	LOS
Angell Street/	AM	0.73	69.3	E	0.75	79.2	E	0.77	86.2	F	0.74	19.4	B
Benefit Street	PM	0.84	65.9	E	0.86	73.6	E	0.88	79.5	E	0.90	32.4	C
Waterman Street/	AM	0.54	44.2	D	0.56	51.3	D	0.57	56.4	E	0.57	13.8	B
Benefit Street	PM	0.63	18.8	B	0.64	19.4	B	0.66	19.9	B	0.66	19.6	B
Hope Street/	AM	0.89	41.7	D	0.92	45.3	D	0.97	56.5	E	0.91	28.7	C
Olney Street	PM	0.91	29.7	C	0.95	34.2	C	0.97	36.7	D	0.95	32.0	C

Source: Synchro 6 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 on the study area roadways between intersections. These interruptions caused congestion along these roadways during the peak hour periods. As a result, the observed delay times at some intersections exceeded the calculated values.

■

Angell Street and Waterman Street Corridors

There are thirteen (13) signalized intersections along Angell Street and Waterman Street between Gano Street and Benefit Street. Due to the relatively close spacing of the intersections, many of the traffic signals were originally designed and programmed to run coordinated with each other. However, many of the intersections do not run coordinated with the adjacent traffic signals along the corridors. As a

result, the progression of vehicles was poor and the queue lengths at some intersections were observed to extend through the adjacent intersections and block intersections during the peak periods.

The University will work with the City of Providence Department of Traffic Engineering to fine-tune the traffic signal timings along Angell Street and Waterman Street to minimize queue blockages of intersections and reduce the delays to vehicles and pedestrians along these principal arterial roadways.

Improvements along Angell Street and Waterman Street will also lessen the need for alternate east-west vehicle connections through the campus, such as Olive Street, and would keep vehicles on the arterial roadways.

■

The Walk Pedestrian Crossings

The opening of the Life Sciences Building and the construction of The Walk, the Sidney E. Frank Hall, and the Creative Arts Center will result in an increase in pedestrian activity between the Central Campus and the Pembroke Campus. Many Brown University pedestrians that currently walk along Brown Street and Thayer Street are expected to use The Walk as they travel between campus locations. When the projected pedestrian volumes have materialized, it is recommended that pedestrian actuated traffic signals be installed at The Walk crossings at Angell Street and Waterman Street. The new traffic signals would be hardwire interconnected with the existing traffic signals at the Thayer Street intersections and closely coordinated so through vehicles along Angell Street or Waterman Street would only be required to stop once, if at all, between the Walk and Thayer Street.

The proposed signalized crossings will provide for a safe place for pedestrians to cross both roadways at controlled locations rather than the random pedestrian crossings that currently occur between Thayer Street and Brown Street. In addition, the coordination of the pedestrian signals with the Thayer Street traffic signals will provide for improved progression of vehicles along Angell Street and Waterman Street.

The design of The Walk roadway crossings will improve the visibility of the crosswalks through changes in paving materials, wider crosswalks, lighting, and signing. The crossings will also have well designed pedestrian queuing areas on both sides of the roadways.

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Cushing Street Pedestrian Crossings

The proposed Jonathan Nelson Fitness Center is expected to become a draw on campus and will result in an increase in pedestrian traffic to the Brown University Athletic Complex area from points throughout the campus. Cushing Street will

serve as the major pedestrian connection from The Walk and the Pembroke Campus. The sidewalks along Cushing Street will be upgraded as part of the University's Utility Renewal project. The pedestrian crossing of Hope Street at Cushing Street will also be upgraded to improve the visibility of the crosswalk.

Due to the existing configuration and on-street parking at the intersection of Brook Street and Cushing Street, the sight distance and visibility of pedestrians crossing Brook Street is often restricted. The intersection currently operates at a calculated LOS B during the weekday morning peak hour and LOS C during the weekday evening peak hour period. With the projected increase in pedestrian traffic under 2010 Build conditions, the intersection is expected to operate at LOS C during the weekday morning and LOS D during the weekday evening. Due to the sight distance restrictions and the projected increase in pedestrian traffic, it is recommended that 4-way stop control be considered at this location. Under 4-way stop control, the intersection would improve to LOS B during both peak hour periods with projected 2010 Build traffic volumes, and it would provide for safer pedestrian crossings.

5

Short Term Construction Impacts

Construction Management

With respect to the construction of the projects in the Master Plan, Brown University will apply the following construction management practices utilized for construction on the campus.

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Parking for Construction Workers

Brown University requires its contractors to make arrangements for the transportation of workers to the job site. Consistent with past practices and University policy, no parking for construction workers working on major projects on College Hill is provided within the campus parking facilities. Limited 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.

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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 for each project and reviewed by the City of Providence Department of Traffic Engineering and the Department of Public Works.

Brown 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. Since most of the projects contained within the Master Plan are located on the northern sector of the campus, construction traffic is not expected to use roadways located to the south of the campus.

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.

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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.