Signal Warrant Analysis

at the Intersection of

Roosevelt Avenue and Roosevelt Terrace

in the City of Springfield, MA

October 2023

PREPARED UNDER THE DIRECTION OF THE PIONEER VALLEY MPO BY:
THE PIONEER VALLEY PLANNING COMMISSION

In Cooperation with The City of Springfield

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Contents

The City of Springfield requested the Pioneer Valley Planning Commission (PVPC) to conduct an assessment of existing traffic and operational characteristics at the intersection of Roosevelt Avenue and Roosevelt Terrace as a part of the Unified Planning Work Program 2023. This analysis also includes a review of existing traffic volumes to determine if the minimum required thresholds for the installation of a traffic signal are met. The following sections provide an overview of the study area, an assessment of existing conditions and a series of recommendations to improve traffic flow and safety.

Study Area

The intersection of Roosevelt Avenue and Roosevelt Terrace is a three-legged unsignalized intersection located in the heart of Springfield, east of Interstate 291 along one of the important north-south transportation corridors of the City. The Roosevelt Terrace approach to this intersection is controlled by a 'Stop' sign. Land uses in the vicinity of the intersection are predominantly residential along Roosevelt Terrace with a number of academic institutions including the Springfield High School of Science and Technology, STEM Middle Academy, and Roger Putnam Vocational Technical College on Roosevelt Avenue.

Figure 1: Aerial View of the Intersection from Google Maps

Roosevelt Terrace intersects Roosevelt Avenue along a horizontal curve. Sidewalks are provided on the north side of Roosevelt Terrace and the west side of Roosevelt Avenue. Granite curbing is provided in the vicinity of the intersection. A double line crosswalk is located across the Roosevelt Terrace approach. The curbing, the pavement, and the pavement markings are all in good condition and seem to have been recently upgraded.

Figure 2: View from the Northwest Corner of the Intersection

Roosevelt Avenue is a four-lane undivided highway classified as urban minor arterial which is aligned in the northeast-southwest directions in the vicinity of the study area. Streetlights are installed along the west side of Roosevelt Avenue in the vicinity of the intersection. A speed limit sign restricting the speed to 35 mph for vehicles travelling southbound along Roosevelt Avenue is located north of the intersection.

Roosevelt Terrace is a local residential street approximately 28 feet wide with one travel lane in each direction. It does not have a double yellow center line demarcating the travel lanes. It connects several other local residential streets to Roosevelt Avenue and provides access to an elementary school. It is the only local street in the neighborhood with direct access to Roosevelt Avenue.

Existing Conditions

This section provides a technical evaluation of the transportation components for the intersection. It includes a presentation of the data collected, analysis of traffic operations, and a series of observations and conclusions derived from the analysis.

Average Daily Traffic

The Pioneer Valley Planning Commission (PVPC) collected a 13 hour Turning Movement Count utilizing a pole mounted video camera in late September 2023 on a typical weekday. The results were obtained from a private video processing service. Table 1 presents the traffic volume along the three approaches.

Table 1: Hourly Traffic Volume along the Intersection

	Roosevelt Avenue Approaches		Roosevelt Terrace Approach
Time	**Northbound**	**Southbound**	**Eastbound**
6:00 AM	687	331	102
7:00 AM	862	757	209
8:00 AM	631	524	162
9:00 AM	430	345	94
10:00 AM	342	362	69
11:00 AM	391	420	94
12:00 PM	463	450	107
1:00 PM	565	492	137
2:00 PM	562	688	148
3:00 PM	761	794	192
4:00 PM	688	805	194
5:00 PM	596	727	186
6:00 PM	356	389	104

Speed

Appendix 1 depicts the travel speed of vehicles in the vicinity of the intersection separated by direction of travel. The speed limit along the southbound approach of Roosevelt Avenue is 35 mph. There is a regulatory speed limit sign located north of the intersection for southbound traffic closer to Blunt Park and the Vocational Technical College. Speed limit signs were not installed along the northbound approach of Roosevelt Avenue in the vicinity of the intersection. The average speed and 85th percentile speeds (speed at or below which 85 percent of all vehicles are observed to travel) along the three approaches are summarized in Table 2.

Table 2: Traffic Speed in the Vicinity of the Intersection

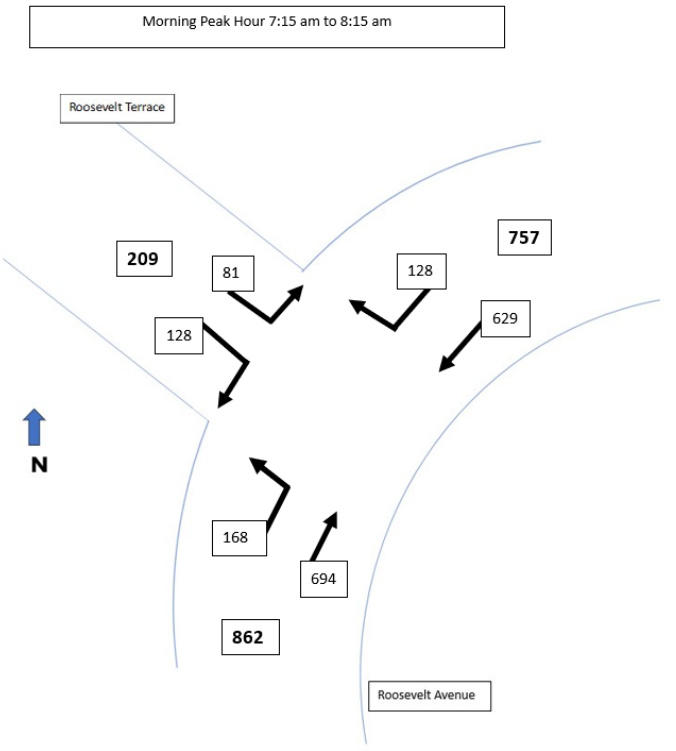
Location	Approach	Speed in miles per hour Direction of Travel					
		Northbound or Eastbound		Southbound or Westbound		Combined	
		Average	85th %	Average	85th %	Average	85th %
Roosevelt Avenue north of Roosevelt Terrace	Southbound	41.2	48	**38.9**	**44**	40	46
Roosevelt Avenue south of Roosevelt Terrace	Northbound	**42.7**	**48**	43.6	49	43.1	48.5
Roosevelt Terrace west of Roosevelt Avenue	Eastbound	**24.7**	**28**	24.5	29	24.6	28.5
Numbers in red indicate the speed of traffic entering the intersection							

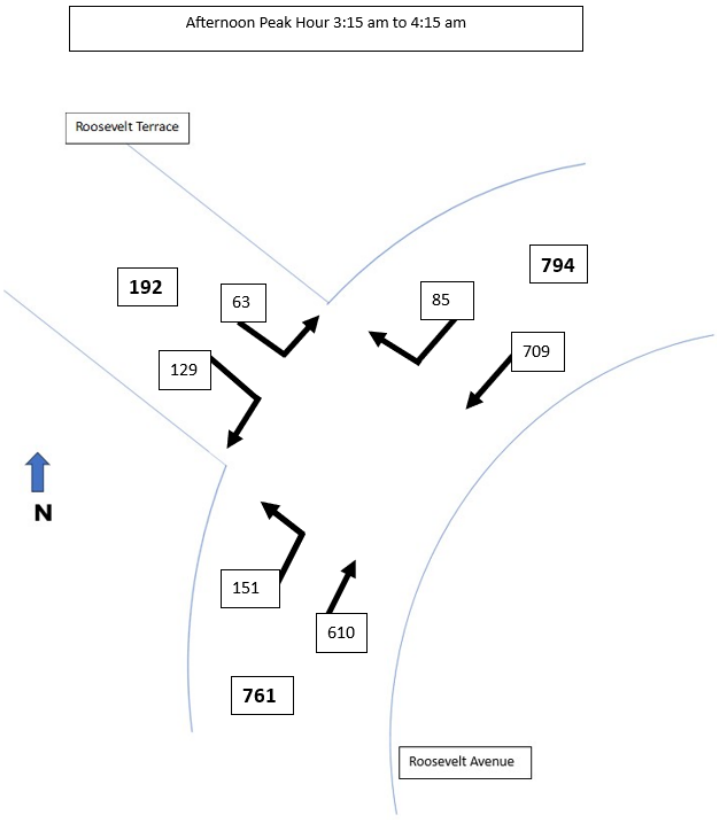
Peak Hour Volume and Turning Movement Counts

Turning Movement Counts (TMCs) were conducted for the intersection utilizing a pole mounted video camera as mentioned previously in this section. The weekday peak commuter period occurs during the morning hours of 7:00 AM to 9:00 AM and the afternoon hours of 2:00 PM to 6:00 PM. The TMC's were conducted to identify the peak four consecutive 15-minute periods of traffic through the intersection. These consecutive peaks 15-minute periods constitute a location's Peak Hour Volume. The peak hour of traffic volume represents the most critical period for operations and will be the focus for some of the analysis conducted in this study. Figure 3 depicts the peak hour interval and volumes at the intersection.

The TMC data also identifies the number of heavy vehicles on the roadway. Heavy vehicles include trucks, recreational vehicles, and buses. The percentage of heavy vehicles in the traffic flow is an important component in calculating the serviceability of a corridor or intersection. Trucks impact traffic flow because they occupy more roadway space than passenger cars and have poorer operating capabilities with respect to acceleration, deceleration, and maneuverability. The impact of these factors is utilized as an input to obtain the level of service for the intersection.

Figure 3: Peak Hour Turning Movement Counts





Almost 20% of northbound traffic along Roosevelt Avenue makes a left turn into Roosevelt Terrace during both the morning and afternoon peak hours. Queuing of more than three vehicles with long wait times were observed for the left lane of this approach during data collection. Driver frustration led to a few close calls and near crashes as observed by PVPC staff. Furthermore, PVPC staff also observed longer wait times for vehicles attempting to exit Roosevelt Terrace.

Congestion and Level of Service

The intersection was examined regarding capacity and delay characteristics to determine the existing Level of Service (LOS). LOS is an indicator of the operating conditions which occur on a roadway under different volumes of traffic and is defined in the Highway Capacity Manual by six levels, 'A' through 'F'. Several operational factors can influence the LOS including geometry, travel speeds, delay, and the number of pedestrians. Depending on the time of day and year, a roadway may operate at varying levels. Level of Service 'A' represents the best operating conditions and is an indicator of ideal travel conditions with vehicles operating at or above posted speed limits with little or no delays. Conversely, LOS 'F', or failure, generally indicates forced flow conditions illustrated by long delays and vehicle queues. Level of Service 'C' indicates a condition of stable flow and is generally considered satisfactory in rural areas. Under LOS 'D' conditions, delays are considerably longer than under LOS 'C' but are considered acceptable in urban areas. At LOS 'E' the roadway begins to operate at unstable flow conditions as the facility is operating at or near its capacity. Table 1 depicts the delay and LOS designations along unsignalized intersections as per Highway Capacity Manual. Table 2 depicts the results of PVPC's LOS Analysis.

Based on the results of the capacity analysis, Roosevelt Terrace was calculated to operate at level of service 'F' which means that there are long delays, and this approach is heavily congested during both morning and afternoon peak hours. The left turns from the Roosevelt Avenue northbound approach also experience higher delays than depicted in the analysis. The intersection analysis is based on uniform arrival rates throughout the analysis period; however, the field conditions vary and queueing and longer delays are experienced when there is large volume of opposing through traffic. The basic assumption at an unsignalized intersection is that through moving traffic on the major street is not hindered by other movements. In reality, as minor street delays increase, vehicles are more likely to accept smaller gaps in the traffic stream causing through moving vehicles to reduce speed and suffer some delay

Table 3: LOS Designations

Level of Service	Expected Delay to Minor Street	Average Control Delay (s/vehicle)
A	Little or no delay	0.0 to 10.0
B	Short Traffic Delays	>10.0 to 15.0
C	Average Traffic Delays	>15.0 to 25.0
D	Long Traffic Delays	>25.0 to 35.0
E	Very Long Delays	>35.0 to 50.0
F	Extreme Delays	>50.0

Table 4: Existing LOS at the Intersection of Roosevelt Avenue and Roosevelt Terrace

Street	Approach	Movement	Level of Service (LOS)			
			Morning Peak Hour		Afternoon Peak Hour	
			Delay in Seconds	LOS	Delay in Seconds	LOS
Roosevelt Avenue	Northbound	Left	2.6	A	2.6	A
		Through	1.9	A	2.1	A
	Southbound	Through/Right	0	A	0	A
Roosevelt Terrace	Eastbound	Left/Right	**225.3**	**F**	**104.9**	**F**

Crash Data

Local Crash Data was obtained from the Springfield Police Department for the last five years. Between the calendar years of 2018 to September of 2023, a total of 38 crashes were reported at this location. Table 5 presents the number of crashes and their severity during each year. Figures 4 and 5 depict the manner of collision and roadway surface conditions at the time of crash.

Table 5: Number of Crashes and Severity by Year

Year	Number of Crashes	Severity	
2018	6	Personal Injury	3
		Property Damage Only	3
2019	10	Personal Injury	2
		Property Damage Only	8
2020	3	Property Damage Only	3
2021	6	Personal Injury	6
		Property Damage Only	1
2022	4	Personal Injury	4
		Property Damage Only	3
2023 (Through September)	5	Personal Injury	1
		Property Damage Only	4

Figure 4: Manner of Collision

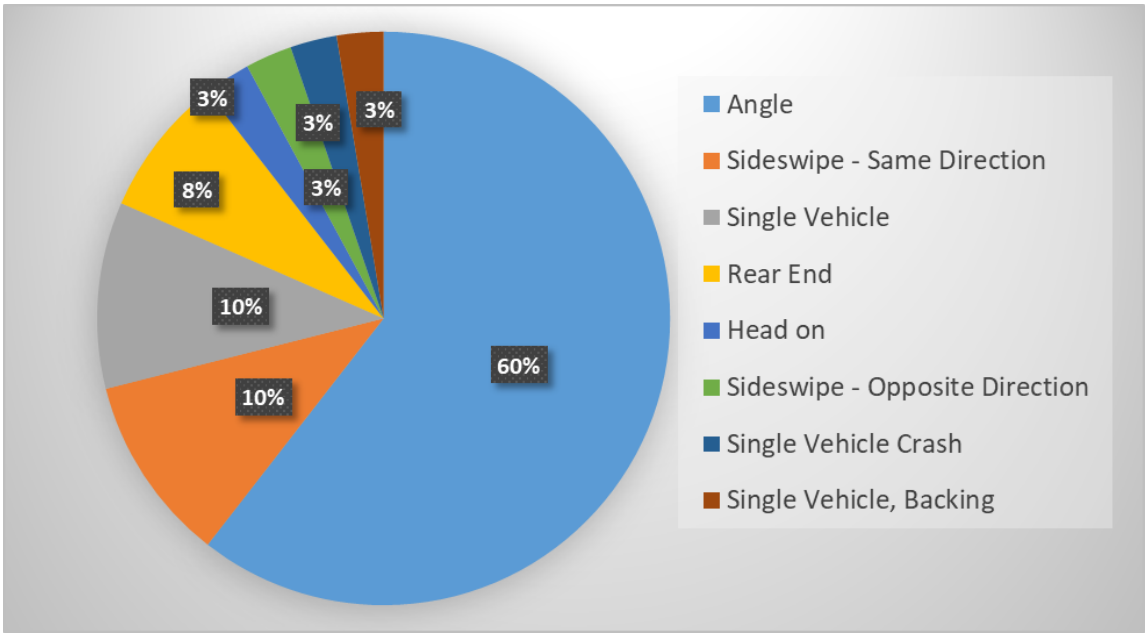
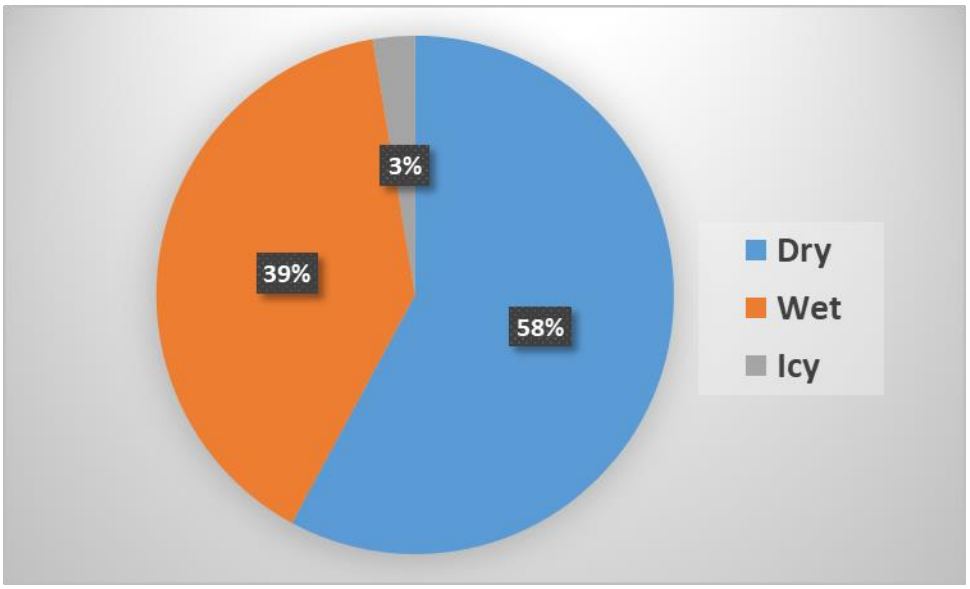


Figure 5: Roadway Surface Condition



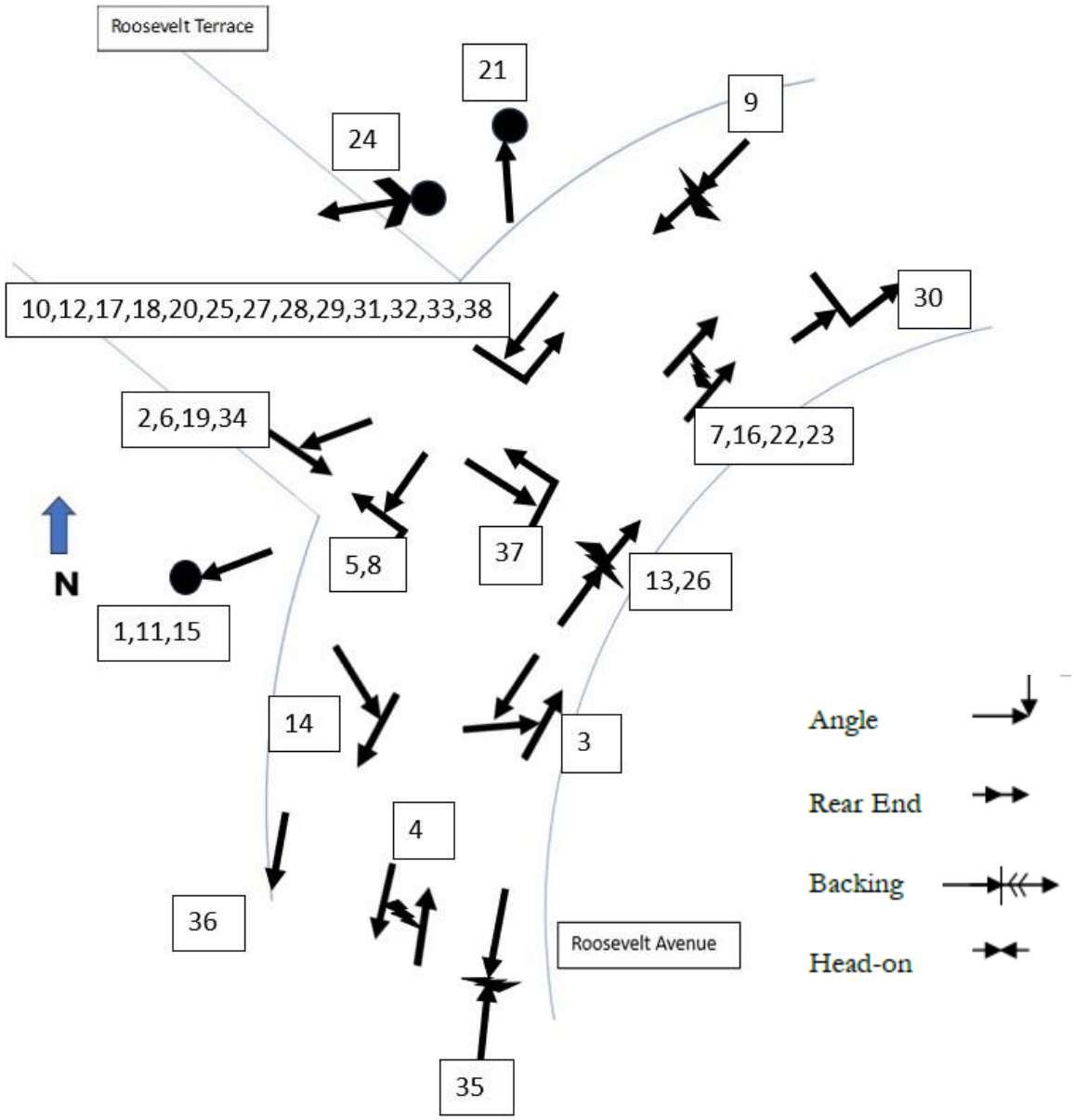
More than 42% of these crashes resulted in personal injury. This number is significant considering the impact of higher severity crashes on both individuals and the economy. The higher speeds along the corridor are one of the contributing factors that increase the severity of a crash.

Figures 4 and 5 depict the distribution of manner of collision and roadway conditions during which these crashes occurred. Almost 60% of crashes were angle type collisions. More than 10% were sideswipe crashes that occurred because of longer delays for left turning vehicles experienced along Roosevelt Avenue. These are crashes that can be addressed by the installation of a traffic signal.

Collision Diagram

Local Crash Data obtained from the Springfield Police Department was further utilized to create a collision diagram for the study area intersection. A collision diagram is a graphical representation of the location and manner of collision of crashes that occurred in the vicinity of the study area. Appendix 2 provides detailed information about each crash depicted in the collision diagram included in Figure 6.

Figure 6: Collision Diagram



The collision diagram clearly depicts a predominant pattern of angle type collisions that occurred between the left turning vehicles from the Roosevelt Terrace approach and through moving vehicles from the southbound Roosevelt Avenue approach (13 out of 38 or more than 34%). As observed during the Congestion and Level of Service Analysis, this approach operates at very high delays during the peak hours. These delays contribute to driver frustration and the tendency to take a risk and try to perform the left turns in the absence of adequate gaps.

The second most occurring pattern (4 crashes) was observed along the Roosevelt Avenue northbound approach. These crashes were side swipe collisions between vehicles travelling in the same direction. All of these crashes occurred when a driver attempted to change lanes to avoid waiting behind vehicles that were either stopped or slowing down while trying to perform a left turn into Roosevelt Terrace.

One last notable pattern was of single vehicle crashes along the southwest corner of the intersection. These crashes were a result of a combination of factors from roadway geometry, wet road surface, inadequate nighttime visibility, and higher speeds.

Signal Warrants

The Manual on Uniform Traffic Control Devices (MUTCD) identifies eight different warrants to evaluate if an intersection meets the minimum requirements for signalization. One or more warrants must be satisfied to justify the installation of a traffic signal; however, engineering judgment ultimately dictates if an intersection warrants the installation of a signal. The installation of a traffic signal must also improve the safety and operation of the location under study. Of the eight total warrants for the installation of a traffic signal, Warrant1 – Eight Hour Vehicular Volume is generally considered the most important as it requires minimum volumes to be met on both the major and minor streets for at least eight hours. Warrant 2 – Four Hour Vehicular Volume and Warrant 3 – Peak Hour Volume also require minimum volumes to be met but over shorter timeframes. Warrant 7 – Crash Experience requires 80% of the volume requirements of Warrant 1 to be satisfied and at least 5 crashes of a type correctable through traffic signalization to have occurred over the last year. This warrant also requires that less restrictive remedies such as improved signage and pavement markings be tried and have failed to reduce crashes before a signal can be installed.

Results and Interpretation

Table 6 represents the results of the signal warrant analysis (SWA) conducted utilizing Highway Capacity Software (HCS) 2022.The intersection meets volume requirements for the first three warrants and crash warrant as specified by the MUTCD. The detailed analyses sheets from HCS are presented in Appendix 3.

Table 6: Signal Warrant Analysis Results

	Description	Result
Warrant 1	Eight – Hour Vehicular Volume	Satisfied
Warrant 2	Four- Hour Volume	Satisfied
Warrant 3	Peak Hour Volume	Satisfied
Warrant 4	Pedestrian Volume	N/A
Warrant 5	School Crossing	N/A
Warrant 6	Coordinated Signal System	N/A
Warrant 7	Crash Experience	Satisfied
Warrant 8	Road Network	N/A
Warrant 9	Intersection Near a Grade Crossing	N/A

N/A = Not Applicable

Crash Warrant

Crash data depicts a total of 33 crashes in the last five years between 2018 - 2022. A vast majority of these crashes can be addressed by installation of a signal as discussed above. This number is more than the required average of five annual crashes which can potentially be prevented by the installation of a signal. It is worthy to note that it is outside the scope of the current study to examine all historical improvements made along this location to improve safety; however, installation of a signal would potentially help in improving traffic safety at this location. Therefore, it is safe to consider that the Crash Warrant is satisfied under current conditions.

Level of Service with a Signal

The installation of a signal would also potentially decrease delay and queueing along the Roosevelt Terrace approach. PVPC conducted a supplementary Level of Service Analysis to understand the potential impact of a signal on traffic operations along all three approaches of the intersection. The results depicted that the delays along the Roosevelt Terrace were reduced during the afternoon peak hour and the level of service improved from 'F' to 'B'. There was a marginal increase in delays along Roosevelt Avenue; however, both approaches would still operate at LOS 'B' with less than 20 seconds of delay for all movements during both peak hours.

It is also worthy to note that these analyses are based upon actual, unadjusted traffic volumes collected at the intersection during the school year. There is a significant reduction in traffic volume during summer and when there are school breaks. Furthermore, traffic volumes tend to fluctuate by day of the week and time of the year.

Recommendations to Improve Transportation Conditions

The following recommendations are presented for the City of Springfield to consider improving traffic safety and travel conditions in the vicinity of the intersection.

1. It is recommended that the City consider painting a double yellow center line along Roosevelt Terrace Approach to demarcate the travel lanes.

2. There are no chevrons along Roosevelt Avenue in either direction. Three single vehicle crashes occurred at this location during nighttime, these crashes could potentially be prevented by high visibility pole mounted chevrons especially along the southbound approach of Roosevelt Avenue.
3. In addition to chevrons, curve ahead warning signs along Roosevelt Avenue would further help in alerting the drivers about the geometry of the road. It is recommended that the City of Springfield consider installing those along Roosevelt Avenue.
4. Currently there are no advance warning signs to alert drivers about the intersection and the potential of entering traffic as they approach the intersection. It is recommended that the City of Springfield consider installing appropriate supplemental 'Intersection Ahead' warning signs along both approaches of Roosevelt Avenue.
5. Installation of a guard rail along the southwest corner of the intersection along with chevrons would further improve the nighttime visibility and potentially reduce the severity of damage at this location. It is recommended that the City of Springfield consider examining the possibility of installing a guardrail at this location.
6. It is recommended that the City consider installation of a Speed Limit sign along the northbound approach of Roosevelt Avenue which will help in identifying the travel speed in this direction.
7. The intersection meets the volume and crash requirements for installation of a traffic signal. Additionally, Roosevelt Terrace is the only local street that connects Roosevelt Avenue to the neighborhood in this area, which makes this intersection significant for the residents at this location. It is recommended that the City of Springfield consider obtaining the services of a licensed professional engineer to study the feasibility of installing a signal at this location. This engineering study should also examine the need to coordinate a signal at this intersection with the signal at the nearby intersection of Roosevelt Avenue with Blunt Park Road.
8. Currently there are no bicycle accommodations along Roosevelt Avenue. The study area is located in the vicinity of several academic institutions, athletic fields, and parks. This corridor could benefit from a larger long-term study to examine the need and adequacy of vulnerable road users' accommodations and the feasibility of installing amenities like bike lanes and crosswalks at appropriate locations to improve connectivity in the area.