Paul Robeson Place, Wiggins Street, Hamilton Avenue Corridor Final Report

Municipality of Princeton

DECEMBER 2020

FINAL REPORT

Contents

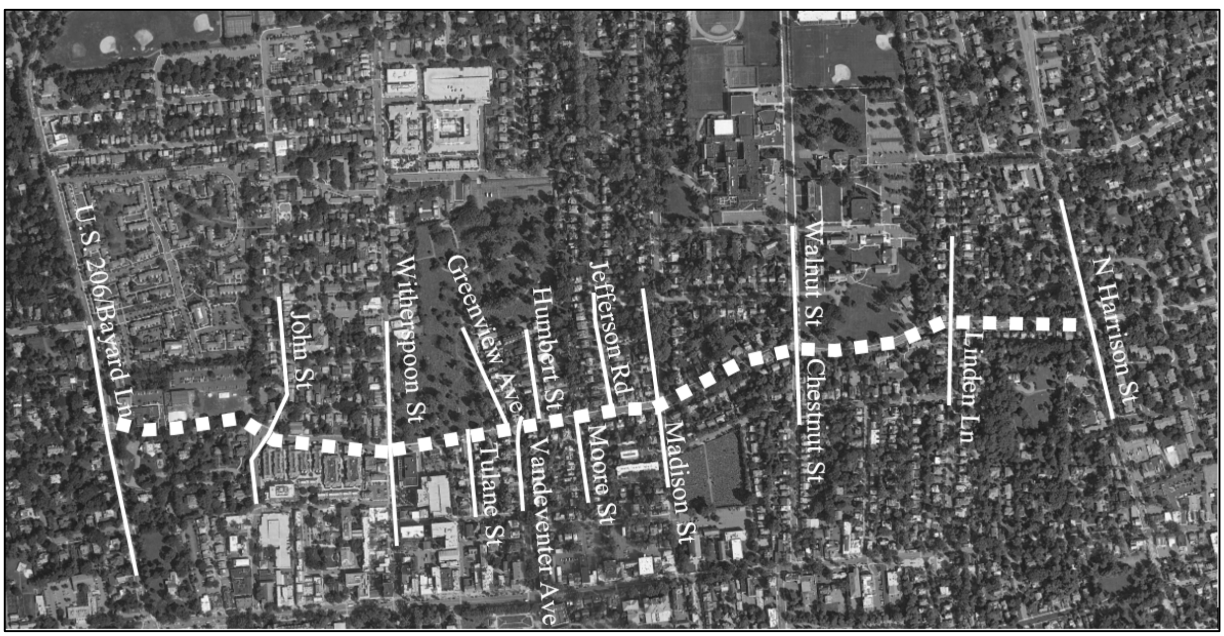
Introduction

Study Corridor and Purpose

This study concerns the 1.07-mile corridor constituting Paul Robeson Place, Wiggins Street and Hamilton Avenue between U.S. 206 (Bayard Lane) to the west and North Harrison Street to the east in the Municipality of Princeton, NJ. Throughout this report, this span will be referred to as the study corridor and is presented as a dashed white line in Figure 1. This corridor serves as the nearest local parallel route to NJ 27 (Nassau Street) to the south which runs through downtown Princeton, serving local and regional traffic running northeast between Princeton and Newark. In addition to serving residential uses directly fronting the corridor, the corridor is used for local parking for downtown Princeton and Princeton University, as an alternate to congested Nassau Street, and as a means of accessing nearby institutions including Westminster Choir College, Princeton Unified Middle School and Princeton High School.

The purpose of this multimodal corridor study is to provide recommendations for the creation of an integrated and consistent design and road user experience for all road users, including pedestrians, cyclists, and motorists. Complete Streets, ADA-compliance, and connections and linkages were considered in this corridor study. Local stakeholders were engaged and data on the corridor's existing conditions was obtained to formulate the concept recommendations.

Figure 1: Study Corridor



Princeton Bicycle Mobility Plan (2017)

Princeton's recent bicycle mobility plan provides the community with a framework for the future of bicycling in the municipality. The plan provides clarity to the purpose of bicycle improvements, as well as the strategy for implementing where and what type of bicycle facilities will be developed in the future. The plan will guide Princeton towards its vision of a town where users of all ages can safely and comfortably ride a bicycle regardless of their abilities, the purpose of their trip, or their destination.

The plan ultimately recommended nearly 70 miles of new bicycle facilities throughout Princeton. This includes enhanced shared-lane markings along the study corridor between U.S. 206 and North Harrison Street in the short-term. This kind of facility can take the form of typical sharrows with a bright green background (see Figure 2 for an example of such a facility in Newark, NJ), dramatically improving their visibility. Such a treatment can help promote the corridor as an important bicycling route though these markings alone do not create a bicycle connection for bikers of all ages and abilities. The plan states:

"achieving this objective will require trade-offs to implement more substantial improvements in the long term. While the typical roadway width of 30 feet is the minimum necessary to accommodate standard bicycle lanes, minor widening may be required in some sections. Existing on-street parking would also need to be removed."

The long-term recommendation for the corridor is to install standard bicycle lanes, widening the roadway and removing parking as needed.

A desire for a safer, more protected, and more consistent facility along the study corridor from the community and stakeholders has led to the development of this final corridor study.

Figure 2: Enhanced Shared-Lane Markings

Data Collection and Assessment

The multi-modal assessment consisted of comprehensively obtaining and assessing data concerning the existing conditions of the corridor, including the following components:

1. Cross-Sections
2. Parking Analysis
3. Crash Analysis
4. Traffic Data (vehicular, pedestrian, and cyclist)
5. Bicycle Level of Traffic Stress

Cross-Sections

The first task of the Paul Robeson-Wiggins-Hamilton Multimodal Corridor Study was to obtain the existing cross-section widths of the corridor. Cross-sections widths of the study corridor and intersecting roadways were measured in the field to assure accuracy.

Maps displaying cross-section widths along the corridor are presented in Figure 3, Figure 4, and Figure 5.

As seen from the maps, the cross-section of the corridor begins as 30' at the western end before expanding to 41' east of Chambers Street, and to 51' at the Witherspoon Street intersection before narrowing to 29-31' for the remainder of the corridor. The width of intersecting streets ranges from 22' on Humbert Street to 40' on the south leg of Witherspoon Street.

Figure 3

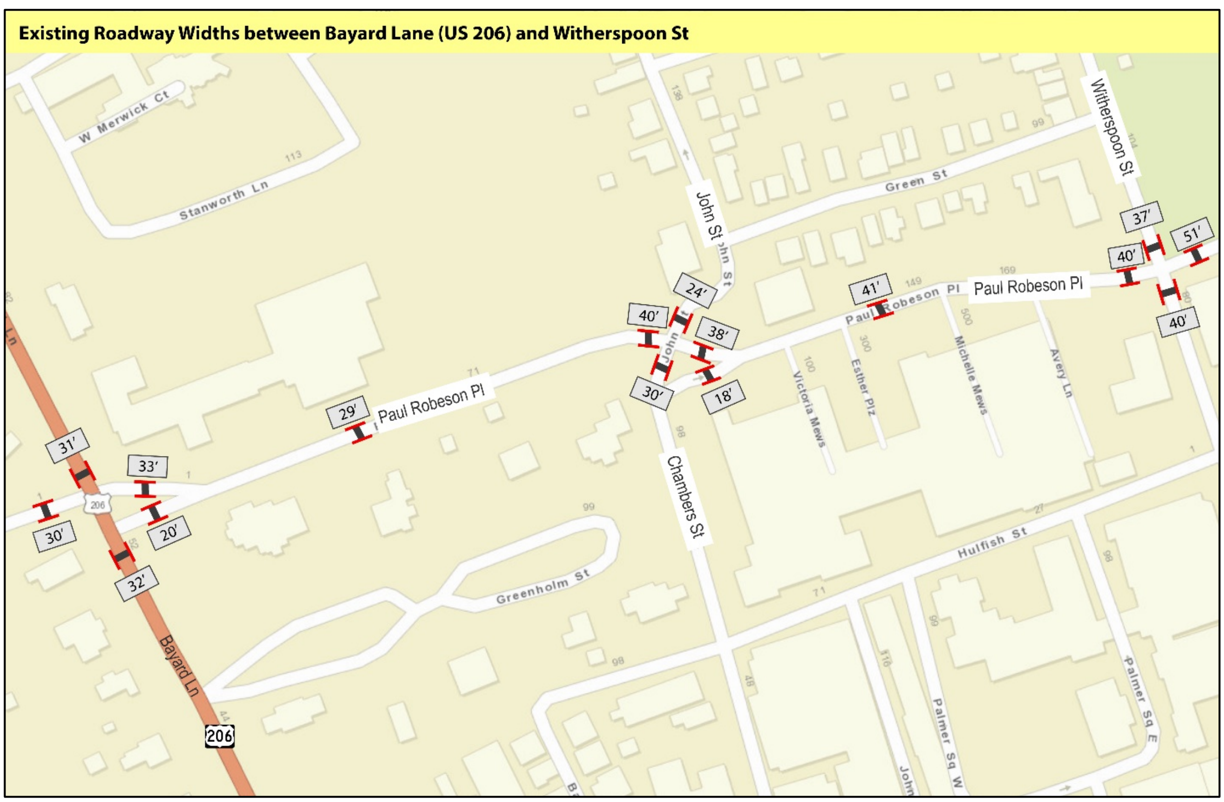


Figure 4

Figure 5

Parking Analysis

The availability and regulation of parking along the corridor and the larger downtown Princeton area was cited by many stakeholders as a concern due to the popularity for locals and visitors alike to frequent downtown Princeton and the shopping, educational, social, and cultural opportunities it provides. Therefore, a parking inventory was undertaken. Project team members counted the number of parked vehicles on each block of the corridor from 6:45 AM to 6:45 PM on two weekdays (Tuesday November 27, 2018 and Friday November 30, 2018/Friday December 21, 2018) and one weekend (Saturday December 29, 2018). Portions of two Fridays were not counted due to inclement weather.

There are presently 73 eastbound parking spaces and 17 westbound parking spaces along the corridor. All westbound spaces are metered parking. The block between Chambers Street and Witherspoon Street offers three hour metered parking on both sides. Wiggins Street between Vandeventer Avenue and Moore Street has two hour parking from 8:00 AM to 6:00 PM, Monday through Saturday. All other parking is non-metered and unrestricted. Overnight on-street parking between 2:00 AM and 6:00 PM is prohibited in the corridor.

Summary graphics for each of the parking utilization periods are shown in Figure 6, Figure 7, Figure 8, Figure 9, and Figure 10. Table 1 presents a summary of parking utilization along the corridor.

The western portion of the corridor (west of Moore Street) had higher utilization during the midday and evening hours, and higher weekend utilization than weekday. The eastern portion of the corridor (east of Moore Street) had higher utilization during the midday, and minimal morning and weekend demand. Utilization of metered parking was found to be similar to that of free parking.

Figure 6: Chambers Street to Witherspoon Street-Average Utilization (Metered Parking)

Figure 7: Vandeventer Avenue to Moore Street-Average Utilization

Figure 8: Moore Street to Chestnut Street-Average Utilization

Figure 9: Chestnut Street to Linden Lane-Average Utilization

Figure 10: Linden Lane to North Harrison Street-Average Utilization

Table 1: Parking Utilization Summary

Extents		Side of Street	Spaces	Morning		Midday		Evening	
				Wkdy	Wknd	Wkdy	Wknd	Wkdy	Wknd
Chambers St	Witherspoon St	Eastbound	11	16%	9%	72%	80%	75%	95%
		Westbound	17	7%	2%	40%	63%	56%	88%
Vandeventer Ave	Madison St	Eastbound	6	17%	13%	86%	100%	97%	90%
Madison St	Moore St	Eastbound	6	2%	4%	60%	71%	80%	77%
Moore St	Chestnut St	Eastbound	17	58%	4%	100%	40%	59%	58%
Chestnut St	Linden Ln	Eastbound	24	9%	0%	62%	0%	26%	5%
Linden Ln	N Harrison St	Eastbound	9	3%	0%	17%	4%	9%	5%

Note: “Wkdy” refers to weekday utilization, “Wknd” refers to weekend utilization

Crash Analysis

Safety is of the utmost concern in developing recommendations for the study corridor. A roadway can only be effective and efficient when it is safe for all users. For this purpose, crash data along the study corridor and nearby roadways was gathered and reviewed to determine trends and problem locations.

Crash data was obtained from the New Jersey Department of Transportation's Safety Voyager crash database for 2013-2018, the most recent six-year period offering available data. The crash analysis included all crashes occurring within 100 feet of the study corridor. During this timeframe, 224 crashes occurred along the study corridor. The number of crashes along the corridor each year, both in raw numbers and as a percentage of crashes occurring throughout Princeton remained relatively stable from 2013-2017 with a slight decrease in 2018 as shown in Table 2.

Table 2: Crashes by Year

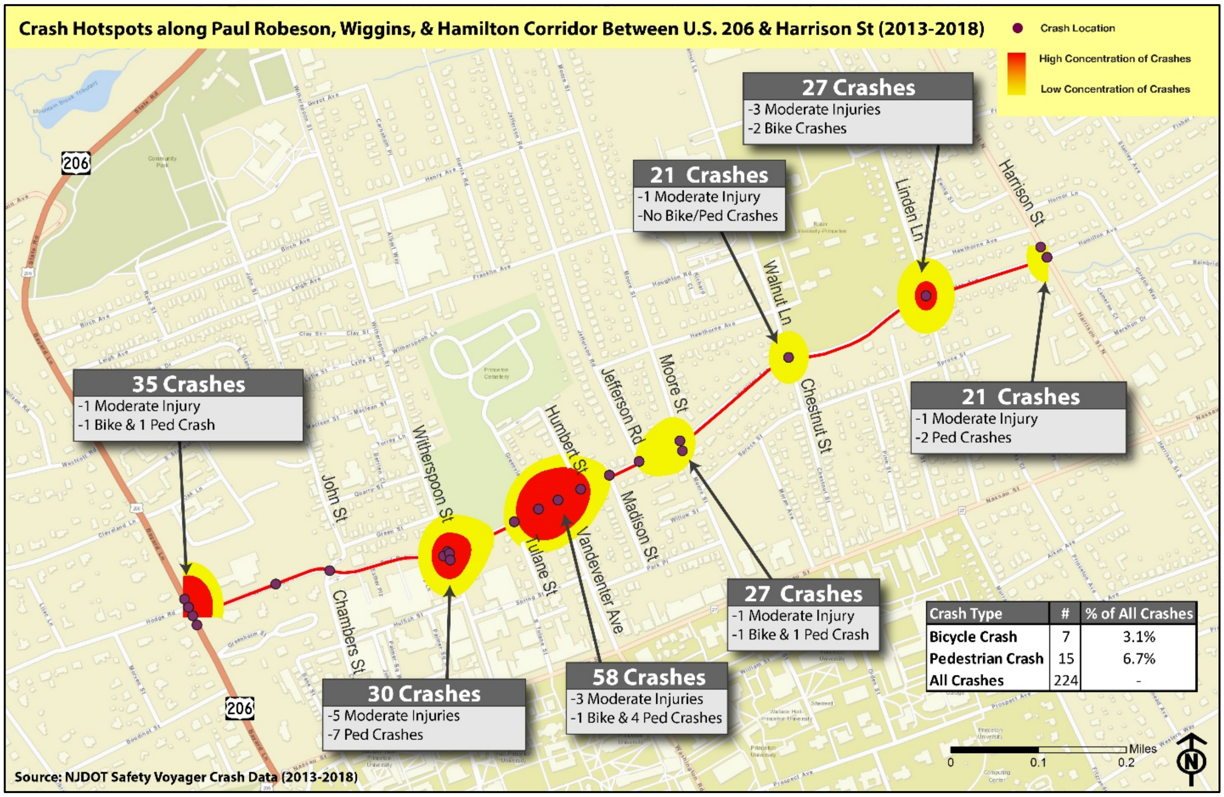
Year	Crashes in Study Corridor	Total Princeton Crashes	Percent
2013	33	741	4.5%
2014	41	881	4.7%
2015	40	691	5.79%
2016	40	770	5.3%
2017	44	795	5.5%
2018	26	748	3.5%
Average	**37**	**771**	**4.8%**

Using raw crash data, crash hotspots were identified where a greater number of crashes were located. A summary of the crash hotspots and crash locations at each hotspot are shown in Figure 11. The figures shown in the graphic apply to not only the designated intersection, but also the larger hotspot which in some instances constitute multiple intersections. Crash figures for each intersection and segment are presented in Figure 12.

Of the 224 crashes along the corridor, 26 occurred at the corridor's intersection with U.S. 206, 23 at the intersection with Linden Lane, and 22 at the intersection with Vandeventer Avenue. Nearly 30% of crashes along the corridor were right angle collisions, and nearly 20% were same direction rear ends.

The intersection with Vandeventer Avenue was the location of three moderate injury crashes, one cyclist and four pedestrian crashes. The intersection with Witherspoon Street was the location of five moderate injury crashes and seven pedestrian crashes. The intersection with Linden Lane was the location of three moderate injury crashes and two cyclist crashes.

Figure 11



Corridor-wide Trends

In addition to dividing crashes by type at each intersection, the data was compared across a corridor-wide, town-wide and statewide scale, as shown in Table 3, where overrepresented crash types along the study corridor are bolded. Please note that throughout the analysis, statewide averages provided refer to statewide averages for crashes along municipal roadways. Summary crash characteristics can vary widely based on the type of roadway. Statewide municipal roadway crash statistics are provided because the study corridor is a municipal roadway. Each of the following crash types are significantly overrepresented compared to town-wide averages:

- 29.5% of study corridor crashes involve a right angle collision compared to 14.8% in Princeton and 17.3% statewide
- 3.1% of study corridor crashes involve a cyclist compared to 1.4% in Princeton and 1.0% statewide
- 6.7% of study corridor crashes involve a pedestrian compared to 2.3% in Princeton and 2.9% statewide

Table 3: Crashes by Type

Crash Type	Corridor Crashes		All Princeton Crashes		Statewide Average	Overrepresentation
	#	%	#	%	%	(Y/N)
Backing	10	4.5%	292	6.3%	7.9%	N
Encroachment*	**3**	**1.3%**	**25**	**0.5%**	**0.4%**	**Y**
Fixed Object	23	10.3%	578	12.5%	10.5%	N
Left Turn/U Turn	**8**	**3.6%**	**92**	**2.0%**	**2.0%**	**Y**
Non-Fixed Object	**1**	**0.5%**	**17**	**0.4%**	**0.4%**	**Y**
Opposite Direction (Head On)	4	1.8%	81	1.8%	3.3%	N
Opposite Direction (Sideswipe)	1	0.5%	78	1.7%	N/A	N
Pedalcyclist	**7**	**3.1%**	**64**	**1.4%**	**1.0%**	**Y**
Pedestrian	**15**	**6.7%**	**106**	**2.3%**	**2.9%**	**Y**
Right Angle	**66**	**29.5%**	**685**	**14.8%**	**17.3%**	**Y**
Same Direction - Rear End	**44**	**19.6%**	**1283**	**27.7%**	**15.1%**	**Y**
Same Direction - Sideswipe	12	5.4%	306	6.6%	9.9%	N
Struck Parked Vehicle	30	13.4%	816	17.82%	26.0%	N
Other	0	0%	203	4.4%	3.4%	NA
Grand Total	224		4626			

Bolded crash types are overrepresented along corridor compared to the statewide average
*Encroachment is a situation where a vehicles' lane of travel is entered by another vehicle.

The corridor also presents a significant overrepresentation of moderate injury crashes; 7.1% vs. 4.4% for the town and 3.2% statewide. Fortunately, there were no crashes resulting in major injury or a fatality along the corridor during the study period.

Table 4: Crashes by Severity

Severity	Corridor Crashes		All Princeton Crashes		Statewide Average	Overrepresentation
	#	%	#	%	%	(Y/N)
Fatal	0	0.0%	2	0.04%	0.1%	N
Major Injury	0	0.0%	18	0.4%	0.3%	N
Moderate Injury	**16**	**7.1%**	**205**	**4.4%**	**3.2%**	**Y**
Minor Injury	33	14.7%	659	14.2%	15.3%	N
Property Damage	175	78.1%	3742	80.9%	81.0%	N
Grand Total	224		4626			

Bolded data is overrepresented along corridor compared to the statewide average

The location of crashes relative to an intersection was also reviewed across the corridor, as well as specifically for cyclist and pedestrian crashes, as shown in Table 5, Table 6, and Table 7. Crashes along the study corridor were twice as likely to be at intersections (rather than between intersections) compared to the town-wide average. In addition to the high number of crashes at the signalized intersections with U.S. 206, Witherspoon Street, and North Harrison Street, the unsignalized intersections of Vandeventer Avenue, Walnut Lane/Chestnut Street, and Linden Lane had a high number of crashes at each intersection. The high presence of cyclist and pedestrian crashes at intersections suggest the need for improved bike and pedestrian infrastructure at select intersections.

The number of crashes along each segment and intersection are shown in Figure 12.

Table 5: Crashes at Intersections (All Crashes)

Location	Corridor Crashes		All Princeton Crashes		Statewide Average	Overrepresentation
	#	%	#	%	%	(Y/N)
At Intersection	**108**	**48.2%**	**1091**	**23.6%**	**31.7%**	**Y**
Not at Intersection	116	51.8%	3535	76.4%	68.2%	N
Grand Total	224		4626			

Bolded data is overrepresented along corridor compared to the statewide average

Table 6: Cyclist Crashes at Intersections

Location	Corridor Crashes		All Princeton Crashes		Overrepresentation
	#	%	#	%	(Y/N)
At Intersection	**6**	**85.7%**	**37**	**57.8%**	**Y**
Not at Intersection	1	14.3%	27	42.2%	N
Grand Total	7		64		

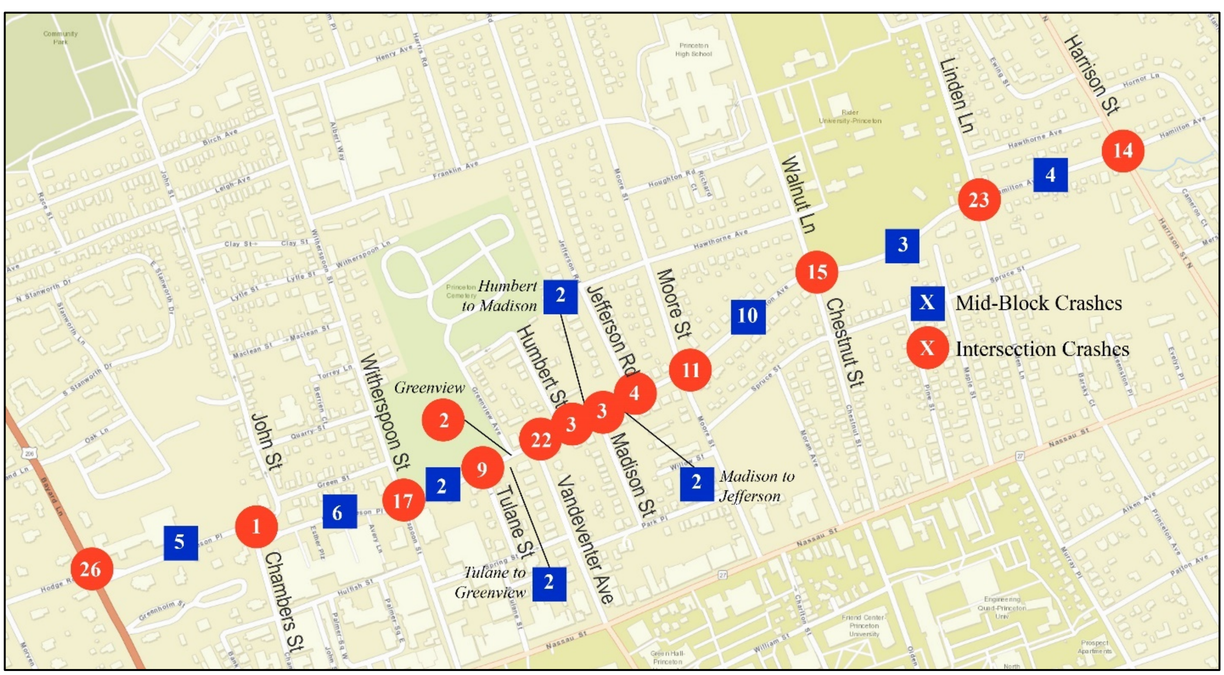
Bolded data is overrepresented along corridor

Table 7: Pedestrian Crashes at Intersections

Location	Corridor Crashes		All Princeton Crashes		Overrepresentation
	#	%	#	%	(Y/N)
At Intersection	**10**	**66.7%**	**44**	**41.5%**	**Y**
Not at Intersection	5	33.3%	62	58.5%	N
Grand Total	15		106		

Bolded data is overrepresented along corridor

Figure 12: Crashes at Intersections and Along Segments



Lighting and pavement conditions during crashes were reviewed for the study corridor. Lighting conditions during crashes were consistent with town-wide and statewide averages with 78% of crashes occurring during the day. Slightly more crashes (17.9%) along the corridor occurred with wet pavement conditions compared to town-wide (15.7%) and statewide (14.3%) while most (78.6%) occurred in dry conditions, consistent with town and statewide trends. More detailed data on each of these variables is shown in Table 8 and Table 9.

Table 8: Lighting Conditions

Lighting Conditions	Corridor Crashes		All Princeton Crashes		Statewide Average	Overrepresentation
	#	%	#	%	%	(Y/N)
Daylight	**174**	**77.7%**	**3502**	**75.7%**	**68.3%**	**Y**
Dusk	**6**	**2.7%**	**116**	**2.5%**	**2.4%**	**Y**
Dark	41	18.3%	920	19.9%	26.1%	N
Dawn	1	0.4%	34	0.7%	1.1%	N
Unknown/Other	2	0.9%	54	1.2%	2.1%	N
Grand Total	224		4626			

Bolded data is overrepresented along corridor compared to statewide average

Table 9: Pavement Conditions

Pavement Conditions	Corridor Crashes		All Princeton Crashes		Statewide Average	Overrepresentation
	#	%	#	%	%	(Y/N)
Dry	**176**	**78.6%**	**3683**	**79.6%**	**78.5%**	**Y**
Wet	**40**	**17.9%**	**727**	**15.7%**	**14.3%**	**Y**
Snow	6	2.7%	126	2.7%	3.6%	N
Ice	2	0.9%	55	1.2%	2.0%	N
Unknown/Other	0	0.0%	35	0.8%	1.7%	N
Grand Total	224		4626			

Bolded data is overrepresented along corridor compared to statewide average

Crash Rates

Crash rate represents the number of crashes along a segment after accounting for the number and distance vehicles traveled. Using annual average daily traffic (AADT), the number of crashes and the length of each roadway segment, crash rates were developed for portions of the study corridor and compared to the statewide average crash rate for roadways with identical cross-section geometry. Only crashes occurring directly on the corridor were utilized in calculating crash rates, compared to crashes occurring on side streets at intersections. The crash rate figures provided below represent the annual crash rate expressed in crashes per million vehicular miles traveled. Each segment was defined based on the availability of crash data, and the state of each cross-section.

Crash rates are highest toward the middle of the corridor where there is more demand for parking, more frequent intersections, and higher pedestrian volumes.

Crash rates for the corridor are shown in Figure 13 and Table 10.

Figure 13

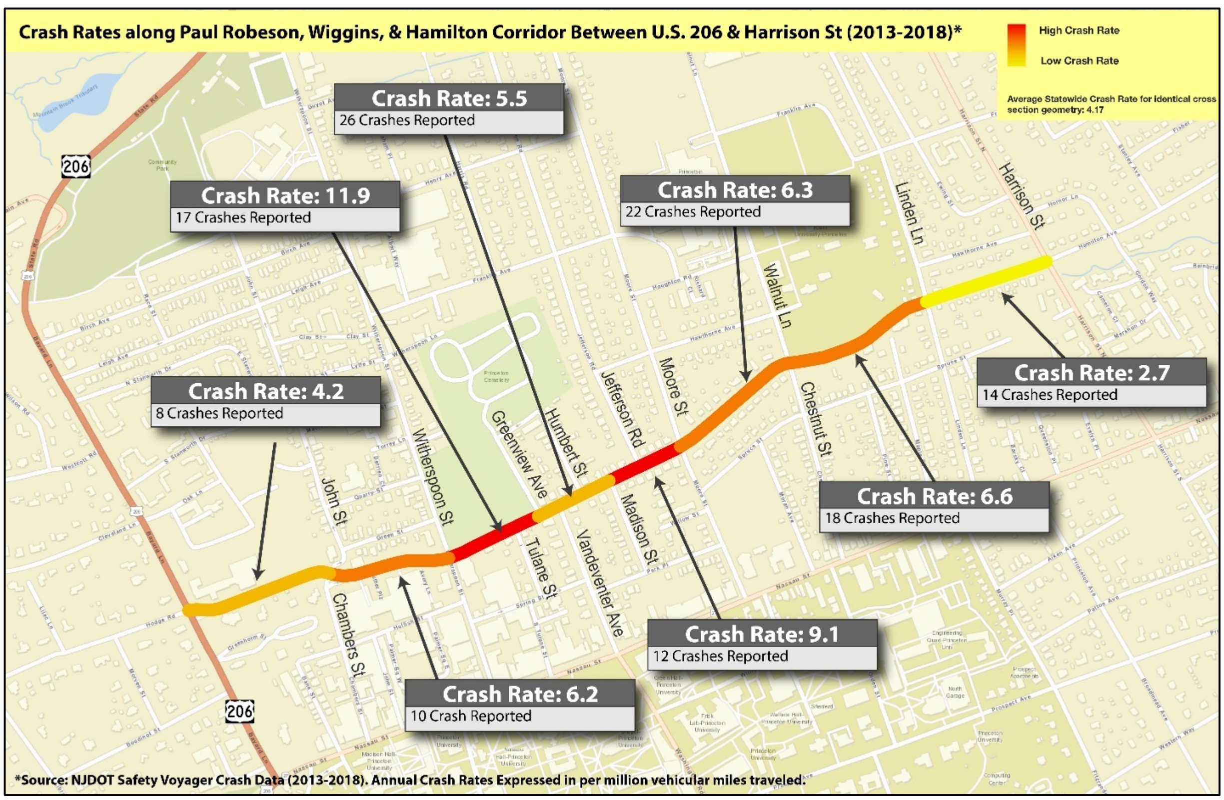


Table 10: Crash Rates by Segment (listed from west to east)

Segment	Number of Crashes	ADT	Segment Length (Ft)	Segment Crash Rate*
US 206 to Chambers St/John St	8	7914	888	4.2
Chambers St/John St to Witherspoon St	**10**	**7914**	**731**	**6.2**
Witherspoon St to Greenview Ave	**17**	**11,102**	**595**	**11.9**
Greenview Ave to Madison St	**26**	**11,102**	**476**	**5.5**
Madison St to Moore St	**12**	**11,102**	**476**	**9.1**
Moore St to Walnut Ln/Chestnut St	**22**	**7066**	**823**	**6.3**
Walnut Ln/Chestnut St to Linden Ln	**18**	**7066**	**928**	**6.6**
Linden Ln to N Harrison St	14	7066	760	2.7
Grand Total	127	-	5677	7.4**

***Bolded data is overrepresented along corridor compared to statewide crash rate of 4.2 for comparable cross-section**

****The corridor crash rate is 7.4**

Traffic Count Data

Traffic count data provides insight into how many vehicles use the corridor and what times of day are the busiest. This data is essential to assure engineering and traffic recommendations do not unduly impact the level of service for motorists.

Traffic count data was obtained using four mid-block automatic traffic recorders (ATR) and six intersection turning movement counts (TMC). Each ATR compiled seven full days of data and tabulated vehicle class (passenger vehicle, truck, etc.), speed, and volume. Each TMC compiled data for four specific time periods: 6:30-9:30 AM weekday, 11:30 AM-2:30 PM weekday, 3:30-6:30 PM weekday, and 10:30 AM-2:30 PM Saturday. Tabulated TMC data included vehicle classifications, each turning movement count, and pedestrian and cyclist counts. Saturday counts for the TMC at Vandeventer Avenue were not obtained because this supplemental count was conducted separately from the project's data collection plan in which all other counts were conducted.

Traffic count locations are shown in Figure 14.

Data was obtained on the following days and locations:

Automatic Traffic Recorders (November 5, 2018- November 11, 2018)

- Paul Robeson Place between U.S. 206 and John Street/Chambers Street
- Witherspoon Street between Green Street and Quarry Street
- Wiggins Street between North Tulane Street and Greenview Place

- Hamilton Avenue between Linden Lane and North Harrison Street

Miovision Intersection Counts (#1-4, #6 counted Thursday November 1, 2018 and Saturday November 3, 2018, #5 counted Tuesday April 9, 2019)

- Paul Robeson Place at U.S. 206
- Paul Robeson Place at Chambers Street/John Street
- Paul Robeson Place at Witherspoon Street
- Hamilton Avenue at Moore Street
- Wiggins Street at Vandeventer Avenue
- Hamilton Avenue at Walnut Lane

Figure 14

ATR Data

ATR data is summarized below and shown in Table 11 and Table 12.

Traffic counts along the study corridor are highest in the central portion between North Tulane Street and Greenview Avenue. Here more than 11,000 vehicles travel daily compared to 8,000 to the west and 7,200 to the east. Throughout the corridor, 9:00-10:00 AM represents the peak morning hour with between 550 and 825 vehicles traveling the corridor, depending on the segment. Evening volumes were slightly higher with between 625 and 1,025 vehicles traversing the corridor in the evening peak hour (5:00-6:00 PM westbound, 6:00-7:00 PM eastbound).

Speeds along the corridor were measured using both the mean (average) speed and 85th percentile speed. The corridor's speed limit is 25 mph throughout. 85th percentile speed is the speed at or below which 85 percent of all vehicles are observed to travel under free-flowing conditions. 85th percentile speeds along the corridor ranged from 27 to 31 mph while mean speeds along the corridor ranged from 22 to 27 mph with the lowest speeds along the higher volume portion between North Tulane Street and Greenview Avenue and higher speeds along the less traveled portion adjacent to North Harrison Street. This eastern end of the study corridor has less parking utilization and a longer straight roadway span lacking intersections, which facilitate higher speeds.

Additionally, roughly 2.5% of vehicles along the corridor are trucks (more than two axles). The percentage of vehicles traveling more than 35 mph were also reported, which correlated with mean and 85th percentile speed. Percent of speed >35 mph ranged from less than 0.5% in the central segment between North Tulane Street and Greenview Avenue to 4.4% between Linden Lane and North Harrison Street. A study from the National Highway Safety Transportation Administration determined five percent of pedestrian crashes with a vehicle traveling 20 mph result in a fatality compared to 40% at 30 mph and 80% at 40 mph.[1]

The ATR conducted on Witherspoon Street showed slightly lower traffic volumes along that corridor and slightly different peak hours. 6,500 vehicles travel Witherspoon Street between Green Street and Quarry Street daily, including nearly 450 during the AM peak (11:00 AM northbound, 9:00 AM southbound) and 525 during the PM peak (6:00 PM northbound, 4:00 PM southbound). Witherspoon Street showed similar traffic speed characteristics as the study corridor and a slightly higher percentage of trucks (4%).

Table 11: Summary of ATR Counts

Location	AADT	AM Peak Hour	AM Peak Hour Vol	AM Peak Hour % of AADT	PM Peak Hour	PM Peak Hour Vol	PM Peak Hour % of AADT	% Truck (2 axle 6 Tire) and Larger
Paul Robeson Pl Between US 206 & John St	8,065	9AM	652	8.1%	5PM	753	9.3%	2.4%
Wiggins St Between N Tulane St & Greenview Ave	11,313	9AM	821	7.3%	6PM EB/ 5PM WB	1,002	8.9%	2.6%
Hamilton Ave Between Linden Ln & N Harrison St	7,200	9AM	557	7.7%	6PM EB/ 5PM WB	636	8.8%	2.6%
Witherspoon St Between Green St & Quarry St	6,562	11AM NB/9AM SB	445	6.8%	6PM NB/ 4PM SB	531	8.1%	4.0%

[1] https://one.nhtsa.gov/people/injury/research/pub/hs809012.html

Table 12: Summary of ATR Counts-Speed Data

Location	Direction	85th % Speed	95th % Speed	Mean Speed	% >35 mph
Paul Robeson Pl Between US 206 & John St	EB	30	33	25	1.7%
	WB	29	32	25	1.1%
Wiggins St Between N Tulane St & Greenview Ave	EB	26	29	22	0.2%
	WB	28	30	23	0.5%
Hamilton Ave Between Linden Ln & N Harrison St	EB	32	34	27	4.4%
	WB	30	33	27	1.8%
Witherspoon St Between Green St & Quarry St	NB	27	30	22	0.5%
	SB	27	30	22	0.6%

Turning Movement Count (TMC) Data

TMC data for the peak hours of 7:30-8:30 AM and 5:00-6:00 PM are shown in Figure 15 and Figure 16.

During the AM peak, the most frequented eastbound right turn from the study corridor was onto Vandeventer Avenue where 98 vehicles turned. The most common eastbound left turn was also at Vandeventer where 124 vehicles turned. Eastbound vehicles reach the study corridor from several sources, the most common of which are U.S. 206 (126 vehicles), Chambers Street (160 vehicles) and Witherspoon Street (150 vehicles). The most frequented westbound right turn from the study corridor is onto Walnut Lane (125 vehicles) while the most frequent westbound left turn is onto Chambers Street (177 vehicles).

During the PM peak, the most frequented eastbound right turn from the study corridor is onto Vandeventer Avenue where 110 vehicles turned. The most common eastbound left turn was onto Witherspoon Street (70 vehicles). The most common means of accessing the study corridor eastbound are U.S. 206 (111 vehicles), Chambers Street (173 vehicles), and Witherspoon Street (161 vehicles). The most frequented westbound right turn from the study corridor is onto Witherspoon Street (101 vehicles), slightly ahead of U.S. 206 (86 vehicles). The most frequented westbound left turn is onto Chambers Street (155 vehicles). Compared to AM volumes, PM motorists are more likely to begin east of the study area where motorists enter the corridor from the study corridor’s eastern terminus at North Harrison Street.

Figure 15: AM Peak Hour Volumes (7:30-8:30 AM)

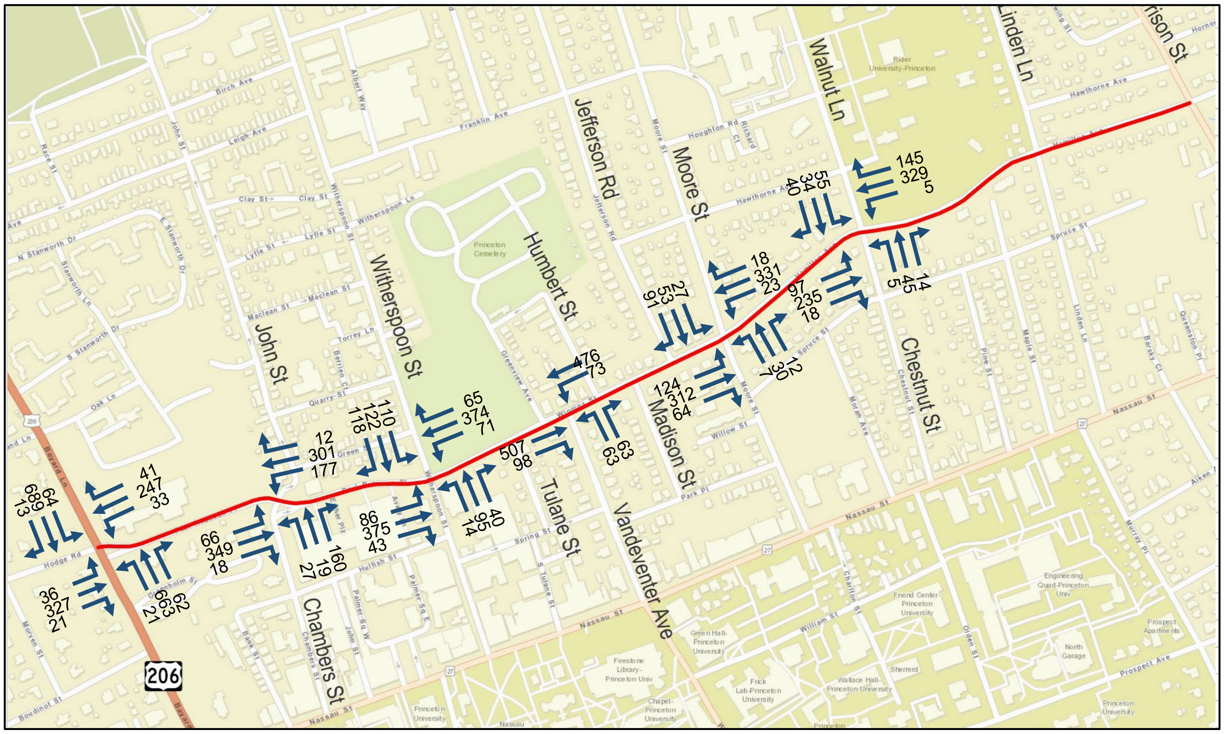
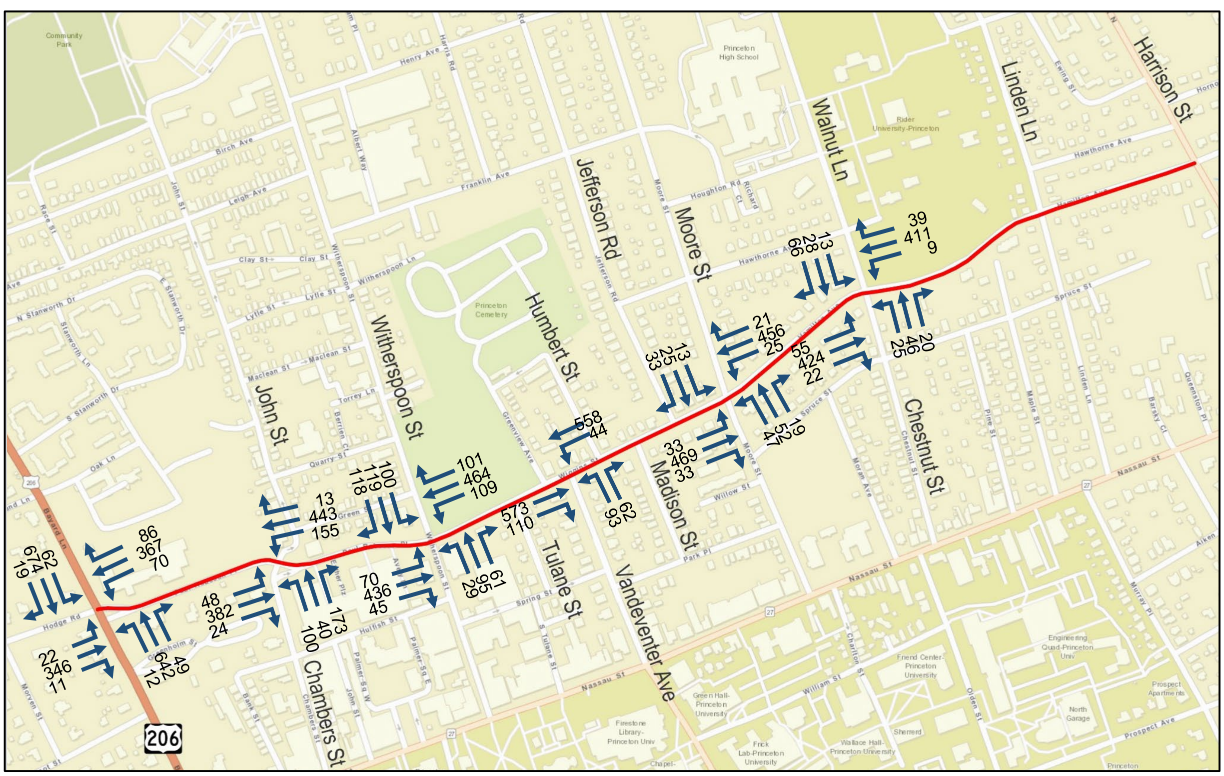


Figure 16: PM Peak Hour Volumes (5:00-6:00 PM)



Bicycle and Pedestrian Counts

The dense central downtown district of Princeton presents a walkable area, and Princeton and the surrounding area has an active cycling community. Bicycle and pedestrian counts were collected by the Delaware Valley Regional Planning Commission (DVRPC), the local metropolitan planning organization, at the following locations, as shown in Figure 17.

Pedestrian

Weekday and Weekend Averages between Friday November 9, 2018 and Wednesday November 28, 2018

- Paul Robeson Place between Chambers Street and U.S. 206
- Hamilton Avenue between Linden Lane and North Harrison Street
- Witherspoon Street between Green Street and Quarry Street

Weekday and Weekend Data Averages between Monday May 14, 2018 and Sunday May 20, 2018

- Wiggins Street between Witherspoon Street and North Tulane Street
- Hamilton Avenue between Moore Street and Chestnut Street

Bicycle

Between Thursday November 8, 2018 and Wednesday November 14, 2018

- Paul Robeson Place between U.S. 206 and Chambers Street/John Street
- Hamilton Avenue between Linden Lane and North Harrison Street
- Witherspoon Street between Green Street and Quarry Street

Thursday November 8, 2018 and Friday November 9, 2018

- Wiggins Street between North Tulane Street and Greenview Avenue

Figure 17

Pedestrian Counts

Table 13 summarizes DVRPC's pedestrian counts. Each figure represents a 24 hour average. Please note that when referring to direction (i.e. northbound), this refers to the side of the street the pedestrian is on rather than the direction they are walking.

The highest counts were found on Witherspoon Street where more than 1,100 pedestrians walk along the southbound side each day, more than twice as many as any segment of the study corridor. Along the study corridor, the highest volumes were found just east of Witherspoon Street where more than 500 pedestrians walk daily along the eastbound side. Throughout the corridor, eastbound pedestrian volumes were higher than westbound.

Table 13: Pedestrian Counts

Street	Extents	Side of Street	24-hour Weekday	24-hour Weekend
Paul Robeson Place	U.S. 206 to Chambers Street	North Sidewalk	146	182
Wiggins Street	Witherspoon Street to N Tulane Street	South Sidewalk	546	621
		North Sidewalk	378	331
Witherspoon Street	Quarry Street to Green Street	East Sidewalk	462	526
		West Sidewalk	1,101	1,125
Hamilton Avenue	Moore Street to Walnut Ln /Chestnut Streets	South Sidewalk	165	152
		North Sidewalk	117	98
Hamilton Avenue	Linden Lane to N Harrison Street	South Sidewalk	65	80
		North Sidewalk	39	42

Cyclist Counts

Cyclist counts from DVRPC were performed using roadway tubes. Therefore, only cyclists riding in the roadway over the tube were counted. Supplemental two-day weekday bicycle counts were collected using infrared counts at Wiggins Streets between North Tulane Street and Greenview Avenue. This count only captured cyclists on sidewalks and lacks weekend data. Additionally, DVRPC applies a factor to the raw cyclist counts to adjust for seasonal bicycle volume fluctuations and to correct for data concerning cyclists on sidewalks.

Table 14 summarizes DVRPC's cyclist counts with raw and factored volumes. Each figure represents a 24 hour average. Please note that when referring to direction (i.e. northbound), this refers to the side of the street the cyclist is on rather than the direction they are biking. Traffic law requires cyclists to obey traffic laws and ride in the direction of traffic, but this does not always occur.

Cyclist volumes follow similar patterns to pedestrian volumes in that Witherspoon Street attracts nearly three times as many cyclists as the other two count sites. Nearly 190 cyclists travel along Witherspoon Street each weekday. Between 40 and 55 cyclists travel along the study corridor daily, dependent on the segment. For all three count locations, weekday counts were higher than weekend.

Table 14: Cyclist Counts

Street	Extents	Side of Street	24-hour Weekday	24-hour Weekend
Paul Robeson Place	U.S. 206 to Chambers Street	Southbound	18 (52)	11 (43)
		Northbound	22 (55)	10 (37)
Witherspoon Street	Quarry Street to Green Street	Eastbound	79 (240)	65 (254)
		Westbound	108 (320)	77 (303)
Hamilton Avenue	Linden Lane to N Harrison Street	Southbound	16 (45)	13 (49)
		Northbound	37 (99)	24 (97)

Note: Volumes in parentheses are DVRPC factored volumes

Bicycle Level of Traffic Stress

Bicycle level of traffic stress (LTS) measures a cyclist's expected comfort on a given roadway based on roadway conditions. Each bicyclist has different tolerances for stress created by the volume, speed, and proximity of automobile traffic. The LTS metric is based on the Dutch concept of low-stress bicycle facilities. In general, lower stress facilities have increased horizontal and/or vertical separation between cyclists and motor vehicles and/or lower speeds and traffic volumes. Higher stress environments generally involve cyclists riding in close proximity to traffic, multi-lane roadways, and higher speeds or traffic volumes, a condition undesirable for most cyclists. Based on an analysis of the criteria, the LTS for a given roadway segment is classified into one of four categories. The four categories build upon one another, so all LTS 4 cyclists would tolerate LTS 1-4 roadways, LTS 3 cyclists would tolerate LTS 1-3 roadways, etc.

The four levels of traffic stress are:

LTS 1: suitable for almost all users (including children and seniors). On LTS 1 links, cyclists are either physically separated from traffic, in an exclusive bicycling zone next to slow traffic, or on a shared-street with a low speed differential.

LTS 2: Suitable for most adults but demands more attention than might be expected from children. Similar cross sections to LTS 1 but with more likeliness for interaction with motor vehicles.

LTS 3: Welcoming level for many people currently riding bikes in this country. Cyclists either ride in an exclusive on-street lane next to moderate speed traffic or on shared lanes on non-multi-lane streets.

LTS 4: Suitable only for the most experienced riders or not suitable for any riders. Roadway is characterized by high travel speeds, multiple lanes, and/or are lacking in dedicated bicycle facilities.

A map of the existing LTS along the study corridor and intersecting roadways, as well as contributing factors for the study corridor LTS, are shown in Figure 18.

The majority of the corridor operates as an LTS 3 roadway, while the most western segment between U.S. 206 and Chambers Street operates as LTS 4. Based on these perceived comfort levels, only the most enthusiastic and experienced riders would feel comfortable biking along the corridor. Along various points of the corridor, the LTS is hampered by the presence of a channelized right turn lane, high right turn speeds, high 85th percentile speeds, and high volumes. The presence of each of these conditions contributes to a higher (less comfortable) bicycle level of traffic stress. The LTS of intersecting streets range from LTS 1 (on low volume roadways with stop controls) to LTS 4 (signalized intersection at North Harrison Street with high volumes). U.S. 206 was not part of the LTS analysis though would likely be LTS 4 due to the roadway lane widths, high speeds and volumes.

A more detailed listing of the existing constraints and challenges to improving cyclist comfort along each segment of the study corridor are presented in Figure 19, Figure 20, Figure 21, Figure 22, and Figure 23.

Measures of improving the LTS are discussed on page 65.

Figure 18

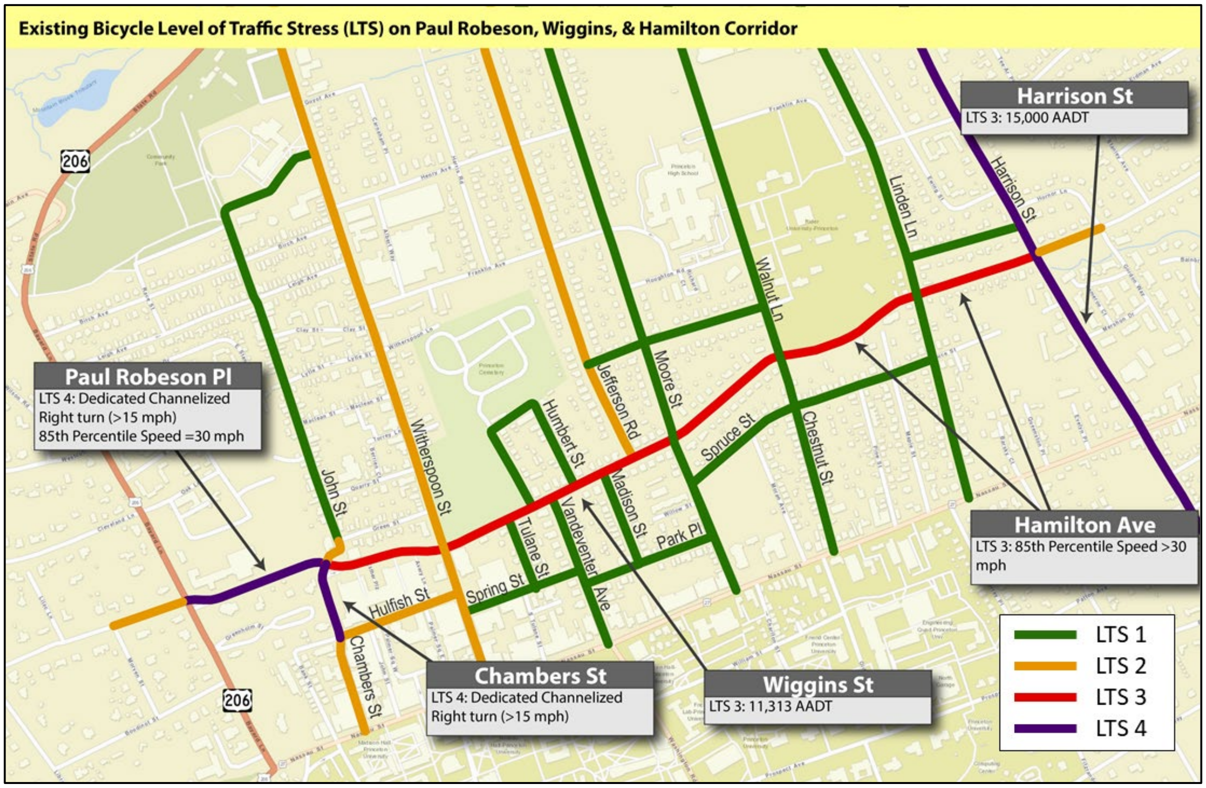


Figure 19: U.S. 206 to Chambers Street Conditions

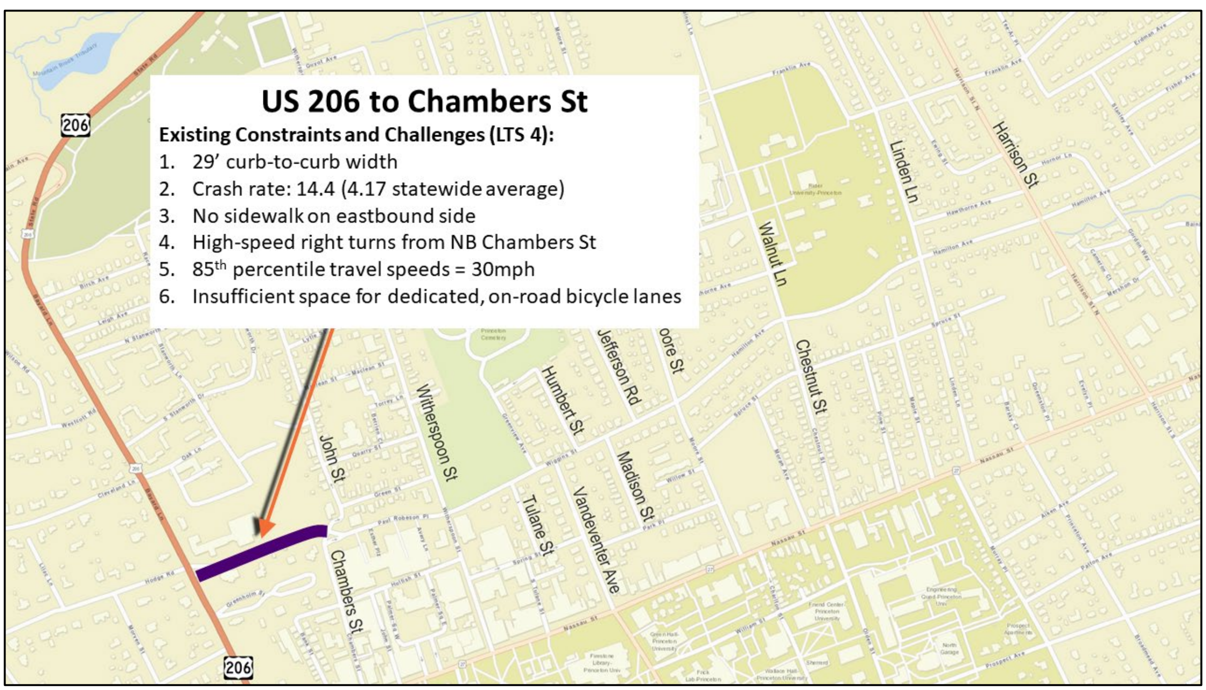


Figure 20: Chambers Street to Witherspoon Street Conditions

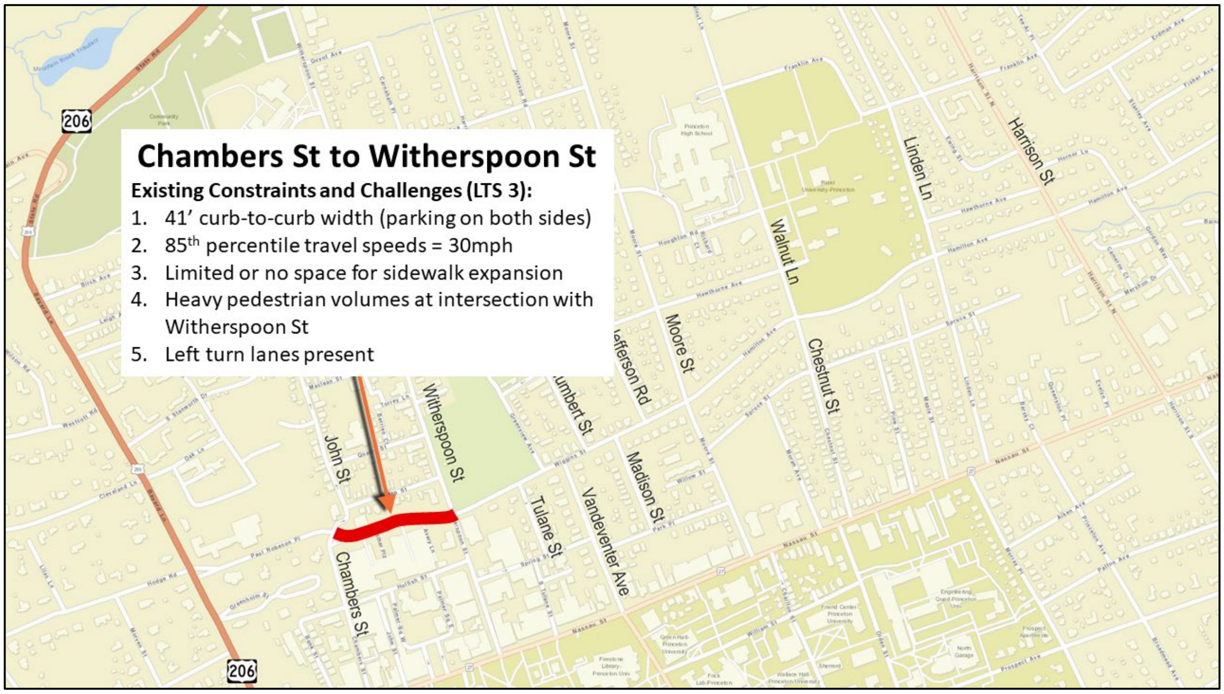


Figure 21: Witherspoon Street to Moore Street Conditions

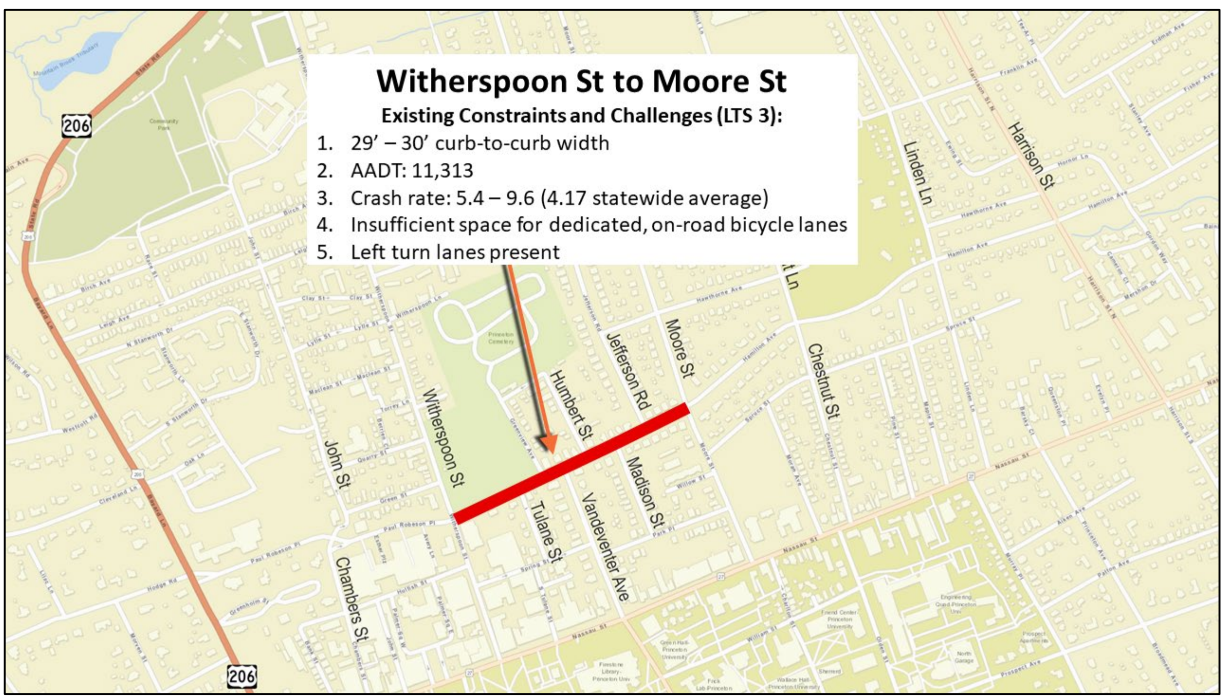


Figure 22: Moore Street to Linden Lane Conditions

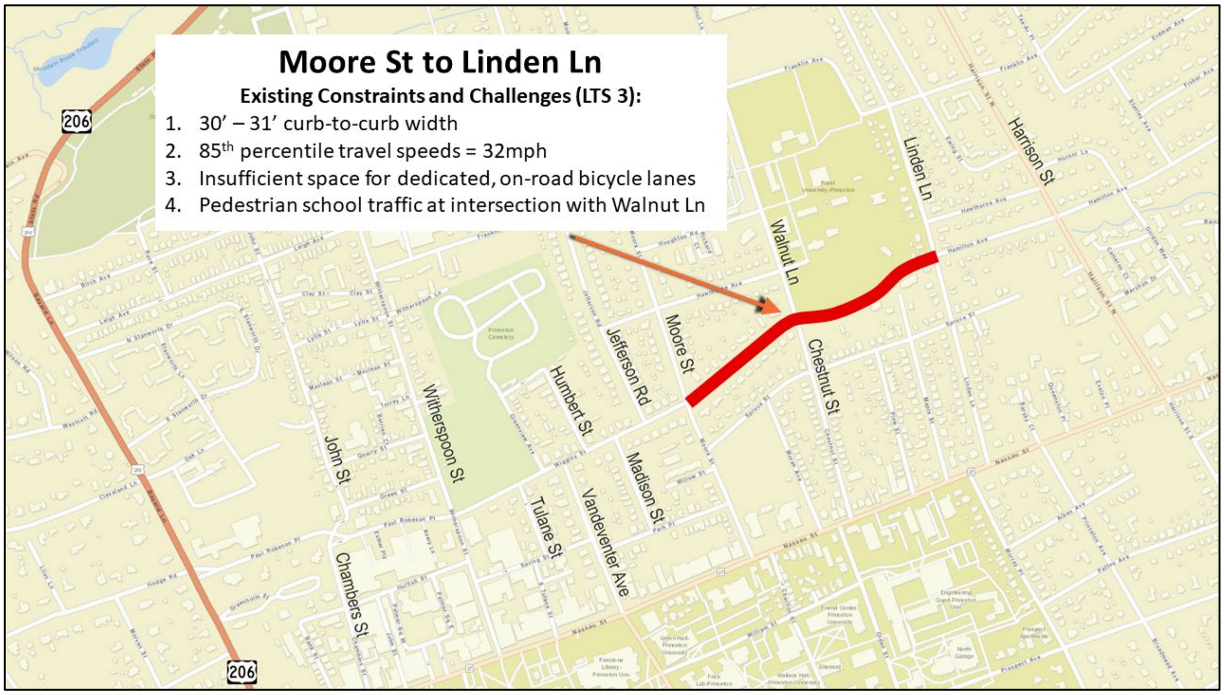
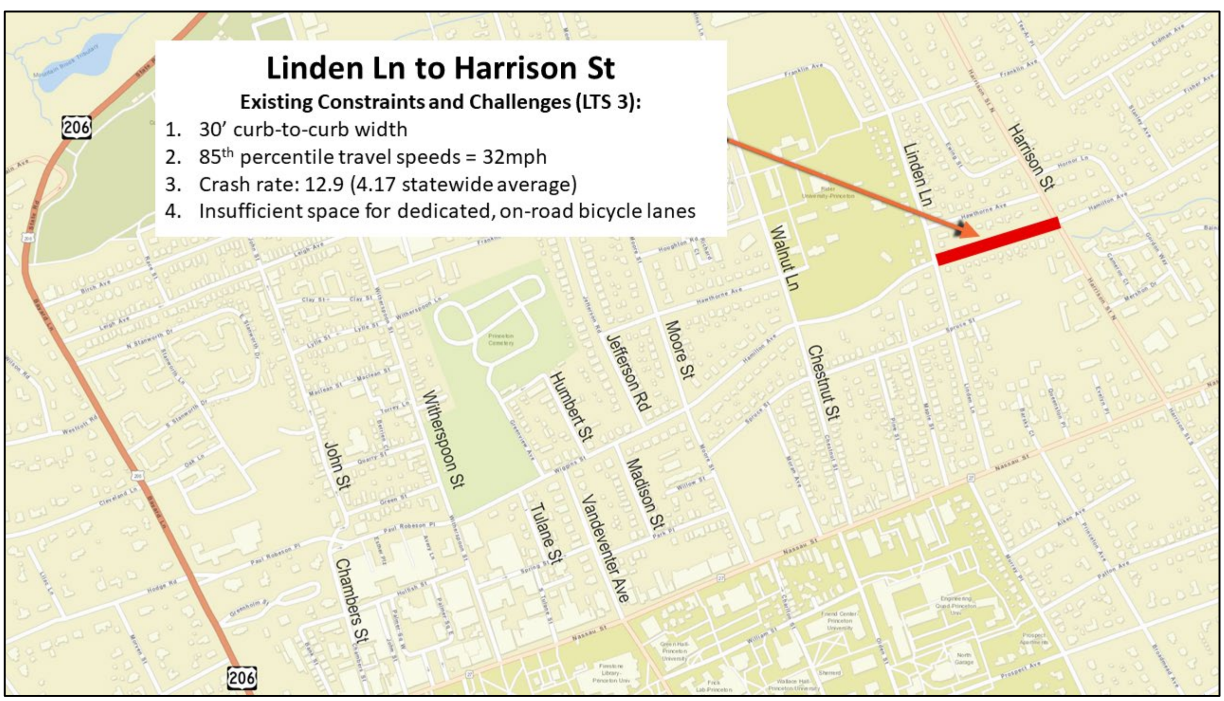


Figure 23: Linden Lane to North Harrison Street Conditions



Community Outreach

Community outreach is essential toward the successful completion of a project. Outreach provides invaluable feedback that can only be provided by people who live, work, or travel within the project area. The community outreach for this corridor study primarily consisted of the holding of four targeted stakeholder meetings, summarized below. Additionally, a fact sheet, comment card, and questionnaire were designed and distributed to stakeholders, the final version of which are shown in Figure 24, Figure 25, and Figure 26.

Figure 24: Project Fact Sheet

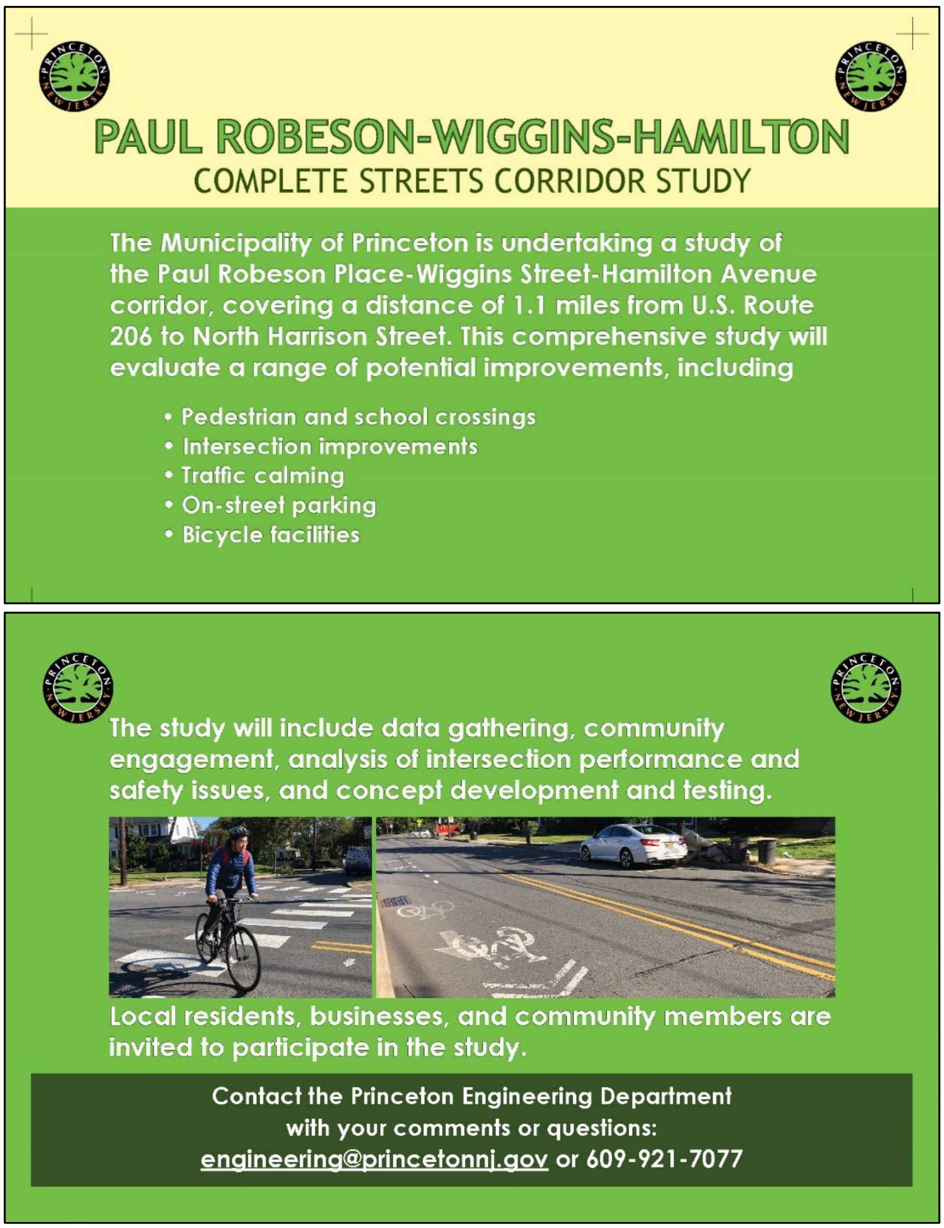


Figure 25: Project Comment Card

PAUL ROBESON-WIGGINS-HAMILTON
COMPLETE STREETS CORRIDOR STUDY

Please provide input on your experiences and priorities for walking, biking, and driving within the study corridor. Your thoughts and ideas will help make the best possible plan!

Comments

Please provide your **E-mail** if you would like to receive meeting and plan updates:

Contact the Princeton Engineering Department with your comments or questions: engineering@princetonnj.gov or 609-921-7077

Figure 26: Project Questionnaire

PAUL ROBESON-WIGGINS-HAMILTON
COMPLETE STREETS CORRIDOR STUDY
SURVEY

Please share any comments on areas of concern or ideas you have to improve safety and mobility conditions along the study corridor.

Please provide any comments or feedback on any of the public workshop materials you viewed today.

Where do you currently live?

How did you find out about today's meeting?

Please share your email address if you would like to receive future meeting notices.

Meeting Summaries

Four group meetings were undertaken with local stakeholders at Princeton's municipal building. The four meetings were:

Advocates Meeting-01.24.19

This meeting provided advocates and community groups the opportunity to provide comments and ask questions about the project. The meeting began with a presentation sharing the overall goal and scope of the project and the plan for collecting and analyzing data. Attendees included advocates from the community. Three questions/prompts and stakeholder feedback are provided below:

1. What is your experience with traffic and driving conditions along the study corridor?
    - Is difficult to cross Hamilton Avenue at Linden Lane
    - The corridor is congested during peak school times
    - Pedestrians can be difficult to see when turning onto/off the corridor
    - The corridor serves as a relief route for NJ 27
    - Is difficult to turn onto the corridor from Jefferson Road
    - Pedestrians are more visible when there is no parking on the street
2. What is your experience as a pedestrian and/or cyclist along the study corridor? How well does the street function for pedestrians and cyclists of all ages and abilities?
    - Biking to the library is stressful
    - During rush hour there is frequent tailgating and honking
    - The corridor has narrow sidewalks
3. What would you do to change the design and function of the corridor?
    - Should consider bike signals and leading pedestrian intervals
    - Should consider a roundabout at Chambers Street
    - Lighting along the corridor should be improved
    - A traffic signal should be installed at Walnut Lane

Residents Meeting-02.09.19

This meeting began with a formal presentation introducing the study and its scope to attendees, as well as information concerning the larger public outreach process, before sharing initial results of the data analysis. Over thirty residents were in attendance after flyers were distributed to nearby properties. Attendees completed a questionnaire regarding concerns and ideas to improve safety and mobility conditions along the corridor. Comments included:

- Move on-street parking from corridor to side streets and reallocate corridor space for bike lane
- Improve speed limit enforcement along corridor
- Install a traffic signal at Vandeventer Avenue
- Restrict left turns onto corridor
- Install speed device (like speed hump or speed table) at intersection of Linden Lane
- Install RRFB for crossing pedestrians
    - Motorists frequently speed and turn onto corridor without looking or yielding to pedestrians
- Implement a four-way stop along the corridor at Walnut Lane and Vandeventer Avenue

- Implement leading pedestrian interval at Witherspoon Street

Businesses Meeting-02.11.19

The meeting of local businesspeople included stakeholders from Princeton-based businesses as well as government entities such as the Princeton Public Library and non-profit groups including Princeton Future. This meeting began with a formal presentation introducing the study and its scope to attendees, as well as information concerning the larger public outreach process, before sharing initial results of the data analysis. Group discussion was initiated by four questions/prompts:

1. What has been your experience with driving, walking, and parking conditions along the study corridor?
    - Do you have any specific concerns about traffic or safety?
2. What concerns do you have about employee access and parking?
    - Is the availability and supply of parking for employees acceptable?
3. What about customer access and parking?
    - Does the nature of your business require parking close to your establishment?
4. Do you think changes to the corridor are necessary from a safety and mobility standpoint?
    - If yes, what would you do to change the design and function of the corridor?

Comments and Responses

In addition to public outreach, the project team worked intensively with representatives from the Municipality of Princeton. This included receiving dozens of comments from Princeton's Bicycle Advisory Committee. These comments and conversations further refined the study and ultimately led to more developed recommendations.

Intersection and Corridor Assessment and Concepts

The following pages detail recommended concepts for several problem intersections along the corridor. For each intersection, an aerial image of the intersection is provided in addition to a summary of the intersections' existing conditions, potential improvements, and impact of such improvements. Additionally, several corridor-wide recommendations are made. Where substantial traffic recommendations are proposed that would impact vehicular level of service, the level of service under existing and proposed conditions are provided. In such instances, the proposed level of service for each intersection refers only to changes made at that intersection.

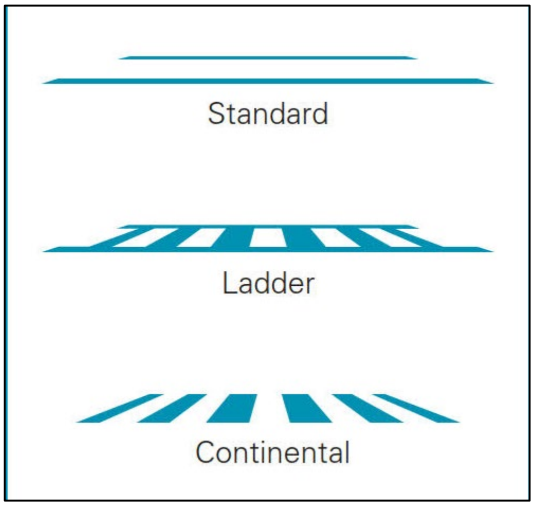
Where temporary (or pilot) infrastructure improvements are feasible, the parameters of such pilot recommendations are discussed. For each, care should be taken to assure the pilot infrastructure improvements provide a similar type of impact as would the long-term implementation to assure proper conclusions can be drawn. Pilots can be as short as one day or run indefinitely, though a 2-4 week pilot allows for data to be collected and metrics assessed. The timing of a pilot study should be carefully chosen to capture normal conditions, such as when busses are running or school is in session.

Pedestrian and biking recommendations made along the corridor or at other intersections were not factored into each proposed level of service. Further discussion surrounding the impact of traffic calming elements on corridor-wide volumes begins on page 65.

Crosswalks are discussed for each intersection. Crosswalks should be marked and maintained at all intersections and crossings where pedestrians are expected to cross. The three primary types of crosswalks are shown in Figure 27.

The three types of crosswalks shown in the graphic are Standard, Ladder and Continental. Standard crosswalk striping often presents poor visibility to motorists, particularly on higher-speed roadways or where striping has faded. Ladder and continental striping are preferable in most situations because they significantly improve the visibility of the crossing for motorists and maintain this visibility better as they age.

Figure 27: Crosswalk Design



A piece of infrastructure related to crosswalks is on-road pedestrian crossing signage, as shown in Figure 28. These signs are installed in the middle of the roadway to alert motorists to the presence of crosswalks and pedestrians.

Figure 28: On-Road Pedestrian Crossing Sign

Paul Robeson Place at Bayard Lane (U.S. 206)

Existing Conditions

U.S. 206 travels from Atlantic and Burlington counties in the south to Somerset County and beyond. The corridor in Princeton is highly used for travel between central and northern New Jersey. The existing geometry of the intersection presents impediments to safe and easy movement for motorists, cyclists and pedestrians. At this signalized intersection, a yield-controlled channelized right turn from northbound Bayard Lane to eastbound Paul Robeson Place results in conflicts due to right-of-way confusion with eastbound drivers from Hodge Road, the western continuance of the corridor. This channelized right turn enters Paul Robeson Place at a straight angle, encouraging speeding. Due to this channelization, minimal driveway conflicts and a lack of eastbound sidewalk, speeds along the segment east of the intersection can be high. Northbound, southbound and westbound traffic have dedicated left turn lanes. Additionally, the westbound Hodge Road receiving lane is offset and unaligned with the Paul Robeson Place thru-lane, causing greater confusion. The intersection's pedestrian signal heads are non-compliant with current standards. All legs of the intersection have ladder-style crosswalks. An aerial photo of existing conditions at the intersection is shown in Figure 29.

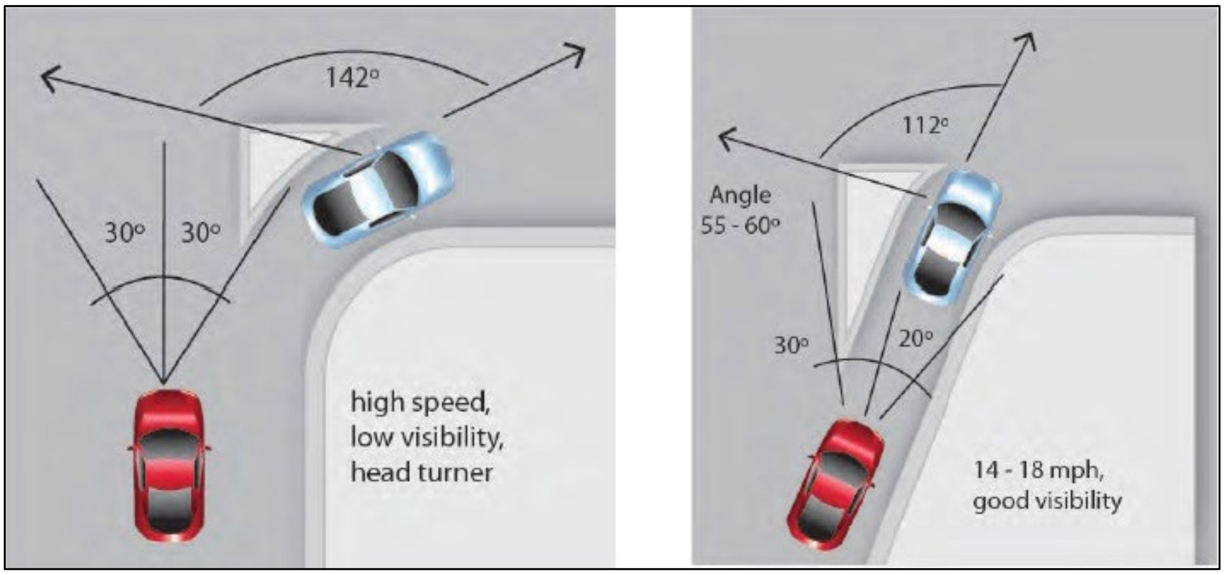
Figure 29: U.S. 206 at Paul Robeson Place

Potential Improvements

- Align the westbound Paul Robeson Place approach with the westbound Hodge Road receiving lane to ease thru-movement and improve ability of motorists to see crossing pedestrians

- Redesign the geometry of the channelized right turn from northbound Bayard Lane to eastbound Paul Robeson Place to reduce vehicular speeds, particularly at the crosswalks, and better enforce yield control. Such treatment would facilitate a safer pedestrian crossing. Left side of Figure 30 shows an example of high-speed channelized right turn geometry and the right side of Figure 30 shows an example of lower speed channelized right turn geometry with improved visibility.
- Install additional yield signage along channelized right turn from northbound Bayard Lane to eastbound Paul Robeson Place to help alleviate right-of-way confusion at channelized right turn merge

Figure 30: Channelized Right Turn

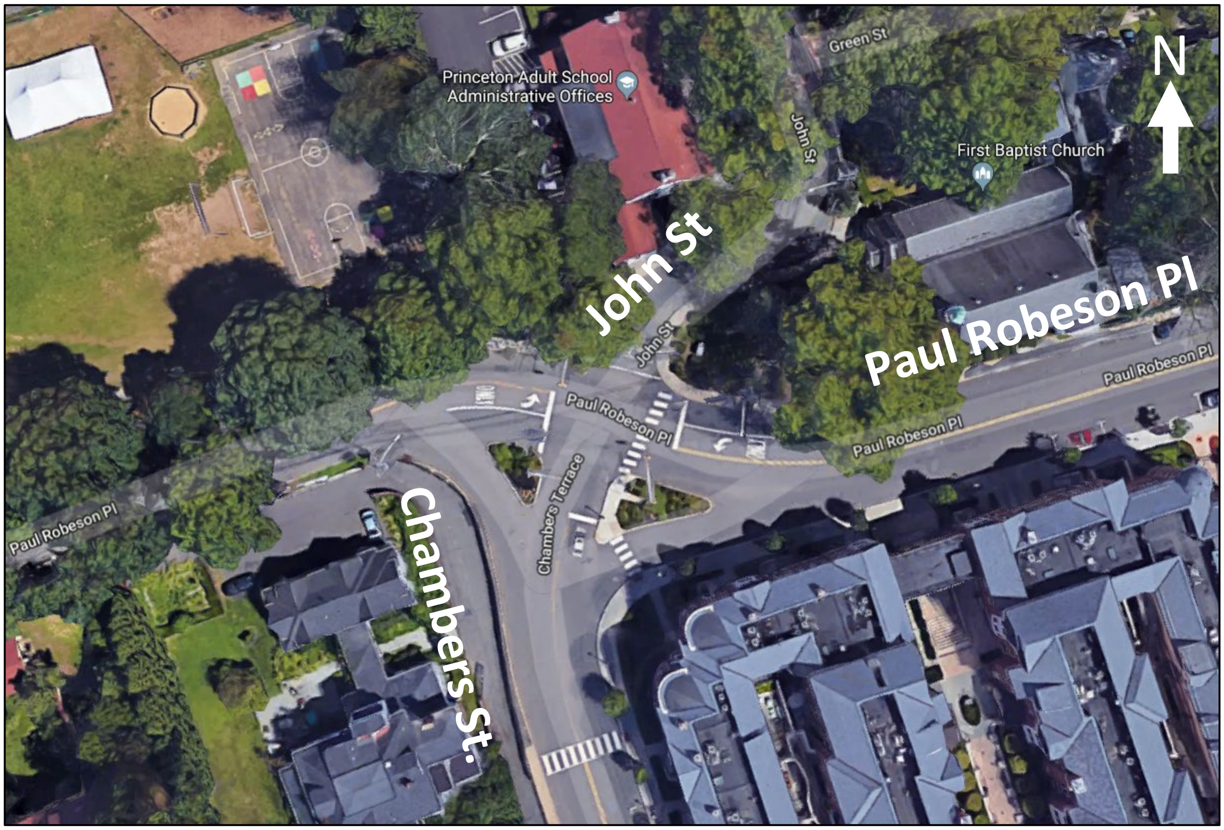


Paul Robeson Place at Chambers Street

Existing Conditions

At the signalized intersection of Paul Robeson Place and Chambers Street/John Street, traffic turning right to and from eastbound Paul Robeson Place have wide channelized yield-control right turn lanes, encouraging speeding, similar to the intersection with U.S. 206. The northern leg of the intersection, John Street, operates with one-way northbound traffic. Northbound and southbound traffic have dedicated left turn lanes. The north leg has a ladder-style crosswalk and the east leg has a continental crosswalk. Despite demand for such movements, the intersection lacks crosswalks along the south and west legs. This leads to pedestrians needing to make multiple crossings and pedestrians crossing outside of a crosswalk. The southwest corner of the intersection along Chambers Street lacks a sidewalk due to a private driveway occupying the public right-of-way. The intersection also presents multiple non-compliant ADA and pedestrian design features, including a pedestrian push button to cross Paul Robeson Place being offset further than required, creating difficulty for ADA accessibility. An aerial photo of existing conditions at the intersection is shown in Figure 31.

Figure 31: Paul Robeson Place at Chambers Street



Potential Improvements

The current use of the western Chambers Street sidewalk as a private driveway should be investigated. It is recommended that a sidewalk be established along this section and crosswalks be relocated to connect desire lines.

- Option 1
  - Remove the channelized right turn on Chambers Street to Paul Robeson Place and investigate the feasibility of constructing a roundabout at the intersection, thereby recapturing roadway space, adding parking spaces, and slowing traffic
    - With the 100 foot diameter available, a mini-roundabout, urban compact roundabout, or urban single lane roundabout are feasible, based on FHWA's Geometric Design Guide
    - Considerations include a mountable median for trucks (100 WB-15 trucks and 10-15 WB-50 trucks traverse the intersection each day)
    - Install crosswalks, and curb extensions as shown in Figure 33
    - Roundabouts have been found to use less space than typical signalized intersections while improving traffic flow. Due to the removal of traffic signal timing dedicated to pedestrians, crosswalks should be marked along each leg of the roundabout. Median islands should be constructed where feasible to allow

for pedestrians to cross one leg of the roadway at a time. Crosswalks should be adequately marked to be visible to oncoming motorists

Existing roundabout diameters elsewhere in Princeton include Faculty Road (two locations) at 100-120 feet and Alexander Road at 100-110 feet.

- Option 2
    - Tighten the turning radii for both channelized right turns to reduce turning speeds and shorten pedestrian crossings
        - The needs of buses and trucks must be considered when reducing turning radii
    - Position pedestrian push buttons next to the sidewalk to be ADA-compliant
    - Install a crosswalk on the west leg of the intersection to improve mobility
    - Install a crosswalk across the channelized right turn from eastbound Paul Robeson Place to improve mobility
        - Encouraging pedestrians to cross a channelized right turn may require the installation of signage promoting pedestrian visibility as motorists are accustomed to more free-flowing travel

Pilot Projects

Under Option 2, the channelized right turn turning radii can be temporarily reduced using paint, flexible delineators, and/or rubber/plastic curbs. These temporary materials would provide some insight into how motorists interact with the treatment while simultaneously allowing them to become accustomed to the change. These temporary materials can be driven over without injuring motorists.

Sketches of the roundabout are shown in Figure 32 and Figure 33. As shown in Figure 34, Figure 35, Figure 36, Figure 36, and Figure 37, the vehicular level of service in the AM peak would slightly improve, and during the PM peak slightly worsen; though, in both peak hours, an acceptable level of service would be maintained.

Figure 32: Proposed Roundabout

Figure 33: Proposed Roundabout

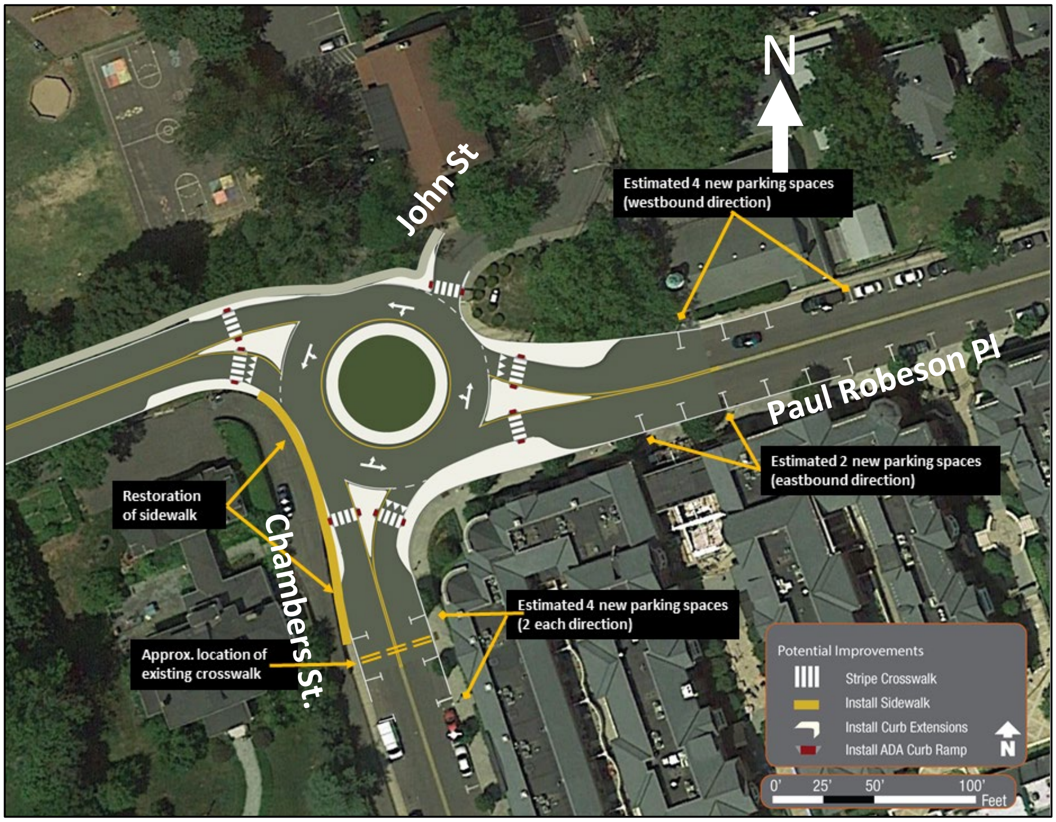


Figure 34: Existing Level of Service (AM Peak)

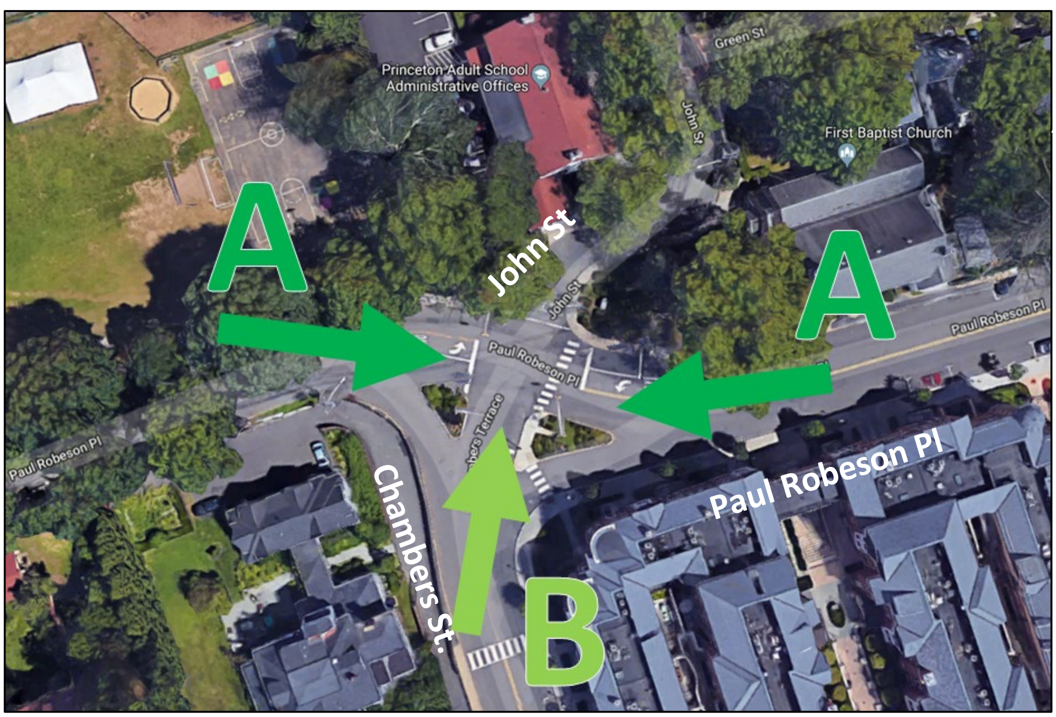


Figure 35: Proposed Level of Service (AM Peak)

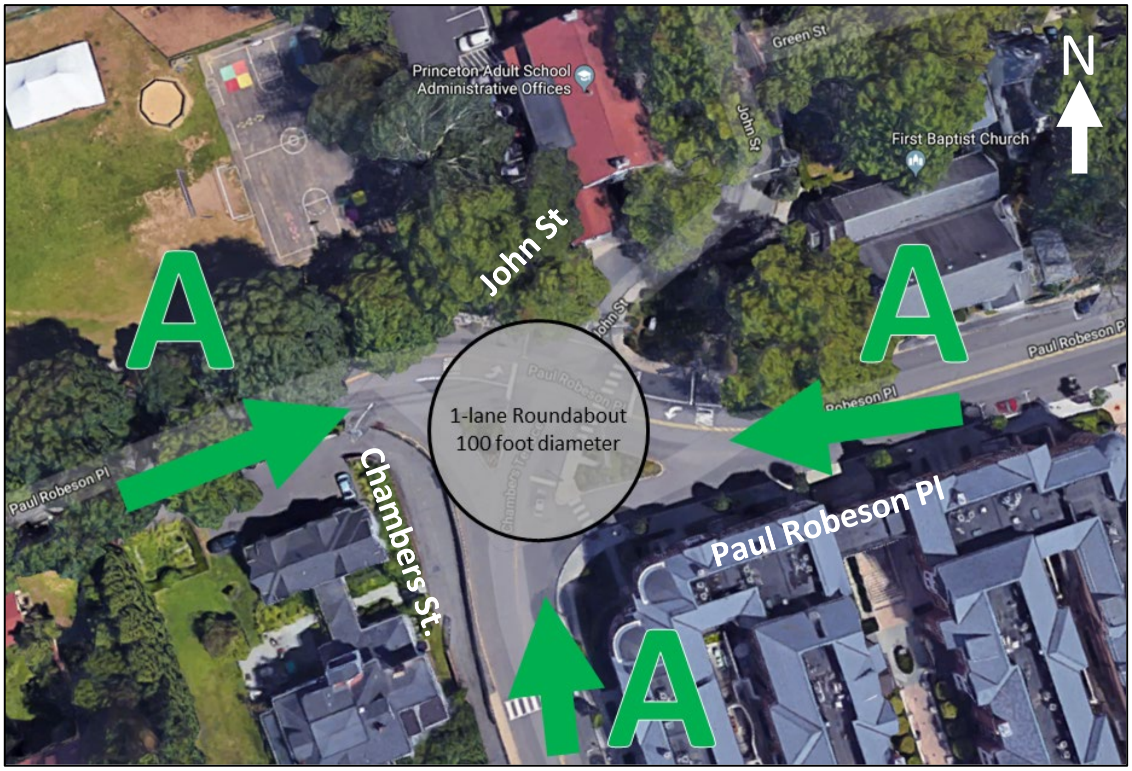


Figure 36: Existing Level of Service (PM Peak)

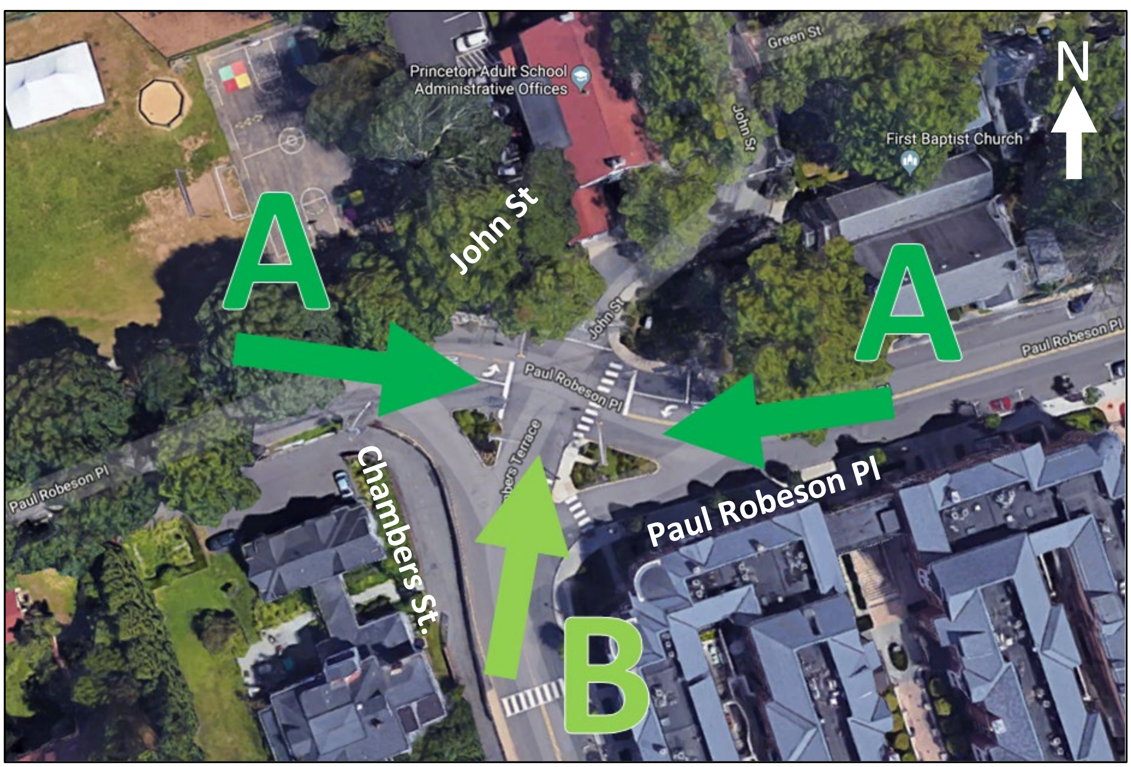
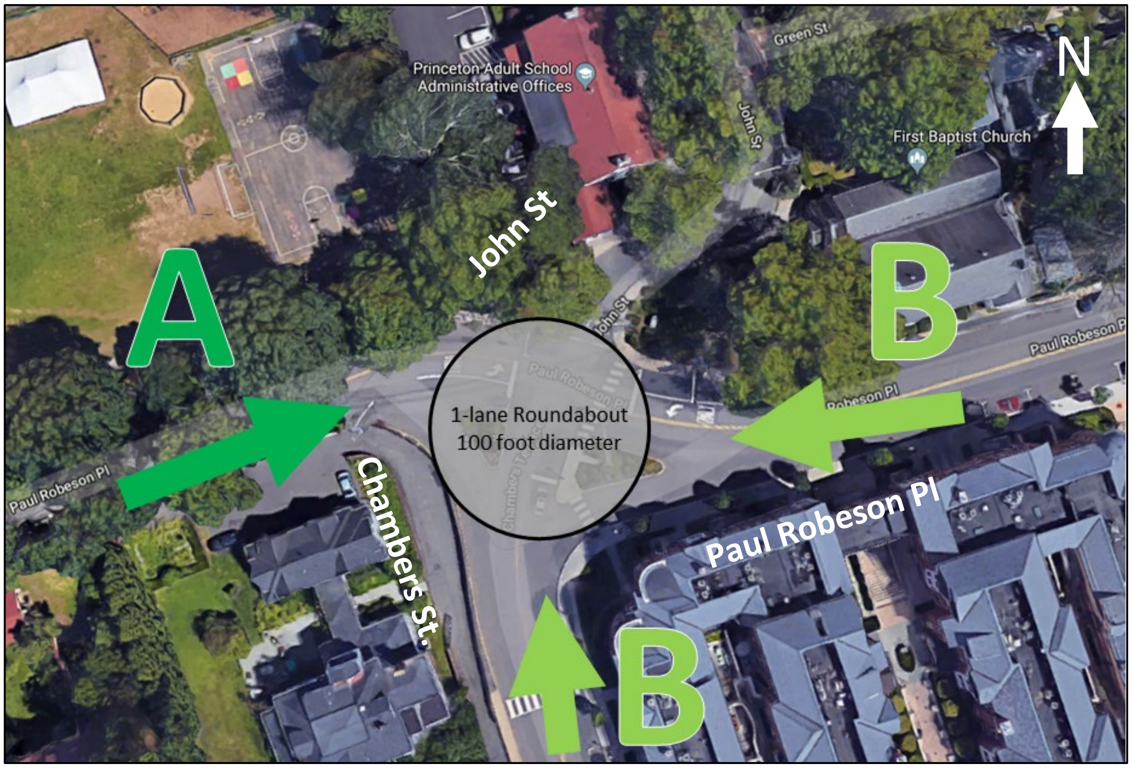


Figure 37: Proposed Level of Service (PM Peak)



Paul Robeson Place at Witherspoon Street

Existing Conditions

Witherspoon Street travels south to Nassau Street and north to U.S. 206, acting as a parallel route to U.S. 206 and Harrison Street. Due to its place in the roadway network, and nearby access to town offices, schools, apartment complexes and downtown Princeton, vehicular volumes are high along the corridor. Consequently, volumes are high for all turning movement approaches at this signalized intersection. Southbound, eastbound and westbound traffic have dedicated left turn lanes, and eastbound and westbound approaches share a protected left turn phase. All legs of the intersection also have high pedestrian and cyclist volumes. All legs of the intersection have continental crosswalks. Due to the signal timing, there can be long waits for pedestrians to cross. An aerial photo of existing conditions at the intersection is shown in Figure 38.

Figure 38: Wiggins Street at Witherspoon Street

Potential Improvements

- Investigate implementing leading pedestrian interval (LPI) design for all approaches to improve pedestrian circulation and safety, and limit pedestrian/vehicle conflicts
  - An LPI provides a few seconds of pedestrian crossing time before vehicle traffic is provided a green light. This lead time allows for increased visibility of pedestrians, reducing the risk of collisions. The need to provide safe crossings for pedestrians must be balanced by the slightly worsened level of service provided to motor vehicles
  - Level of service analysis assumes LPI actuation on 75% of all cycles
- An alternative recommendation is the installation of a simultaneous exclusive pedestrian phase for all approaches (also known as a Barnes Dance); this treatment is currently implemented at the intersection of Nassau Street and Vandeventer Avenue
  - Like implementation of a leading pedestrian interval, the use of an exclusive pedestrian phase will worsen traffic flow. This must be balanced with the need to provide safe pedestrian crossings
- Investigate replacing “no right on red” with electronic version to permit right turns when pedestrian signal is not actuated
  - This will improve traffic flow while still allowing time for pedestrians to safely cross
- Investigate the addition of a northbound left turn lane from Witherspoon Street to Paul Robeson Place
  - This will ease traffic flow by reducing backups caused by a yielding left turning vehicle

Pilot Project

A temporary northbound left turn lane can be installed at the intersection using flexible delineators. This treatment would provide insight into how traffic would be impacted without resorting to immediate long-term changes.

Figure 39, Figure 40, Figure 41, Figure 42, and Figure 43 show the vehicular level of service during the AM peak under various improvement conditions. Figure 44, Figure 45,

Figure 46, Figure 47, and Figure 48 show the vehicular level of service during the PM peak under various improvement conditions. For each peak hour, the level of service for the following conditions are presented:

1. Existing conditions
2. Three second leading pedestrian interval for both crossings
3. Three second leading pedestrian interval for all crossings and the addition of a northbound left turn lane
4. An exclusive pedestrian phase for all approaches
5. An exclusive pedestrian phase for all approaches and the addition of a northbound left turn lane

As seen in the graphics below, the level of service would only slightly worsen under each of the proposed conditions during each peak hour while improving pedestrian comfort and safety.

Figure 39: Existing Level of Service (AM Peak)

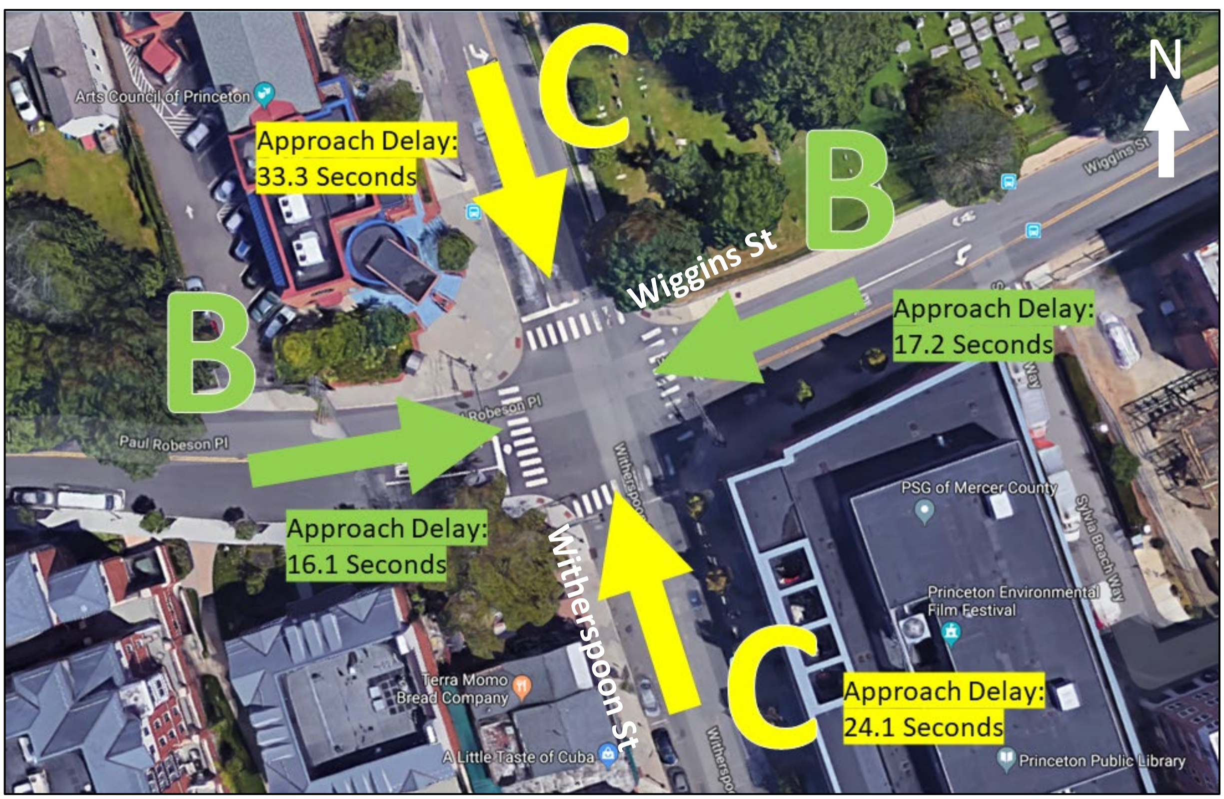


Figure 40: Proposed Level of Service (AM Peak with Lead Pedestrian Interval)

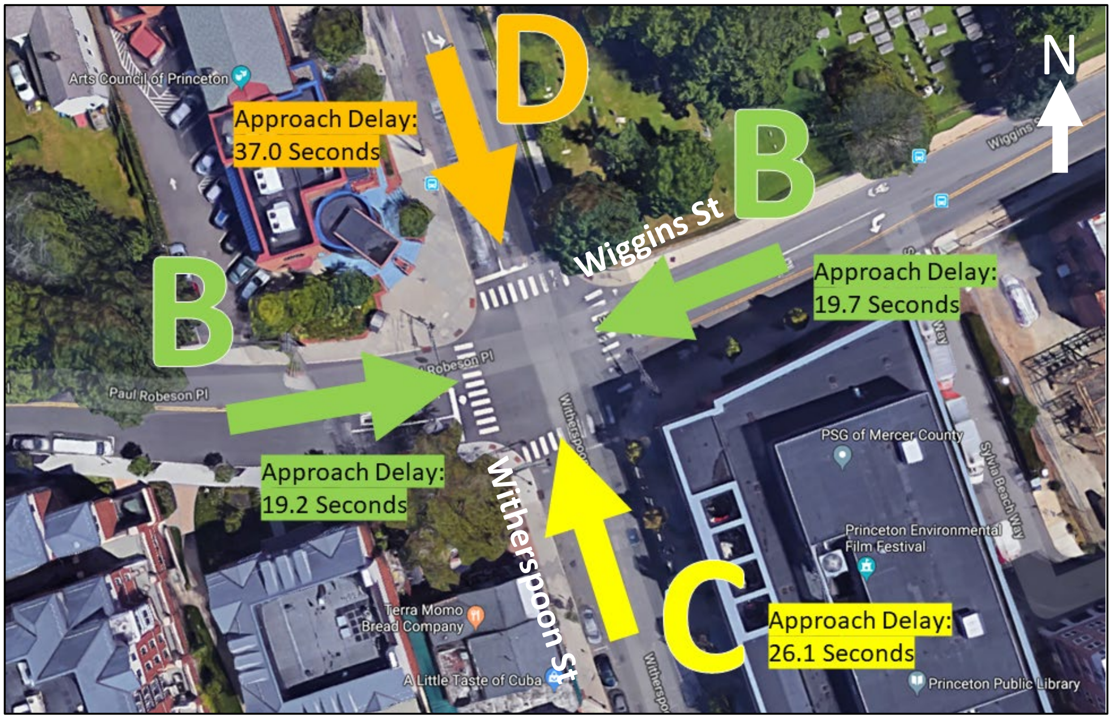


Figure 41: Proposed Level of Service (AM Peak with Lead Pedestrian Interval and Northbound Left Turn Lane)

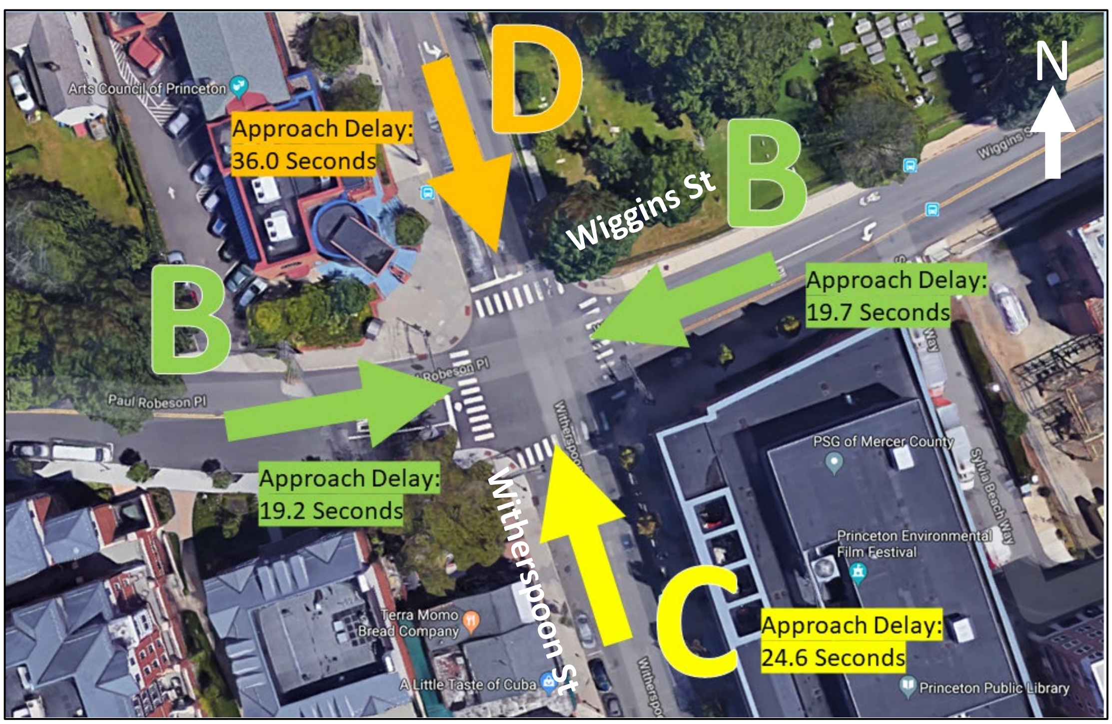


Figure 42: Proposed Level of Service (AM Peak with Exclusive Pedestrian Phase)

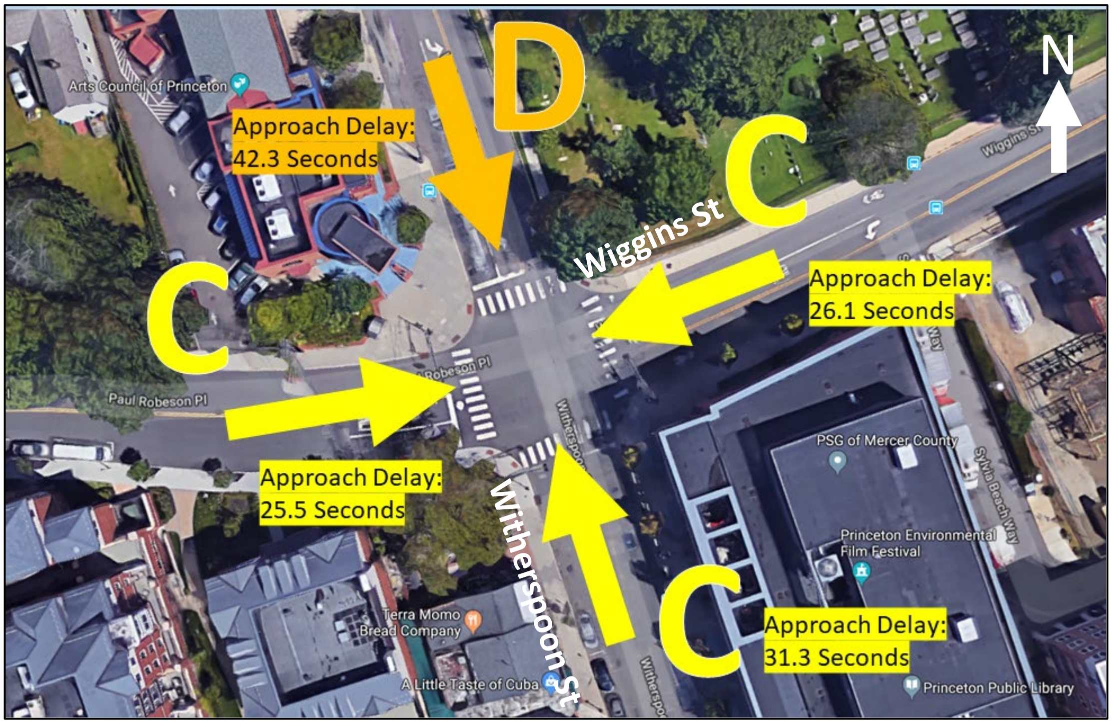


Figure 43: Proposed Level of Service (AM Peak with Exclusive Pedestrian Phase and Northbound Left Turn Lane)

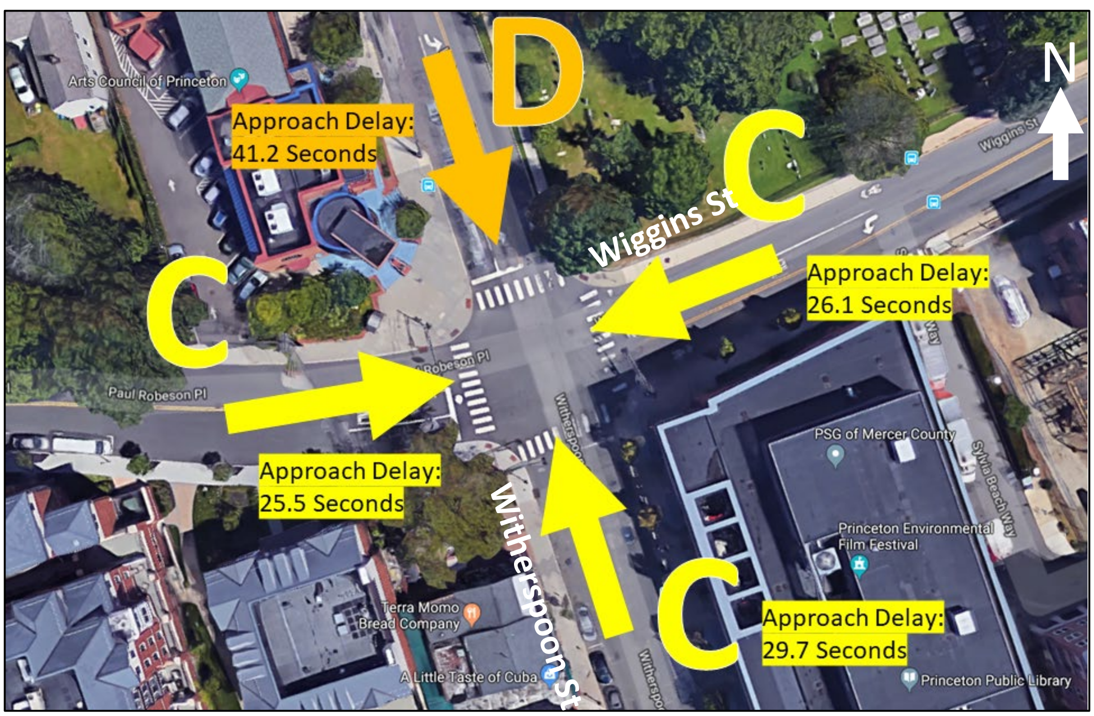


Figure 44: Existing Level of Service (PM Peak)

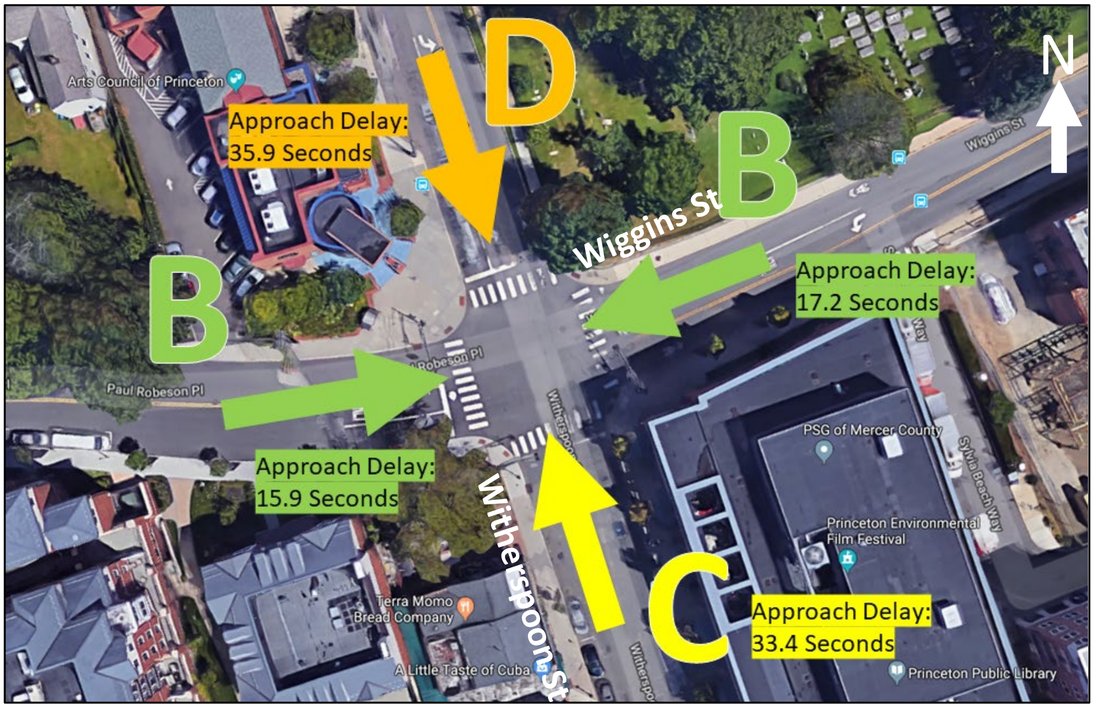


Figure 45: Proposed Level of Service (PM Peak with Lead Pedestrian Interval)

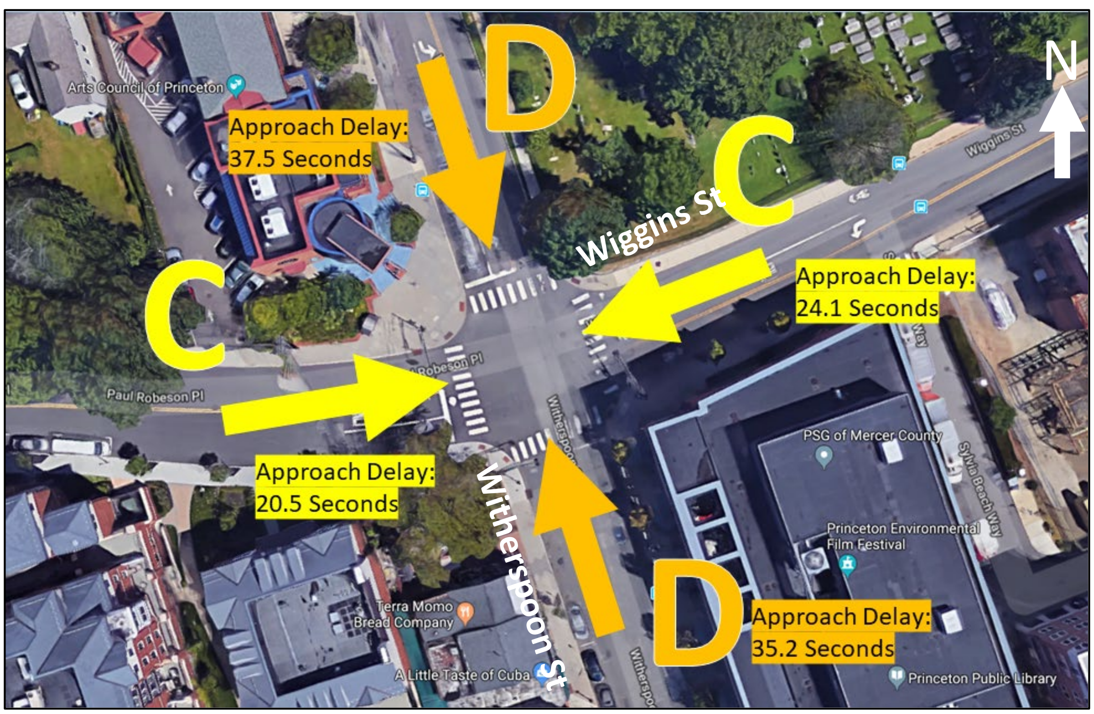


Figure 46: Proposed Level of Service (PM Peak with Lead Pedestrian Interval and Northbound Left Turn Lane)

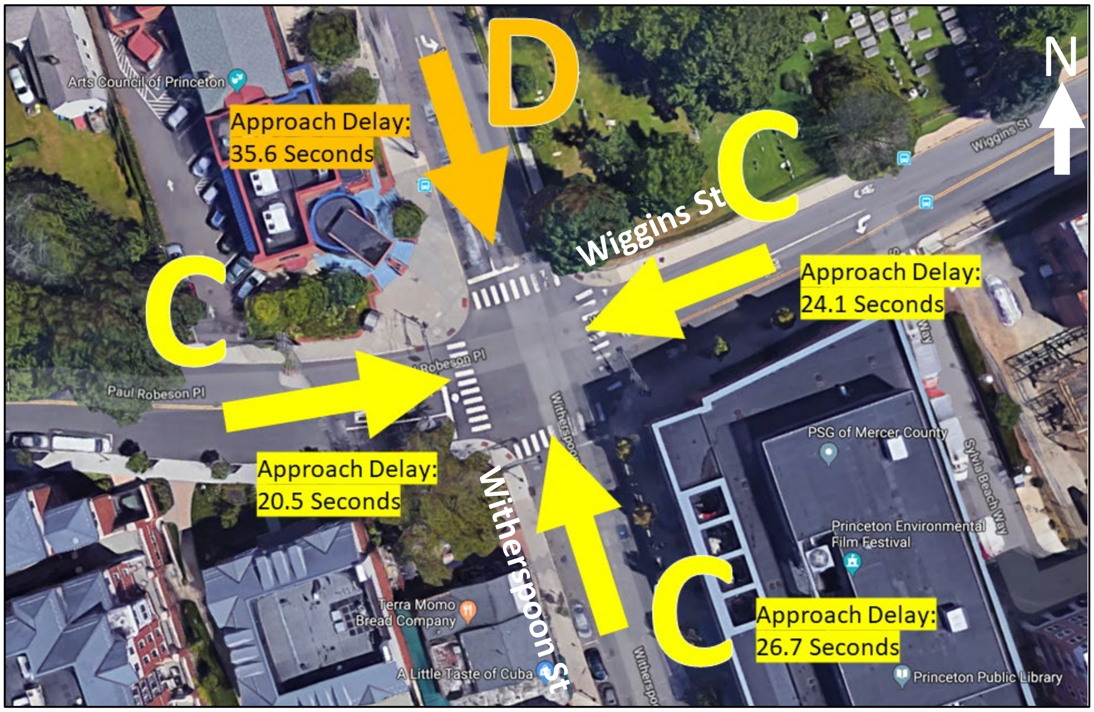


Figure 47: Proposed Level of Service (PM Peak with Exclusive Pedestrian Phase)

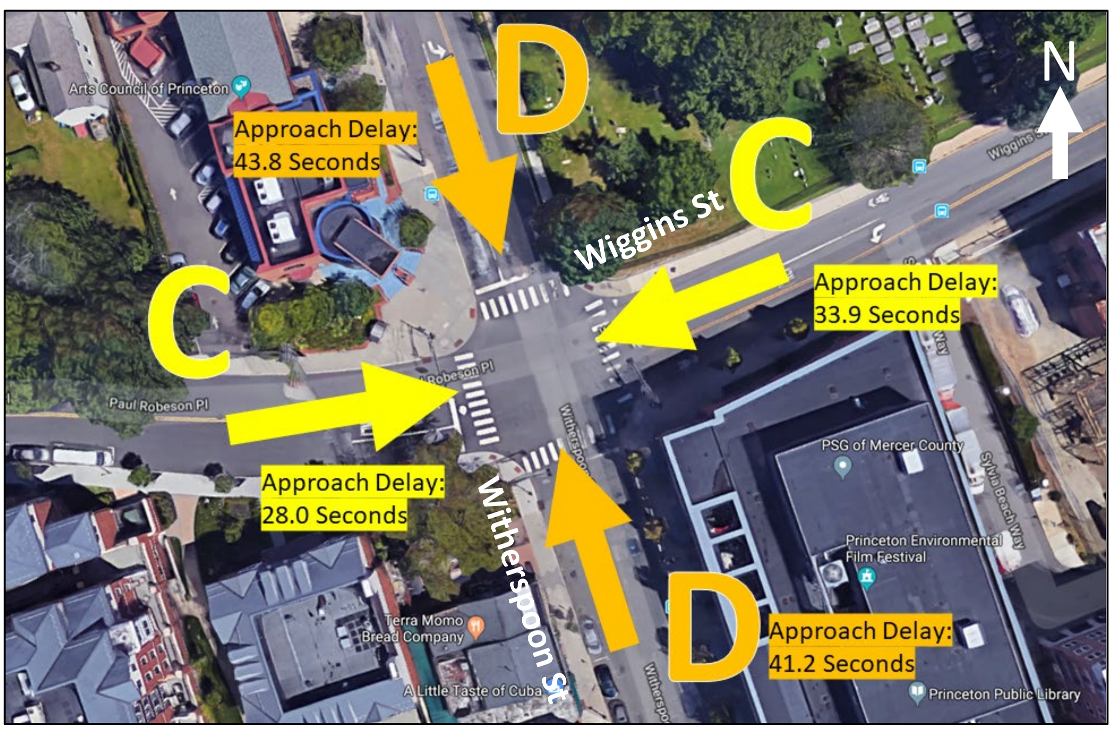
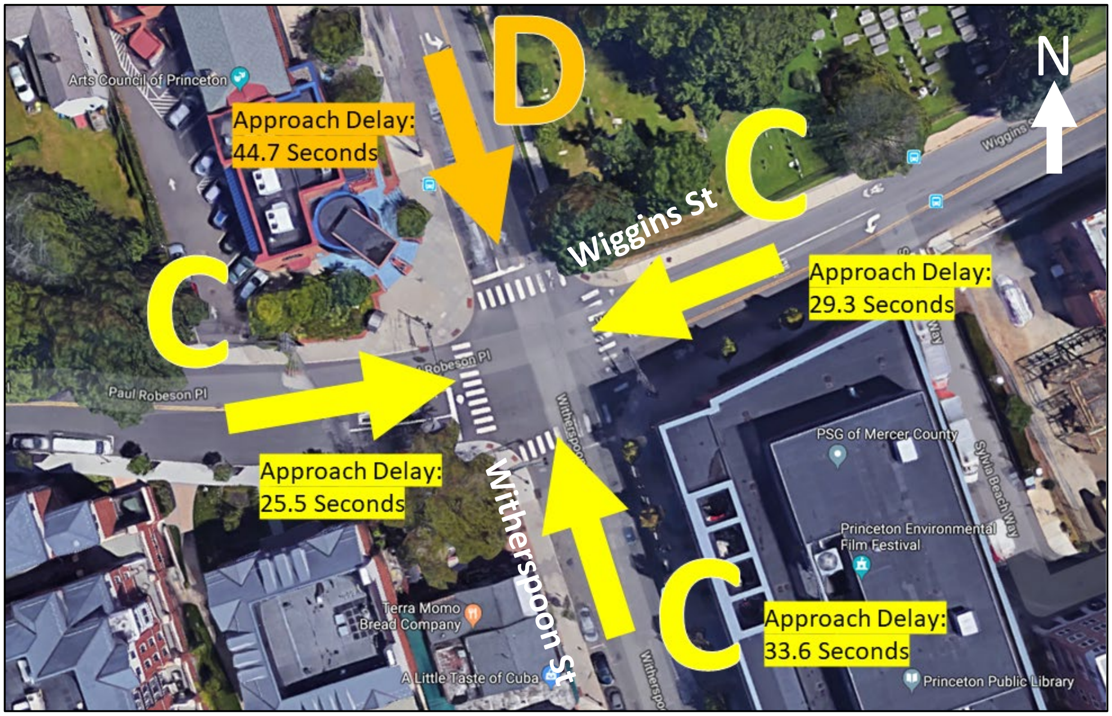


Figure 48: Proposed Level of Service (PM Peak with Exclusive Pedestrian Phase and Northbound Left Turn Lane)



Wiggins Street at Vandeventer Avenue

Existing Conditions

Vandeventer Avenue originates to the north at Wiggins Street and travels south to Nassau Street where it continues south as Washington Road, bisecting the Princeton University campus, and crossing the Delaware & Raritan Canal before intersecting with U.S. 1. Due to this, volumes along Vandeventer Avenue are high, with more than 3,000 vehicles turning at the intersection each day between 6:30 AM and 6:30 PM. Northbound traffic on Vandeventer Avenue has a stop control though sight limitations cause confusion and potentially unsafe situations for motorists turning onto Wiggins Street, and pedestrians crossing Vandeventer Avenue. Due to high volumes on Wiggins Street during peak hours, motorists turning from Vandeventer Avenue often rush to turn when there is a small gap while simultaneously needing to be alert for crossing pedestrians. The south and east legs of the intersection have continental crosswalks. Under existing conditions, this intersection does not meet the warrant for an all-way stop due to insufficiently high volumes on Vandeventer Ave.

An aerial photo of existing conditions at the intersection is shown in Figure 49.

Figure 49: Wiggins Street at Vandeventer Avenue

Potential Improvements

- Investigate a raised crosswalk, or raised intersection (speed table) to calm traffic, daylight the pedestrian crossings, and enhance pedestrian crossing safety
    - These traffic calming elements will slow traffic down without unduly impacting traffic flow. As with any raised or vertical infrastructure, the needs of buses and trucks should be considered.
- Install additional on-road pedestrian crossing signage to improve visibility of crossing and pedestrians

Hamilton Avenue at Moore Street

Existing Conditions

Moore Street travels north, merging with Jefferson Road and eventually intersecting U.S. 206. To the south, the corridor intersects and terminates at Nassau Street. Northbound and southbound traffic are stop-controlled. Similar to Vandeventer Avenue, high volumes on Hamilton Avenue during peak hours can cause motorists to abruptly turn into traffic, creating potentially unsafe conditions for all roadway users. The 124 westbound left turning motorists in the AM peak represent the highest turning volume of any of the unsignalized intersections along the corridor, causing backups and potentially unsafe conditions. This intersection experiences high volumes of pedestrians, particularly children traveling to and from the nearby Princeton Unified Middle School and Princeton High School. Crossing guards serve the intersection during peak times. All legs of the intersection have continental crosswalks. The intersection was found to not meet a warrant for four-way stop controls. An aerial photo of existing conditions at the intersection is shown in Figure 50.

Figure 50: Hamilton Avenue at Moore Street

Potential Improvements

- Investigate installing Rectangular Rapid Flashing Beacon (RRFB) on Wiggins Street and Hamilton Avenue legs to alert drivers of pedestrians and improve yield compliance
    - An RRFB is the combination of signage and an irregular flash pattern of amber LED lights. Together, these increase the visibility of a crossing, and can dramatically improve driver compliance with stopping for pedestrians at a marked crosswalk. An existing RRFB along Alexander Road in Princeton is shown in Figure 51.
- Investigate a raised crosswalk or raised intersection (also known as a speed table) to calm traffic, and daylight the pedestrian crossings
    - These traffic calming elements will slow traffic down without unduly impacting traffic flow. As with any raised or vertical infrastructure, the needs of buses and trucks should be considered
- Install on-road pedestrian crossing signage to improve visibility of crossing and pedestrians

Figure 51: Rectangular Rapid Flashing Beacon (RRFB)

Hamilton Avenue at Walnut Lane/Chestnut Street

Existing Conditions

Chestnut Street travels south from Hamilton Avenue and terminates at Nassau Street. Walnut Lane is the northern leg that provides direct access to Princeton High School, Princeton Unified Middle School, and Westminster Choir College immediately north of the intersection. This driveway to the Westminster Choir College creates conflicts with traffic at the intersection, particularly at times when there are already backups present. Proximity to these schools' results in high peak period pedestrian crossings and high on-street parking demand, necessitating supplemental crossing guards. More than 100 vehicles turn left from eastbound Hamilton Avenue to Walnut Lane, the most of any left turn movement from the eastbound corridor. The roadway geometry limits visibility and compliance with yielding to pedestrians and causes difficulty for left turning vehicles from Walnut Lane/Chestnut Street to Hamilton Avenue. All legs of the intersection have ladder-style crosswalks. An aerial photo of existing conditions at the intersection is shown in Figure 52.

Figure 52: Hamilton Avenue at Walnut Lane/Chestnut Street

Potential Improvements

- Relocate the entrance to Westminster Choir College away from the intersection to reduce conflict points at the intersection
- Install on-road pedestrian crossing signage to improve visibility of crossing and pedestrians
- Redesign the intersection to slow traffic on Hamilton Avenue by tightening the curbs, particularly on the north side
    - Changes to the curb turning radii should consider the need of the many school buses traveling along Walnut Lane accessing Princeton High School and Princeton Unified Middle School, as well as trucks

- Investigate feasibility of installing traffic signal to slow vehicles, improve safety of pedestrian crossings, provide the needed capacity for left-turning vehicles and improve connectivity and mobility between Nassau Street and Hamilton Avenue
    - Traffic signal warrant is met by the number of children crossing intersection to/from school, and projected entering volumes of the intersection being greater than 1,000 vehicles per hour
    - Installation of a traffic signal will provide dedicated time for pedestrians to cross each leg of the intersection, and by assuring dedicated time for vehicles to travel from Walnut Lane and Chestnut Street, a traffic signal will improve the overall traffic flow of the intersection though may cause slight backups along Hamilton Avenue

Pilot Projects

Tightening the intersection, particularly on the north side can be temporarily executed with paint, flexible delineators, and/or rubber/plastic curbs. These temporary materials would provide some insight into how motorists interact with the treatment, particularly the high volume of buses that make this turn, while simultaneously allowing them to become accustomed to the change. These temporary materials can be driven over without injuring motorists.

Figure 53 and Figure 55 below show the existing vehicular level of service during the AM and PM peaks, respectively, while Figure 54 and Figure 56 show the vehicular level of service with the installation of a traffic signal. As seen from the graphics, the level of service would significantly improve with signalization.

Figure 53: Existing Level of Service (AM Peak)

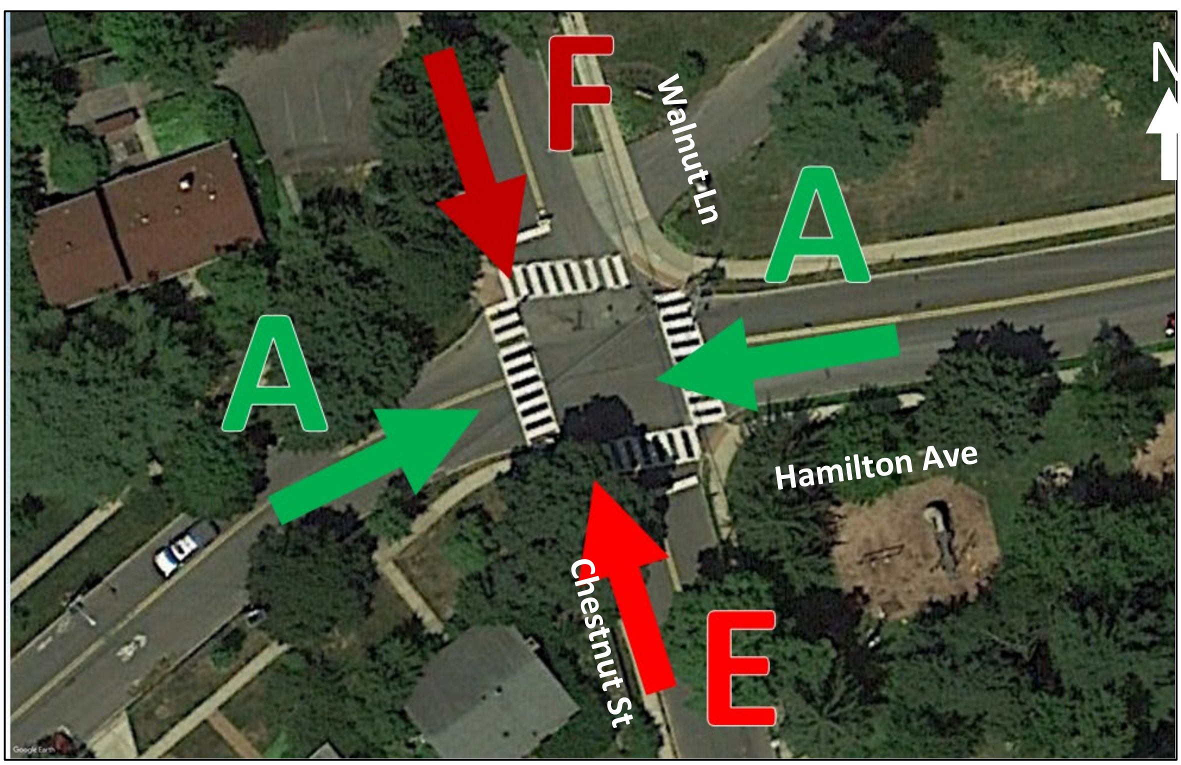


Figure 54: Proposed Level of Service (AM Peak)

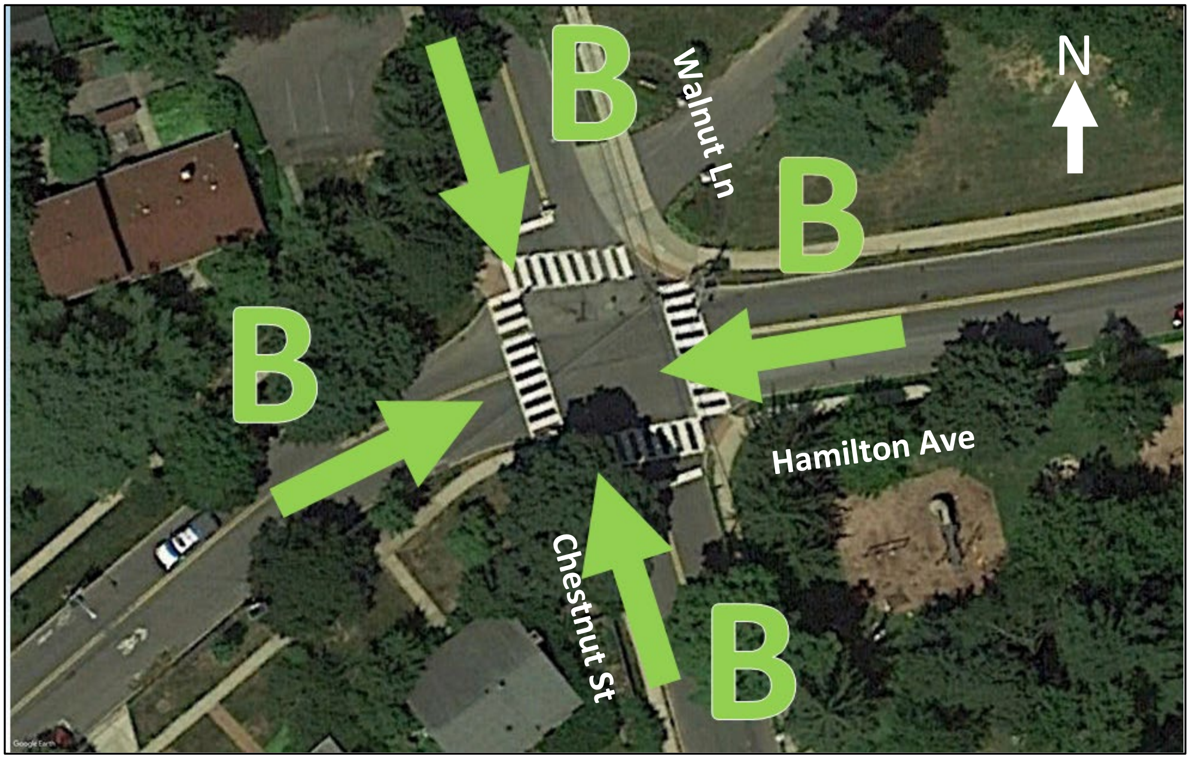


Figure 55: Existing Level of Service (PM Peak)

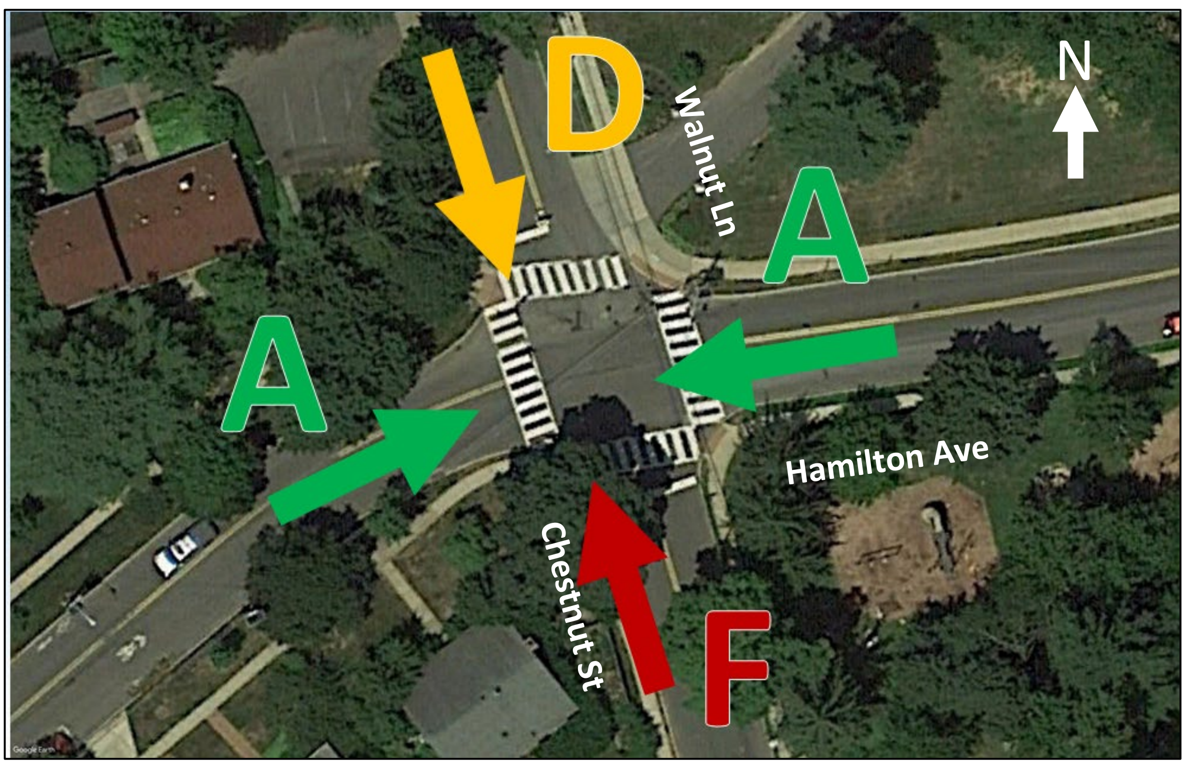
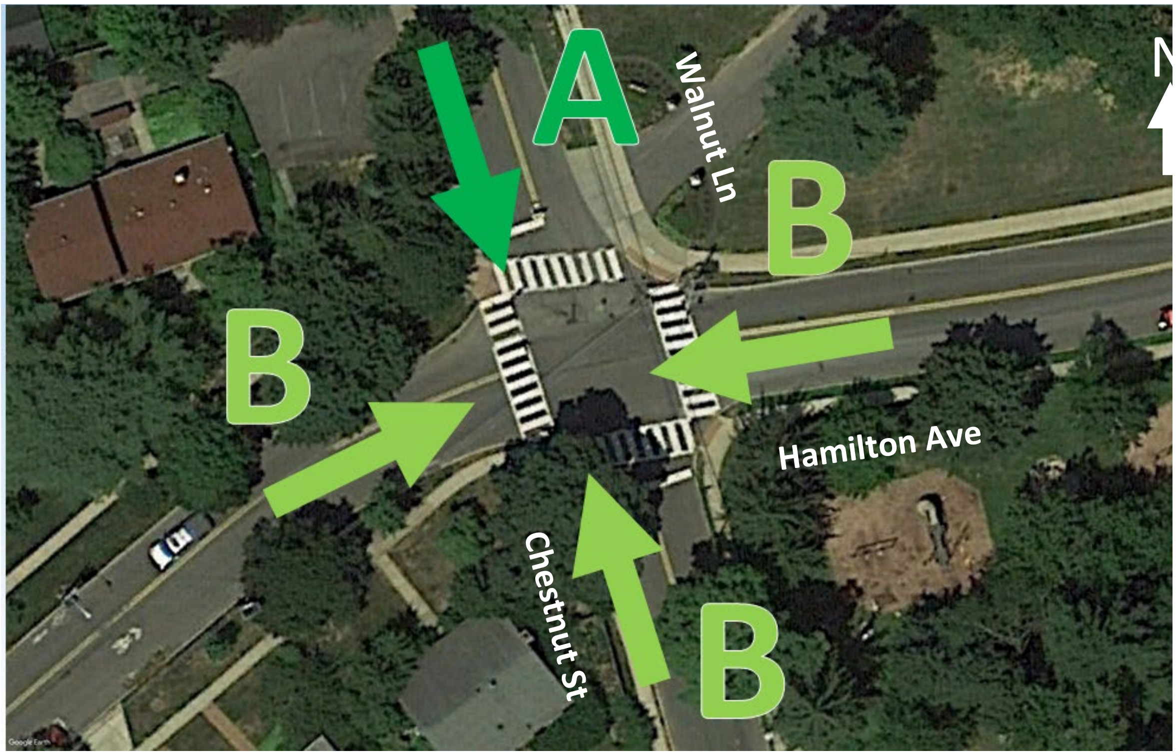


Figure 56: Proposed Level of Service (PM Peak)



Hamilton Avenue at Linden Lane

Existing Conditions

Linden Lane continues south, terminating at Nassau Street, and travels north for a short distance into nearby residential neighborhoods. Due to lower pedestrian volumes, and less parking utilization, this part of the corridor can appear safer to drive at a higher speed, causing higher speeds and unsafe conditions for crossing pedestrians. All four legs of the intersection have ladder-style crosswalks. An aerial photo of existing conditions at the intersection is shown in Figure 57.

Figure 57: Hamilton Avenue at Linden Lane

Potential Improvements

- Investigate a raised crosswalk or raised intersection (also known as a speed table) to calm traffic, and daylight the pedestrian crossings
    - These traffic calming elements will slow traffic down without unduly impacting traffic flow. As with any raised or vertical infrastructure, the needs of buses and trucks should be considered

Pedestrian Improvement Cost Estimates

Cost estimates for the pedestrian improvement concept pieces are provided based on typical implementation. Most of the below data is sourced from “Costs for Pedestrian and Bicyclist Infrastructure Improvements” prepared for the Federal Highway Administration. Costs for several of the improvements are provided below:

- Regulatory Sign (such as a yield sign): $100 per sign
- Roundabout: $85,000
- Curb Extension (each): $12,000
- Crosswalk: $1000 per crosswalk
- Pedestrian Push Button: $1500
- Rectangular Rapid Flashing Beacon: $13,550 per pair
- Raised Crosswalk: $6,500
- Raised Intersection: $50,000

Corridor Improvements

The previously discussed parking analysis reviewed parking utilization along the corridor using existing spaces. If on-street parking is retained, it is recommended that the town consider shifting parking from the eastbound side of the corridor to the westbound side. Doing so would create an additional 29 parallel parking spaces (from 62 to 91) due to the presence of fewer driveways along the westbound side of the roadway. A breakdown of the change in the number of parking spaces per block is provided in Table 15.

Table 15: Proposed Parking Changes

Corridor Segment	Parking Spaces Currently Available		Shift parking along eastbound side of westbound side		Net Change: Shift East Side to West Side	
	EB (Existing)	WB (Existing)	EB (Proposed)	WB (Proposed)	Net Change	% Increase
Bayard Lane (US 206) to Chambers St. (none)	0	0	0	0	0	0%
Chambers St. to Witherspoon St (Metered 3 Hour)	11	17	11	17	0	0%
Witherspoon St to Vandeventer Ave (none)	0	0	0	0	0	0%
Vandeventer Ave to Moore St (Free 2 hour)	12	0	0	15	+ 3	25%
Moore St to Chestnut St (Free No Restrictions)	17	0	0	23	+ 6	35%
Chestnut St to Linden Ln (Free No Restrictions)	24	0	0	34	+10	42%
Linden Ln to Harrison St (Free No Restrictions)	9	0	0	19	+10	111%
Total Parking Spaces	**73**	**17**	**11**	**91**	**+ 29**	**47%**

Princeton should also conduct a study of street lighting along the corridor, particularly the use of pedestrian scale lighting. A pedestrian-scale lighting brochure designed for the New Jersey Department of Transportation is included in the Appendix on page 71. This brochure introduces the benefits and considerations of pedestrian-scale lighting.

The town should also consider amending the local zoning ordinance to streamline approval of T-shaped private driveways to simplify access to the corridor and reduce vehicle conflicts.

Bicycle Facility Concepts

The bicycle lane concepts outlined in this section aim to improve mobility and safety for cyclists along the study corridor. One quantitative measure of determining this is through the previously detailed bicycle level of traffic stress metric. The goal is for the corridor to operate at LTS 1.

The developed concepts considered the potential need for right-of-way and impacts beyond the typical 29'-31' existing cross-section, parking impacts, compatibility with intersection and pedestrian improvements, and the requirement to maintain two 11 foot travel lanes. Eleven-foot travel lanes are required based on the presence of trucks and school buses. Existing roadbed widths are shown beginning on page 5. Existing right-of-way, as obtained from Princeton tax parcel maps, differs throughout the corridor:

- U.S. 206 to Chambers St: 50 feet

- Chambers St to Witherspoon St: 60 feet
- Witherspoon St to Moore St: 50 feet
- Moore St to Chestnut St/Walnut Ln: 70 feet
- Chestnut St/Walnut Ln to N Harrison St: 46-50 feet

For each recommended alternative, the required space needed for the roadbed, bicycle facilities, and sidewalk are provided. The space designated above does not necessarily correspond with the current width of the roadbed along the corridor. In most instances, the roadbed will need to be widened though additional right-of-way may not be necessary.

From these criteria, four bicycle facility alternatives were developed, and two are ultimately recommended for further review. The section concludes with cost estimates for each Alternative, and an additional bicycle recommendation presented from a Princeton Council Member is included in the Appendix.

The section concludes with a discussion of research done for the corridor study investigating the impacts of traffic calming measures on traffic speeds and volumes, as a means of opening the opportunity for other bike facilities.

The implementation of bike infrastructure can have a range of effects on nearby infrastructure and road users. The impact on several of these variables is discussed here:

- Pedestrians
  - Implementation of bike infrastructure typically necessitates greater interactions between cyclists and pedestrians. Under existing conditions without dedicated bicycle facilities, cyclists often ride on the sidewalk, creating conflicts for pedestrians. Dedicated on-road bike infrastructure provides a safe space for cyclists to ride while allowing pedestrians to move at a safe and comfortable speed on the sidewalk unimpeded. The shared use trail facility, discussed below, provides a shared facility for cyclists and pedestrians. To minimize conflicts and allow each user to travel at a comfortable speed, the facility should be built sufficiently wide dependent on cyclist and pedestrian volumes. If a road widening is necessitated to implement bike infrastructure, this will increase crossing distances for pedestrians. Despite this increased distance, the presence of bike facilities can have the impact of slowing traffic down, thus improving safety for pedestrians.
- Curb
  - All pedestrian and bicycle facilities installed above the curb should be ADA accessible. Existing curb lines may need to be moved in certain locations if the roadbed is expanded.
- Drainage
  - Proper and effective drainage should be considered when implementing bike infrastructure. Installation of such facilities can provide the opportunity to deal with any outstanding drainage issues. Existing drainage facilities may need to be moved if the roadbed is expanded.
- Street Trees

  - As many street trees as possible should be maintained when widening the road and/or implementing bike infrastructure. In addition to having a positive visual element and acting as a cue to drive more slowly, street trees improve the overall health of a community.
- Utility Poles
  - Some utility poles may need to be removed to facilitate a road widening and/or implementation of bike infrastructure. Utility companies should be included in the conversation to assure a smooth transit with minimal impacts to the community during construction.
- Left Turn Pockets
  - Existing left turn lanes in the roadway will remain. Where required, a mixing zone between motor vehicles and cyclists will be marked at intersections to ensure the safe movement and turning of motorists and cyclists
- Deliveries and service vehicles
  - Consideration shall be given for stopping, standing and short-term parking activities of delivery companies as well as service vehicles including landscaping companies. If parking is removed, delivery and service vehicles may still stop, stand, and park on-road unless enhanced enforcement activity occurs.

Alternative 1: Existing Shared-Lane Markings

Much of the corridor currently operates with infrequent shared-lane markings, also known as sharrows. An image of this existing facility is shown in Figure 58. Alternative 1 would maintain the existing shared lane facilities. This option would have no financial cost and no right-of-way impacts and is compatible with proposed intersection and pedestrian improvements. On-street parking would be retained with the option of shifting parking to the westbound side for an additional 29 spaces. Shared-lane markings would not improve the existing LTS 3 and 4 corridor and would only cater to the most skilled cyclists. Enhanced shared-lane markings as was recommended in Princeton's 2017 Bicycle Mobility Plan would have similar drawbacks while not meeting current guidance and ineffective at safely promoting biking along the corridor. Both shared-lane and enhanced shared-lane markings would not be compliant with design guidance from the New Jersey Complete Streets Design Guide as shared-lane markings are intended to fill gaps between low-stress bicycle facilities, not serve as a primary facility. Shared-lane markings are not considered appropriate along the study corridor due to volumes being more than 10,000 vehicles per day and 85th percentile vehicular speeds greater than 25 mph.

Due to these reasons, Alternative 1 is not recommended.

Figure 58: Shared-Lane Markings

Alternative 2: Bicycle Lanes

Alternative 2 would involve installing dedicated bike facilities, without a buffer (also called standard bicycle lanes) on both sides of the street between Bayard Street and North Harrison Street, *if volumes and speeds are able to be lowered using traffic calming measures*. This alternative is listed as a long-term recommendation for this corridor in the 2017 Bicycle Master Plan. Discussion concerning the ability to lower speeds and volumes along the corridor to allow for installation of bike lanes begins on page 65. An example of a standard bicycle lane is shown in Figure 59. The roadbed would need to be widened; the specific amount of which would be determined based on the desired bike lane widths and bicycle level of traffic stress. The following options are available and are based on the LTS statistical analysis and New Jersey Complete Streets Design Guide:

- 5 foot bike lanes require a 32 foot cross-section resulting in an LTS 3
- 5.5 foot bike lanes require a 33 foot cross-section resulting in an LTS 2
- 6 foot bike lanes require a 34 foot cross-section resulting in an LTS 1

Although the Complete Streets Design Guidelines refer to metrics that indicate any bike lane 5.5 feet or less should be an LTS 2, our methodology recognizes that fewer people may be comfortable at 5 feet than 5.5 feet and therefore lowers the LTS assignment.

Five feet is the minimum width recommended for bike lanes based on the New Jersey Complete Streets Design Guide. Wider lanes are recommended where space allows as they facilitate a more comfortable ride and can provide a small buffer from traffic. Based on the added comfort provided by increased width, wider lanes are designated with a lower (more comfortable) bicycle level of traffic stress. Bike lanes are not recommended wider than six feet due to the ability for motor vehicles to park or idle in such facilities. Each of the widths provided above refer to the width of the bike facility itself. *At existing speeds and volumes,* it would be necessary to provide a painted buffer (typically 1.5' to 3') for added horizontal separation from moving traffic. Such a buffer would necessitate additional roadway widening 3-6 feet above and beyond the widening for standard bike lanes. Sidewalks add 5 feet on each side to the right-of-way width required.

The presence of dedicated bike facilities as such would require removal of all 73 parking spaces along the corridor which may result in an increase in travel speeds.

Alternative 2 is a recommended alternative if traffic calming measures can reduce the volumes and traffic speeds to acceptable levels for a LTS 1 facility.

Figure 59: Standard Bicycle Lane

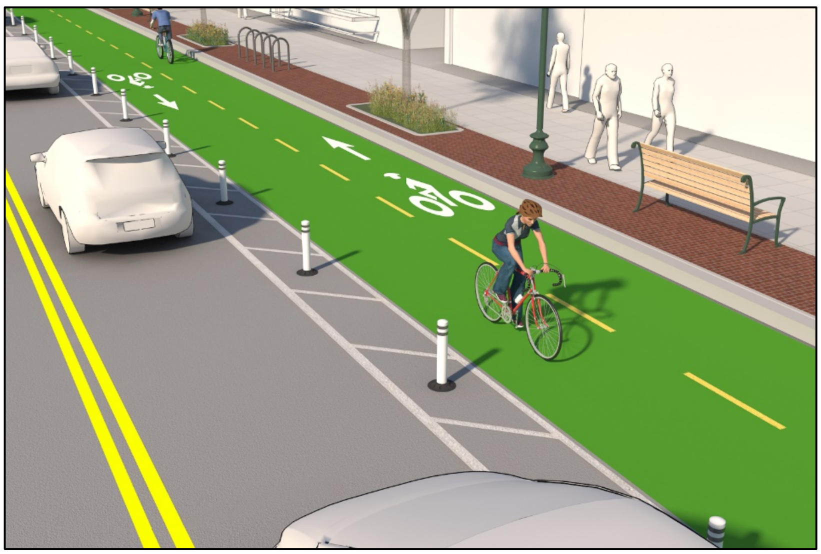
Alternative 3: Two-Way Separated Bicycle Lanes

Alternative 3 involves allocation of two-way separated bicycle lanes, also known as a cycle track. The two-way separated lanes would involve the eastbound and westbound bicycle lanes being located on the same side of the street and require a vertical buffer (such as flexible delineators) separating the lanes from motor vehicle traffic. The facility dedicates and protects space for bicyclists and improves perceived comfort and safety. The side of the street the facility would be located on would be chosen by Princeton based on how the facility would interact with intersecting streets, driveways, and land uses. A rendering from the New Jersey Complete Streets Design Guide of such a facility is shown in Figure 60. Based on guidance from the New Jersey Complete Streets Design Guide, the minimum width of the two-way bicycle lanes is 10 feet with 12 feet preferred. The minimum width of the buffer is 1.5 feet with 3 feet preferred. All 73 parking spaces would need to be removed. To accommodate the two 11-foot travel lanes, two-way separated bike lane, and five foot ADA-accessible sidewalks on either side of the street, between 43.5 and 47 feet of right-of-way would be required. Note, this does not include a green buffer between the road and sidewalk or bike facility and sidewalk.

This type of bike facility is typically not recommended where driveways are frequent due to the added risk of conflicts. This alternative would provide dedicated space for cyclists and facilitate an LTS 1 facility throughout the corridor, making it more attractive to a wide range of bicyclists at all levels and ages. The horizontal and vertical barrier provided by the buffer would reduce the risk of 'dooring' from parked vehicles. The density of driveways along the corridor would present challenges for a two-way separated bike facility though such difficulties could be minimized with proper signage, education, and enforcement. There would be similar challenges for users of the bike facility as are present for users along sidewalks crossing driveways. Treatments that can be used to improve safety at driveways include installing pavement markings through the driveway to draw attention to entering motorists, yield signs for drivers, and ensuring proper sight triangles. Cyclists making left turns would stop and bike across crosswalks to access perpendicular streets. Cyclists would enter and exit the bike facility at intersections. An additional challenge would be visibility of bicyclists for turning motorists. While moving straight through intersections, cyclists would need to slow down and look to ensure no vehicles were turning.

Due to these reasons, Alternative 3 is not recommended.

Figure 60: Two-Way Separated Bicycle Lanes



Alternative 4: Shared-Use Sidepath

Alternative 4 involves installing an off-road shared-use sidepath along the entire study corridor. Sidepaths are distinctly separate from the roadway, separated physically from traffic by either open space or a barrier. Sidepaths accommodate cyclists and pedestrians traveling in both directions. The minimum sidepath width for short segments is 8 feet while the majority of the facility should be at least 10 feet, dependent on need. A horizontal buffer of any distance between the sidepath and roadway is acceptable. Accommodating two 11-foot travel lanes, the ten foot shared-use sidepath, and a five foot sidewalk on the opposite side would require use of at least 37 feet of the right-of-way, plus at least two feet on each side for a grass buffer between the road and the shared-use path or sidewalk.

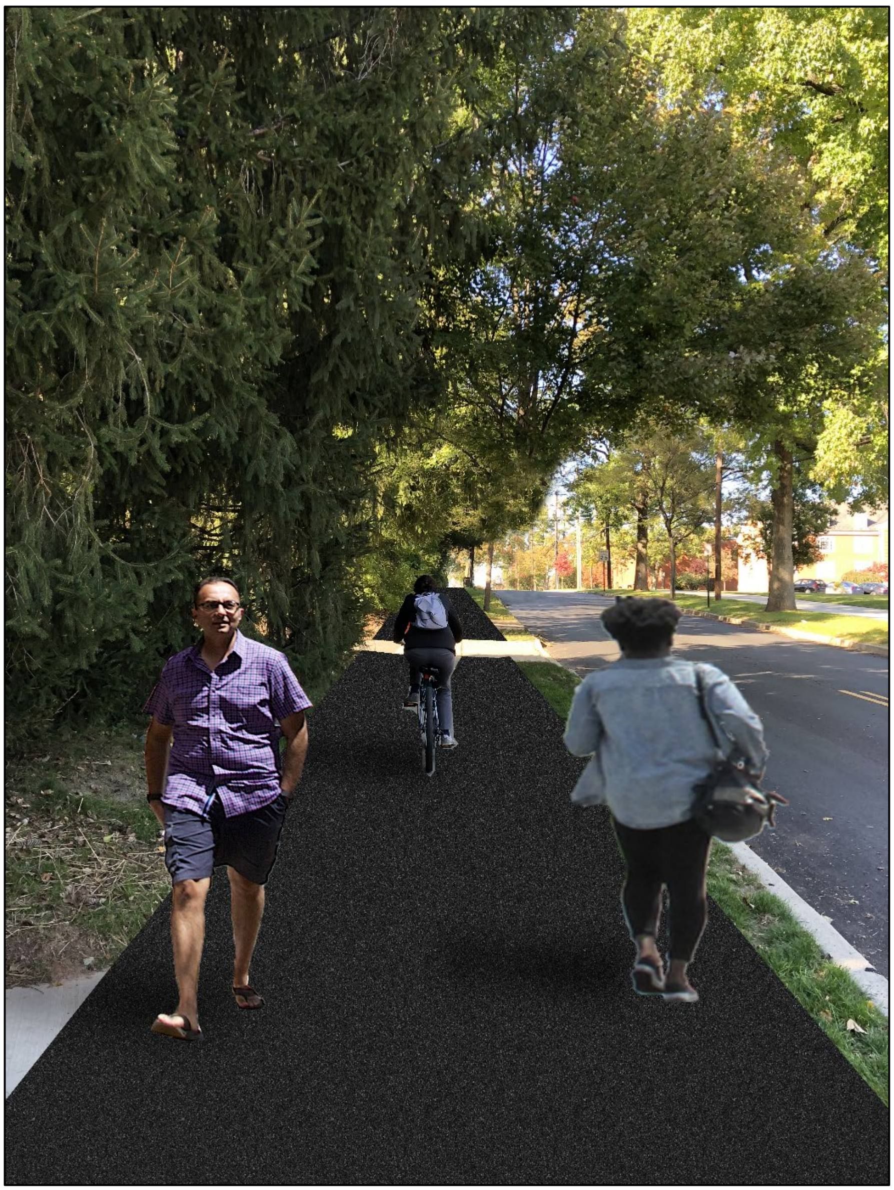
Similar to a two-way separated bike facility, appropriate indications and warnings should be provided for both the path user and roadway user to prevent conflict. Users of a sidepath would need to stop at intersections to ensure no conflicts with motorists are present, similar to pedestrians crossing the street. Along the sidepath, higher speed cyclists would be required to yield to and travel around pedestrians. Cyclists and pedestrians would enter and exit the facility at crosswalks.

Along the study corridor, additional right-of-way would need to be obtained to widen the existing sidewalk to the appropriate width. Alternative 4 would provide the lowest stress facility type for cyclists and eliminate most vehicular conflicts.

A rendering of the shared-use sidepath is provided in Figure 61.

Alternative 4 is recommended for further review, analysis, and consideration by Princeton.

Figure 61: Shared-Use Sidepath



Pilot Projects

Under existing conditions, Princeton can implement a pilot bike lane (also known as a pop-up bike lane). Parking can be temporarily removed from certain blocks (or the entire corridor) and replaced by a combination of raised temporary materials such as cones, flexible delineators and concrete (see Figure

62). This treatment has the benefit of allowing Princeton to determine the days, times, and precise locations of the treatment. The treatment should be undertaken at multiple times of day, and on various days of the week to result in more comprehensive results for analysis. The pilot should also overlap with any seasonal peaks in biking, walking or parking along the corridor. Temporarily removing the parking would yield an additional eight feet of available width. With the existing constraints posed by the narrow portions of 30' roadway width along most of the corridor, a five foot one-way bike lane with a three foot buffer pilot is recommended. The buffer could be either raised or horizontal. Five foot standard bike lanes in either direction with ten foot travel lanes are not recommended as a pilot project. The relatively high volume, speeds, and bus and small truck traffic would create unsafe conditions for cyclists and motorists with narrowed lanes and unbuffered bike facilities. Potential means of reducing speeds and volumes are detailed beginning on page 65.

Pilot bike lanes are often installed for one month to one year, but due to the capital investment required for such a pilot, Princeton may wish to pilot the bike facility for between six months and one year. Due to existing width constraints, the pilot bike facility must be one-way. Width constraints do not allow piloting of Alternative 4 (shared-use sidepath).

Figure 62: Temporary Concrete Bike Facility in Winnipeg, Canada

Bicycle Facility Cost Estimates

Each recommended bicycle facility requires a different amount of excavation and paint, resulting in vast differences in their cost. While providing a safe facility along the corridor is of the utmost concern, cost must also be taken into account. Rough cost estimates for Alternatives 2, 3, and 4 are provided below though existing site and land use conditions can substantially vary the cost. Cost estimates do not include any costs for potential right-of-way acquisition, curb removal and relocation, driveway replacements, storm sewer inlet and piping replacement, utility relocation, tree removal and replacement, etc.

- Alternative 2 (Standard Bicycle Lanes): $16,000
- Alternative 3 (Two-Way Cycle Track): $47,000

- Note that the width of the buffer only contributes minimally (less than 1% difference in cost) to the cost
- Alternative 4 (Shared-Use Sidepath): $500,000-$750,000
  - An 8-foot sidepath would cost closer to the lower end of the range while a 12-foot sidepath would cost closer to the upper end of the range.

Bicycle Recommendation Conclusions

Under the present traffic conditions of the study corridor, Alternatives 2 and 4 are recommended for further review. Each of these provide a more protected bicycle facility than currently exists and builds upon the recommendation of enhanced shared-lane markings made in Princeton's 2017 Bicycle Mobility Plan.

Traffic Calming Impacts

Subsequent to the initial data review and development of concepts and recommendations, the project team created a memo determining the impact of traffic calming measures on speeds and volumes. This was undertaken to judge if traffic calming measures implemented prior to a corridor-wide bike facility could reduce speeds and/or volumes sufficiently to warrant an adjustment in the bicycle recommendations.

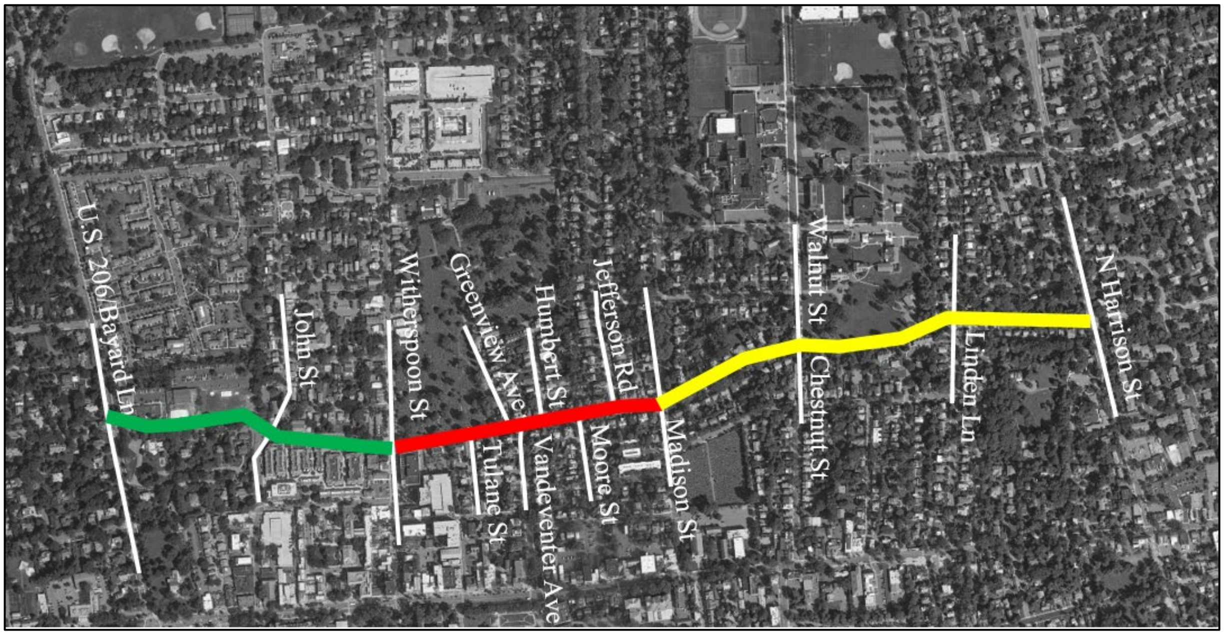
For the purposes of evaluating the impact of traffic calming elements, the corridor is split into three segments based on roadway width, and existing speed and volume data.

Table 16 shows the existing volume and speed for each segment, mapped and color coded in Figure 63. As discussed below, numbers in red are those that must be reduced in order to meet the criteria for a standard bicycle lane.

Table 16: Existing Speeds and Volumes

Street	Color on Map	Extents	AADT (vpd)	AM Peak Vol (vph)	PM Peak Vol (vph)	85% Speed (mph)
Paul Robeson Pl	Green	U.S. 206 and Witherspoon St	8065	652	753	29
Wiggins St	Red	Witherspoon St and Moore St	**11,313**	821	1,002	27
Hamilton Ave	Yellow	Moore St and N Harrison St	7200	557	636	**31**

Figure 63 : Traffic Calming Segments



According to the New Jersey Department of Transportation's Complete Streets Design Guide, the segment between Chestnut Street and North Harrison Street currently meets the criteria for a buffered bicycle lane, separated bicycle lane, or shared-use path due to the 31 mph 85th percentile speed. With the existing volumes, if the 85th percentile speed was one mile per hour lower (30 mph), the segment would be eligible for a standard bicycle lane.

The central portion of the corridor (from Witherspoon Street to Chestnut Street) has an 85th percentile speed below 30 mph, but a volume greater than 10,000 ADT which meets criteria for buffered bicycle lanes, separated bicycle lanes, or a shared-use path.

The western portion of the corridor (between U.S. 206 and John St) meets criteria for a standard bicycle lane, buffered bicycle lane, separated bicycle lane, or shared-use path due to an ADT below 10,000 and an 85th percentile speed below 30 mph.

For the entire corridor to be eligible for a standard bicycle lane, the ADT of the central portion of the corridor must be reduced from 11,313 to less than 10,000, and the eastern portion's 85th percentile speed must be reduced from 31 mph to 30 mph.

A literature review of the proposed traffic calming measures for each study corridor intersection was conducted to determine whether the proposed treatments would likely reduce the traffic volume and 85th percentile speed sufficiently to allow for standard bike lanes. This is summarized below.

Traffic Calming Conclusions

The primary traffic calming means recommended in this study with adequate data available in the literature review are raised crosswalks, raised intersections and roundabouts. The impact of removing on-street parking was reviewed in the literature but returned minimal and inconclusive results.

Traffic calming treatments have been found to result in small decreases in traffic volume and significant reductions in traffic speeds. It is likely that recommended improvements along the eastern segment of the corridor (specifically raised crosswalks/intersections at Moore and Linden Streets, and a traffic signal at Walnut Lane/Chestnut Street) would result in the at least one mile per hour reduction in 85th percentile speed required to make the segment eligible for a standard bike lane.

Conclusions concerning the impact of traffic calming on traffic volumes is less conclusive. Relevant data for impacts on traffic volumes tends to be more general and anecdotal though a traffic model study from Tennessee State University did result in traffic volume decreases greater than the 11.6% decrease necessary along the central segment of the corridor to reduce the volume to below 10,000 AADT and thus be eligible for a standard bike lane. This outcome cannot be guaranteed, though the literature makes it clear that the likelihood of a significant decrease in traffic volume would be maximized by placing traffic calming measures as close together as is feasible. The proposed roundabout would lower 85th percentile speeds, but due to improved traffic flow may actually increase traffic volumes (at least for that segment of the corridor).

Increased use of traffic calming treatments should be placed at all intersections to maximize safety and volume reductions, such as curb extensions and/or raised intersections/crosswalks. To maximize the effectiveness of traffic calming measures, treatments should be installed frequently. A study titled "Simulating the Impact of Traffic Calming Strategies" from the Transportation Research Center for Livable Communities and Tennessee State University determined its best to locate traffic calming measures 630 feet or less from one another. This same study found a 23% reduction in volume with speed tables placed 1050 feet apart and a 32% volume reduction with speed tables placed 350 feet apart. Ample space should be provided between intersections and traffic calming devices though treatments should be located as frequently as their engineering allows.

Installation of several traffic calming devices along the corridor is likely to result in the necessary speed and volume reductions to allow for the recommendation of dedicated on-street bicycle facilities. Such a treatment would require removal of the corridor's on-street parking and/or a widened roadway.

Final Recommendations

As a result of reviewing and analyzing existing conditions along the corridor, a variety of pedestrian and biking improvements are recommended for the corridor. Intersection improvements include the following, with details shown in the table below:

- Realign intersections for improved visibility and safety
- Investigate feasibility of installing a roundabout to slow traffic
- Investigate adding a dedicated turn lane to reduce traffic backups
- Implement leading pedestrian interval to ease pedestrian crossing movements
- Install raised crosswalks, raised intersection, in-road pedestrian crossing signs, and rectangular rapid flashing beacon to slow traffic and improve visibility of pedestrians and pedestrian crossings
- Install traffic signal to improve traffic flow and provide dedicated time for crossing pedestrians

Recommendations

Intersection Concepts	
U.S. 206 at Paul Robeson Place	Align westbound Paul Robeson Pl with westbound Hodge Rd receiving lane
	Redesign geometry of channelized right turn from northbound Bayard Ln to eastbound Paul Robeson Pl
	Install additional yield signage along channelized right turn from northbound Bayard Ln to eastbound Paul Robeson Pl
Paul Robeson Pl at Chambers St	Option A: Remove channelized right turn on Chambers Street to Paul Robeson Pl and investigate feasibility of constructing a roundabout
	Option A: Install crosswalks and curb extensions along each leg
	Option B: Tighten the turning radii for both channelized right turns
	Position pedestrian push buttons next to the sidewalk
	Install crosswalk on the west leg
	Install crosswalk across channelized right turn from eastbound Paul Robeson Pl
Paul Robeson Pl at Witherspoon St	Option A: Investigate implementing leading pedestrian interval
	Option B: Implement exclusive pedestrian phase (Barnes Dance)
	Replace “No Right on Red” with electronic version
	Add northbound left turn lane from Witherspoon St to Paul Robeson Pl
Wiggins St at Vandeventer Ave	Install raised crosswalk or raised intersection
	Install additional on-road pedestrian crossing signage
Hamilton Ave at Moore St	Install Rectangular Rapid Flashing Beacon on Wiggins St/Hamilton Ave legs
	Install raised crosswalk or raised intersection
	Install on-road pedestrian crossing signage
	Relocate entrance to Westminster Choir College away from intersection

Hamilton Ave at Walnut Ln/Chestnut St	Install on-road pedestrian crossing signage
	Redesign intersection by tightening curbs, particularly on north side
	Install traffic signal
Hamilton Ave at Linden Ln	Install raised crosswalk or raised intersection
Corridor Improvements	
Parking	Shift parking from eastbound side to westbound side
Street Lighting	Conduct street lighting study
Zoning	Amend local zoning ordinance to streamline approval of T-shaped private driveways
Bicycle Recommendations	
Alternative 2	Further review proposal of bike lanes
Alternative 4	Further review proposal of shared-use sidepath
Traffic Calming	Implement horizontal and vertical traffic calming measures throughout corridor

Additionally, it is recommended that on-street parking be moved from the eastbound direction to the westbound direction of the corridor to add 29 parking spaces.

Parking Recommendations

Corridor Segment	Parking Spaces Currently Available		Shift parking along eastbound side of westbound side		Net Change: Shift East Side to West Side	
	EB (Existing)	WB (Existing)	EB (Proposed)	WB (Proposed)	Net Change	% Increase
Bayard Lane (US 206) to Chambers St. (none)	0	0	0	0	0	0%
Chambers St. to Witherspoon St (Metered 3 Hour)	11	17	11	17	0	0%
Witherspoon St to Vandeventer Ave (none)	0	0	0	0	0	0%
Vandeventer Ave to Moore St (Free 2 hour)	12	0	0	15	+ 3	25%
Moore St to Chestnut St (Free No Restrictions)	17	0	0	23	+ 6	35%
Chestnut St to Linden Ln (Free No Restrictions)	24	0	0	34	+10	42%
Linden Ln to Harrison St (Free No Restrictions)	9	0	0	19	+10	111%
Total Parking Spaces	**73**	**17**	**11**	**91**	**+ 29**	**47%**

To better facilitate the demand for cycling along the corridor and through Princeton, four alternatives were developed. Two of these alternatives, bike lane and shared use sidepath, are recommended for further review by Princeton to determine which treatment would be preferable. Each of these facilities would vastly improve and safety and comfort of cyclists. It is also recommended that additional traffic calming treatments be placed between intersections to reduce speeding and potentially defer volumes to nearby roads. This reduction in volumes and speeding will allow the safe implementation of other bike facility options.

Together, the recommended improvements will improve the comfort and ability to bike, walk, or drive along the corridor.

Appendix

Pedestrian-Scale Lighting Brochure

Municipal Role

New Jersey counties provide limited support in pedestrian-scale lighting. Primary responsibility lies with municipalities.

Responsible Agencies

- Municipal planning and zoning boards
  - Subdivision ordinances and site plan review
  - Can require developments of certain size to install pedestrian lighting
  - Can require lighting goals in comprehensive master plan

Funding

- Various agencies provide funding for pedestrian-scale lighting

NJ TRANSIT The Way To Go. | NJTPA | South Jersey Transportation Planning Organization | Delaware Valley Regional Planning Commission (dvrpc) | The State of New Jersey Department of Transportation

Crime Prevention Through Environmental Design (CPTED)

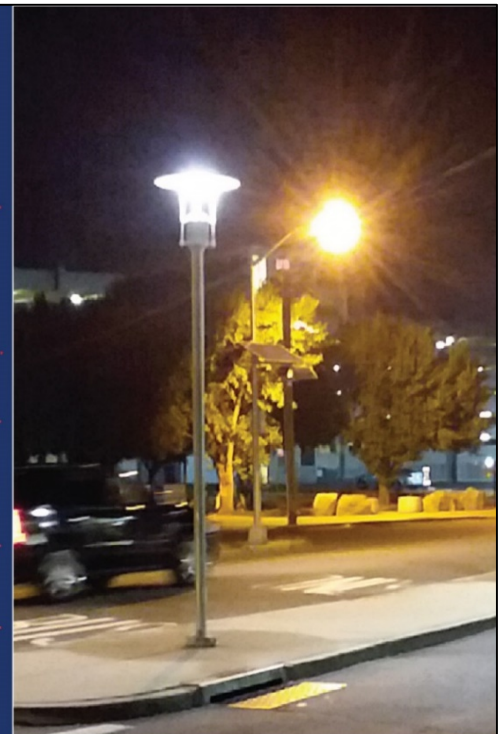
- Arizona State University's Center for Problem-Oriented Policing described CPTED as "an approach to problem solving that asks, what is it about this location that places people at risk, or that results in opportunities for crime? In other words, why here?"

A 2018 study from the *International Journal of Sustainable Transportation* reported "proper street lighting is the main contributor to enhancing the feeling of safety [for pedestrians] on streets."

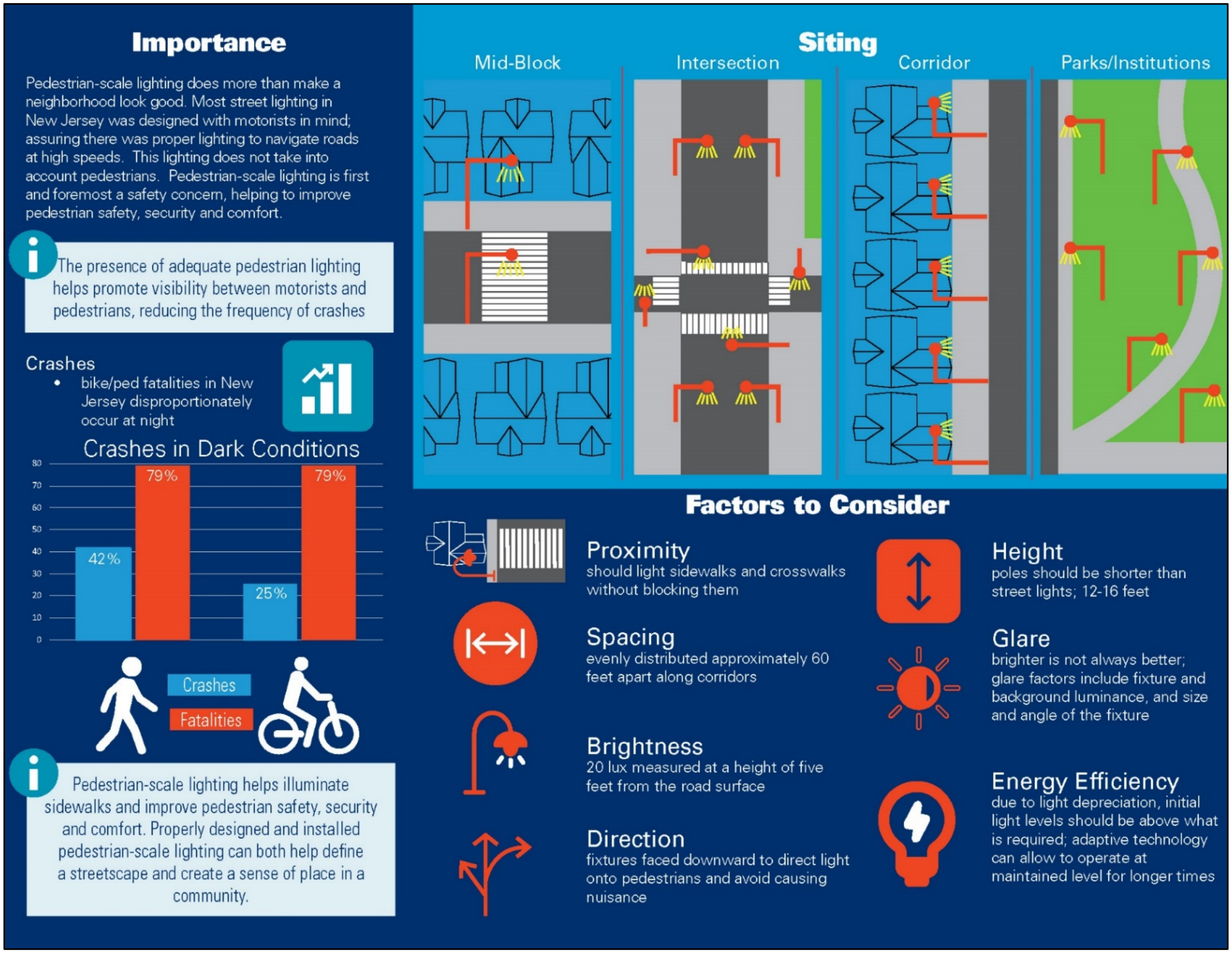
Key Resources

Numerous agencies and organizations have published research and guidance concerning pedestrian-scale lighting best practices. Some are listed below:

New Jersey Department of Transportation Pedestrian Compatible Planning and Design Guidelines	https://www.state.nj.us/transportation/about/publicat/pdf/PedComp/pedintro.pdf
New Jersey Outdoor Lighting Ordinance Guide	https://www.nj.gov/dep/opsc/docs/Sample_Lighting_Ordinance.PDF
Voorhees Transportation Center Report on Pedestrian Lighting in New Jersey: A Means to Improve Pedestrian Safety	http://vtc.rutgers.edu/wp-content/uploads/2014/07/Pedestrian_Lighting_NJ_Final_Report.pdf
Pedestrian and Bicycle Information Center	http://www.pedbikeinfo.org/webinars/webinar_details.cfm?id=13
FHWA Informational Report on Lighting Design for Midblock Crosswalks	https://www.fhwa.dot.gov/publications/research/safety/08053/
U.S. Department of Energy Report on Pedestrian Friendly Outdoor Lighting	https://www1.eere.energy.gov/buildings/publications/pdfs/ssl/2013_gateway_pedestrian.pdf
Seattle Pedestrian Lighting Citywide Plan	http://www.seattle.gov/Assets/Documents/Departments/SDOT/About/DocumentLibrary/PedMasterPlan/PedLightingFINAL.pdf
Chandler (AZ) Report on Crime Prevention Through Environmental Design	http://www.chandlerpd.com/wp-content/uploads/2010/12/CPTED-Handbook-v4-20170627.pdf



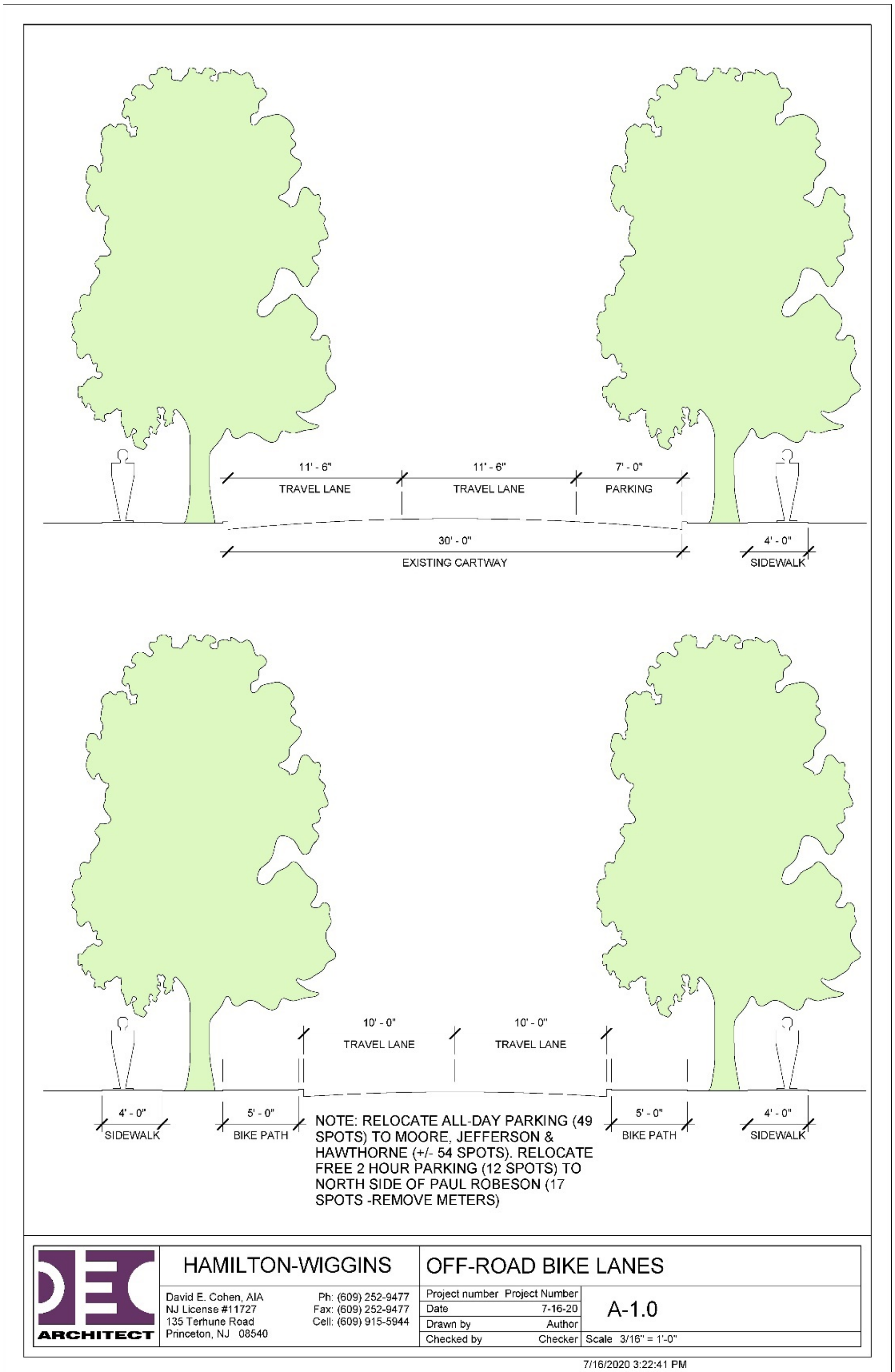
Pedestrian-Scale Lighting Guide for New Jersey


Importance
Pedestrian-scale lighting does more than make a neighborhood look good. Most street lighting in New Jersey was designed with motorists in mind; assuring there was proper lighting to navigate roads at high speeds. This lighting does not take into account pedestrians. Pedestrian-scale lighting is first and foremost a safety concern, helping to improve pedestrian safety, security and comfort.
The presence of adequate pedestrian lighting helps promote visibility between motorists and pedestrians, reducing the frequency of crashes
Crashes
• bike/ped fatalities in New Jersey disproportionately occur at night
Crashes in Dark Conditions
80
70
60
50
40
30
20
10
0
42%
79%
25%
79%
Crashes
Fatalities
Pedestrian-scale lighting helps illuminate sidewalks and improve pedestrian safety, security and comfort. Properly designed and installed pedestrian-scale lighting can both help define a streetscape and create a sense of place in a community.
Siting
Mid-Block
Intersection
Corridor
Parks/Institutions
Factors to Consider
Proximity
should light sidewalks and crosswalks without blocking them
Spacing
evenly distributed approximately 60 feet apart along corridors
Brightness
20 lux measured at a height of five feet from the road surface
Direction
fixtures faced downward to direct light onto pedestrians and avoid causing nuisance
Height
poles should be shorter than street lights; 12-16 feet
Glare
brighter is not always better; glare factors include fixture and background luminance, and size and angle of the fixture
Energy Efficiency
due to light depreciation, initial light levels should be above what is required; adaptive technology can allow to operate at maintained level for longer times

Supplemental Bike Recommendation from Councilmember Cohen

The original bicycle mobility plan calls for bike lanes in this area long-term, not a shared-use side path, and I think for good reason. The amount of pedestrian traffic is too great to have bicyclists share the same real estate, even a 10' shared sidepath is not wide enough for two-way bike and ped traffic.

This proposal keeps all the changes within the existing cartway, saving expense and time for acquiring right-of-way. Critically, it lowers the LTS by elevating the bike paths on the sides of the road, rather than providing on-road bike lanes. This solves any difficulties associated with snow removal from buffered on-road bike lanes. It loses no parking spaces (just relocates them, in many cases closer to the users' destinations than the existing spaces). It preserves all street trees. The 10' travel lanes should be fine since truck traffic really does not need to travel on Hamilton-Wiggins – all trucks which traverse Paul Robeson are for the most part traveling to Witherspoon from 206.



Response to Councilmember Cohen's Suggestion

The largest issue is that with a raised bike lane you would want to see some level of separation between the bike lane and adjacent travel lane – a minimum of 1 foot but 3 feet is preferred. The AADT is pretty high in this area for 10 foot lanes, given there are also buses that travel this route, if there is no separation for the bicyclists. Within the existing 30 foot wide cartway, it is not feasible to get a separated bike lane – maybe in one direction, but not both.

One thing to note here that having the bikes up to curb height would require some redesign with potential drainage impacts. The snow removal issue still remains; Princeton will be clearing the bike path and may need special equipment. Further, snow plowed from the roadway will end up on the bike path (think sidewalks a day after a storm).

Public agreement for the removal of parking spaces may be difficult. Consideration shall be given to each of the existing constraints:

- Jefferson Road has residential permit parking on only one side
- Moore has residential permit parking on only one side not
- Hawthorne Street is only 26' wide and has residential permit parking on only one side
- Paul Robeson Place metered parking spaces are highly used

Relocating all-day parking to Jefferson Road, Moore Street, and Hawthorne Street would require removing permit parking, which property owners would likely not favor.