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An understanding of the City’s overall safety is gathered through a data-driven review of the crash history and other contributing elements.



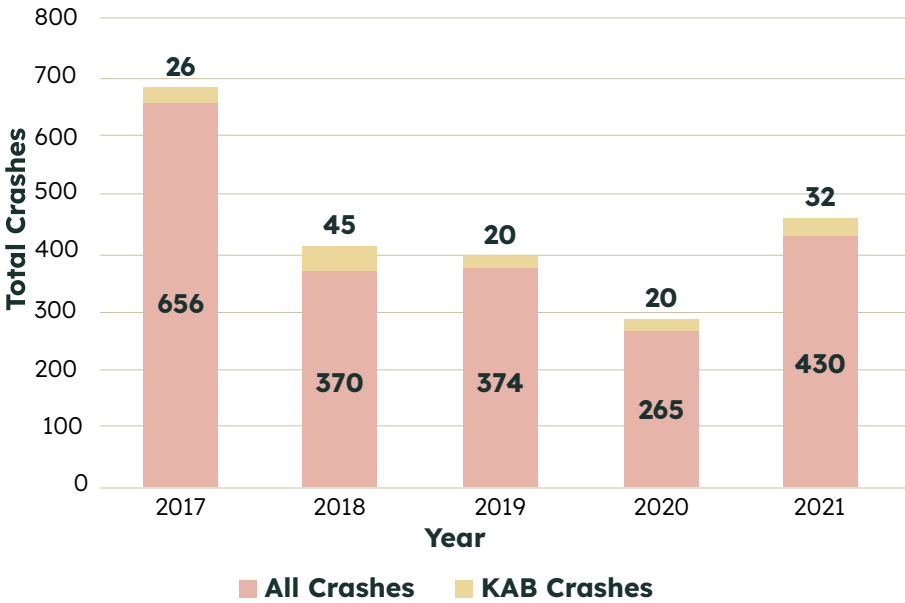
CHAPTER 3: SAFETY ANALYSIS

Chapter 3 elaborates on the state of safety in Tahlequah. An understanding of the City’s overall safety is gathered through a data-driven review of the crash history and other contributing elements. To complete the crash history analysis and the High-Injury Network (HIN), historical crash data for the last available five years (2017-2021) from the Oklahoma Highway Safety Office (OHSO) was used.

CITYWIDE CRASH TRENDS

Crash data from 2017 to 2021 was utilized to identify crash trends in Tahlequah, as summarized in Figure 7. Prior to 2018, Tahlequah had a total number of crashes per year at around 370. In 2020, there was a decrease in the number of crashes occurring in the City (265 crashes) which is attributed to the COVID-19 pandemic. The following year, 2021, had a spike in total number of crashes (430 crashes); this year had the second highest number of both total number of crashes and KAB crashes in the five-year time frame.

FIGURE 7. TOTAL CRASH SUMMARY (2017-2021)



The total number of fatal (K), serious injury (A), and minor injury (B) crashes have increased since 2020 and exceeded three of the four previous years’ totals as shown in Table 2. KAB crashes reached a total of 32 in 2021, which is over 50% higher compared to the previous two years.

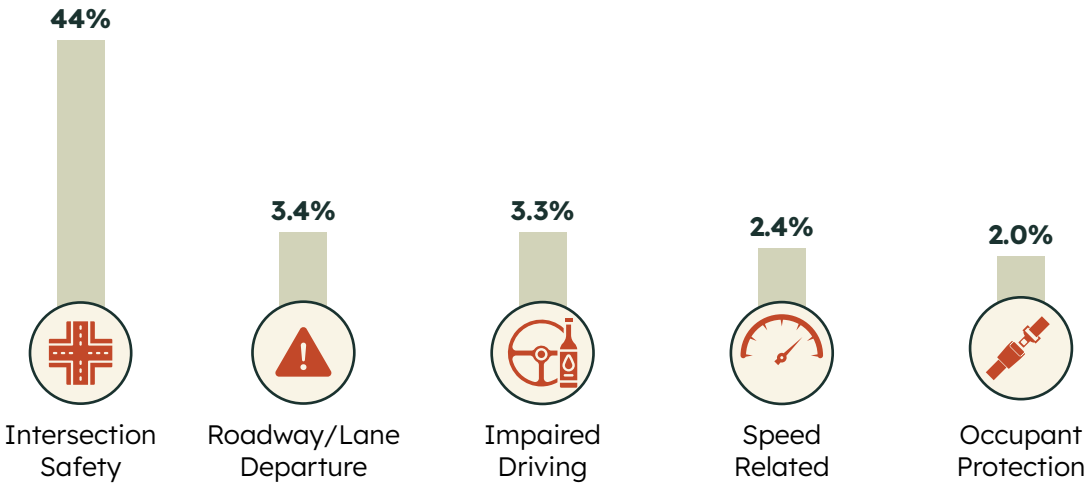
TABLE 2. TOTAL CRASHES BY SEVERITY (2017-2021)

Year	K- Fatal Injury		A - Suspected Serious Injury		B - Suspected Minor Injury		C - Possible Injury		O - Not Injured		99 - Unknown	
2017	0	0.0%	7	0.3%	19	0.9%	70	3.3%	539	25.7%	10	0.5%
2018	4	0.2%	3	0.1%	38	1.8%	40	1.9%	272	13.0%	5	0.1%
2019	2	0.1%	2	0.1%	16	0.8%	60	2.9%	281	13.4%	7	0.3%
2020	1	0.1%	3	0.1%	16	0.8%	40	1.9%	193	9.2%	5	0.2%
2021	0	0.0%	7	0.3%	25	1.2%	48	2.3%	335	16.0%	11	0.5%

Indicates the two highest years by percentage

The top manners of collision and how the crash occurred between vehicles in Tahlequah are shown in Figure 8. In the City, the top manners of collision were ‘Intersection Safety’ (44%), ‘Roadway/Lane Departure’ (3.4%), and ‘Impaired Driving’ (3.3%).

FIGURE 8. TOP CONTRIBUTING CRASH FACTORS (2017-2021)



TAHLEQUAH

CRASH HEAT MAP

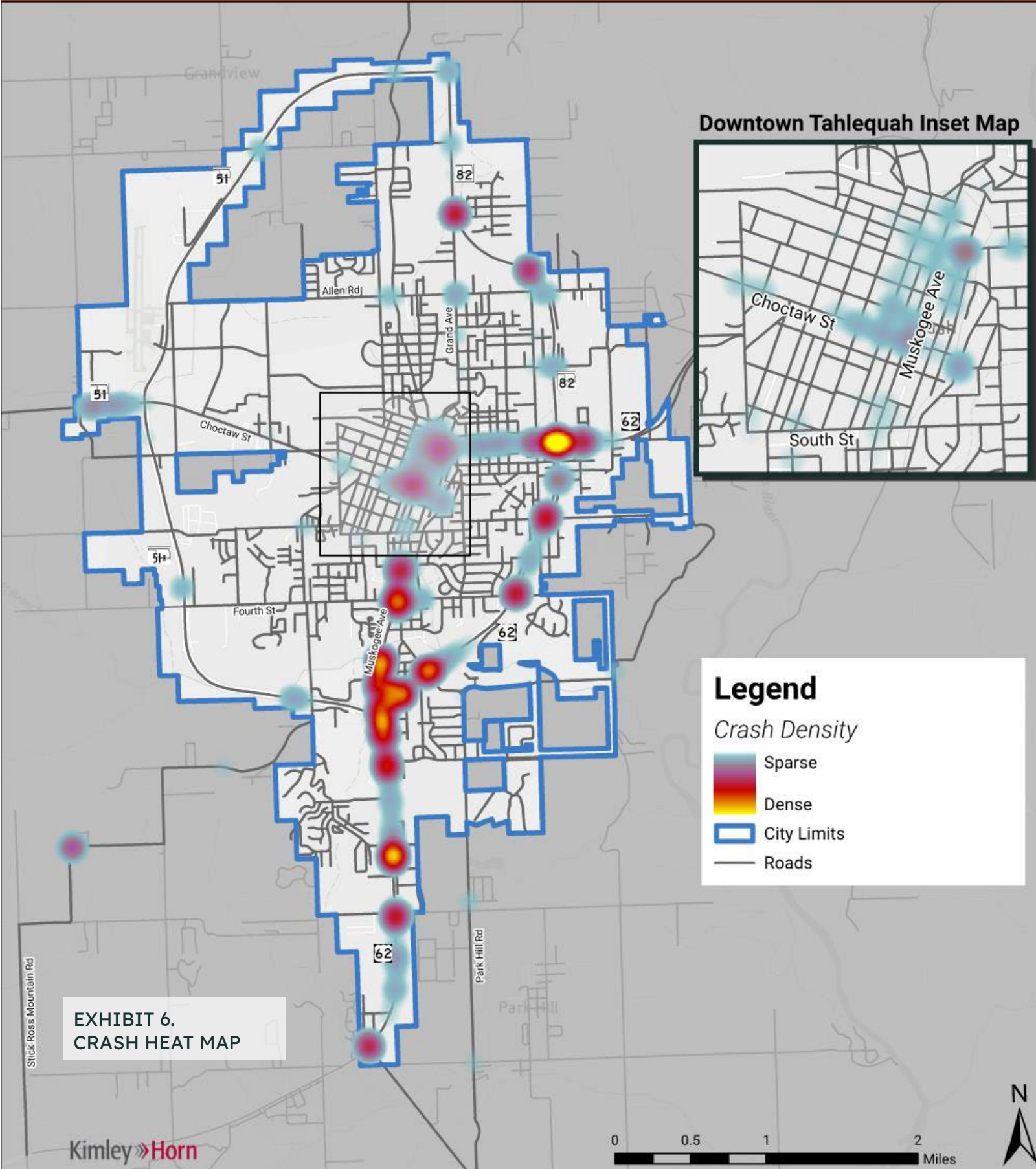
A crash heat map was created to highlight the density of crashes within the City of Tahlequah from 2017-2021, as seen in **Exhibit 6**. This map is a visual representation of the density of crash counts at various locations in Tahlequah. However, the crash heat map does not account for traffic volumes, number of lanes, or speed limits, these factors to affect the frequency of crashes.

The highest concentration of crashes occurs along Muskogee Avenue and the Bypass (US-62/SH-82), with the highest densities at high volume intersections along the Bypass. Two of the largest densities on the crash heat map are near the intersections of US-62 & the US-62/SH-82 Bypass and the US-62/SH-82 Bypass & S Muskogee Avenue.



Crash Heat Map

Source: OHSO Crash Data (2017-2021)



KAB CRASHES

KAB crashes, which are comprised of fatal, severe injury, and possible injury crashes, serve as a critical component in the safety analysis of Tahlequah roadways. With the number of KAB crashes increasing since 2020, it is pertinent to discern the root causes behind these crashes and investigate what countermeasures can be identified to prevent these crashes. The KAB crashes in Tahlequah, seen in **Exhibit 7**, show that these crashes are dispersed throughout the City, often on the busiest roadways such as Muskogee Avenue, the US-62/SH-82 Bypass, SH-82, and US-62. The locations and information about these severe crashes are an important data point when developing the City’s High Injury Network. Since these types of crashes are the most impactful to the community, the factors of how these crashes occur, where they are occurring, and how they can be prevented is a core tenant of this plan.



Fatal, Serious Injury, and Minor Injury Crashes

Source: OHSO Crash Data (2017-2021)

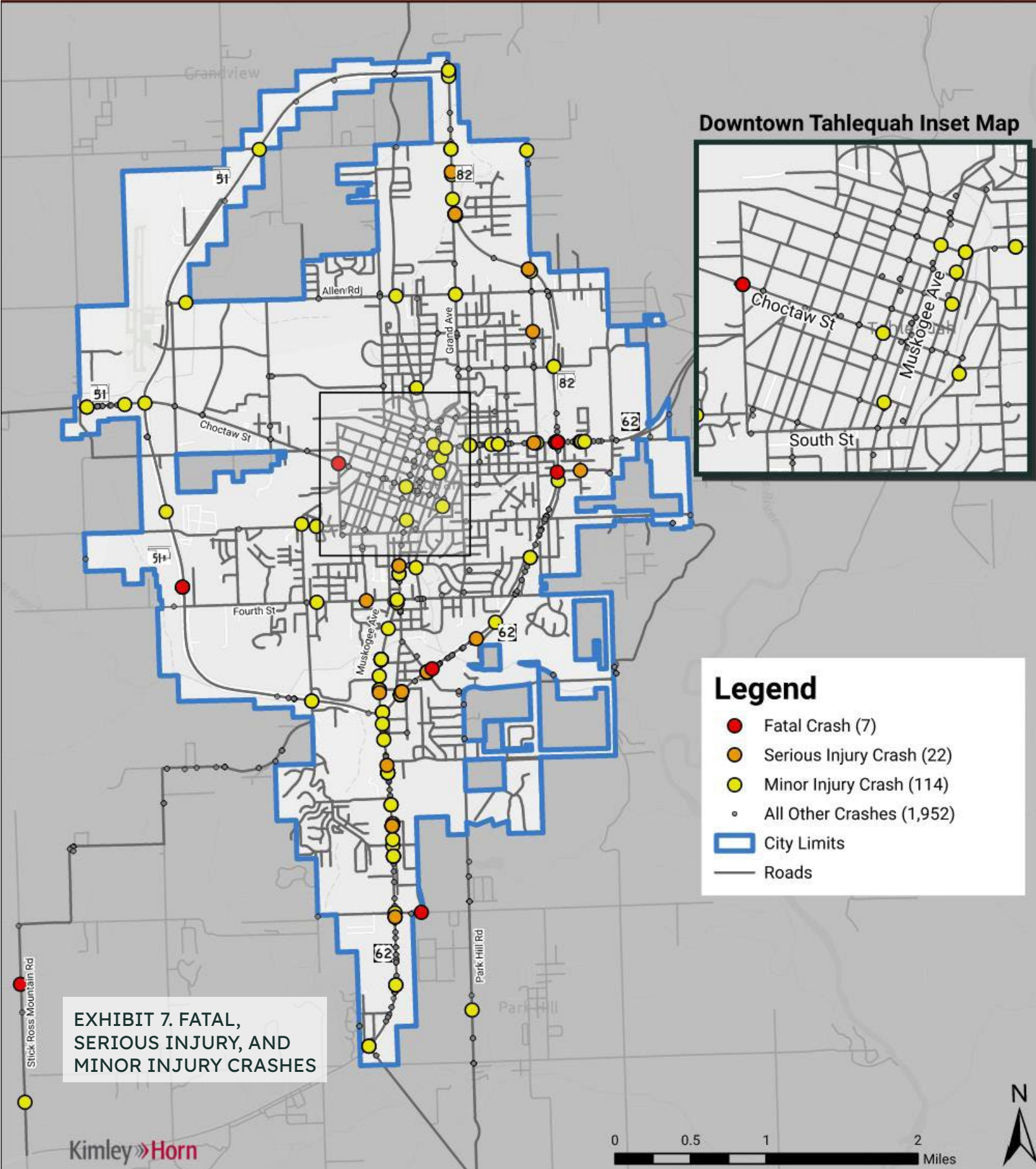


EXHIBIT 7. FATAL, SERIOUS INJURY, AND MINOR INJURY CRASHES

HIGH CRASH INTERSECTIONS

Approximately 44% of all crashes in Tahlequah occur at intersections. Intersections can become safety hazards for all roadway users since these are areas where the most conflicts for vehicles, pedestrians, and bicyclists occur. In the City of Tahlequah, the intersection of the US-62/SH-82 Bypass & US-62 had the most crashes over the five-year study period; the US-62/SH-82 Bypass is a 4-lane divided roadway and US-62 is a 4-lane undivided roadway. Of the 10 intersections listed in **Table 3**, eight (8) of them involve Muskogee Ave, SH-82, or US-62. **Exhibit 8** on Page 30 contains a map that highlights the locations of the high crash intersections in the City.

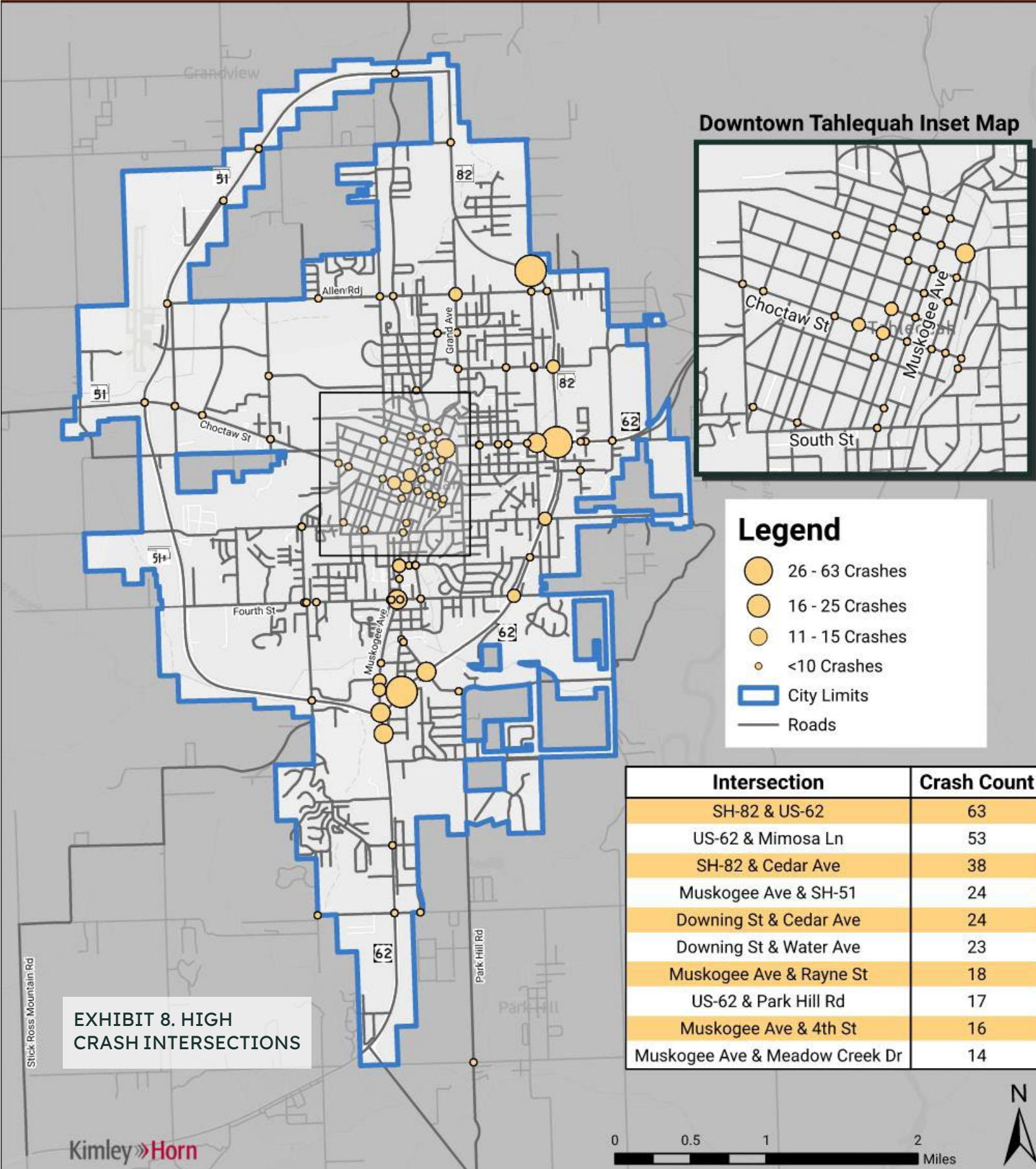
TABLE 3. HIGH CRASH INTERSECTIONS

Rank	Intersection	Crash Count
1	SH-82 & US-62	63
2	US-62 & Mimosa Ln	53
3	SH-82 & Cedar Ave	38
4	Muskogee Ave & SH-51	24
5	Downing St & Cedar Ave	24
6	Downing St & Water Ave	23
7	Muskogee Ave & Rayne St	18
8	US-62 & Park Hill Rd	17
9	Muskogee Ave & 4th St	16
10	Muskogee Ave & Meadow Creek Dr	14



High Crash Intersections

Source: OHSO Crash Data (2017-2021)



BICYCLE & PEDESTRIAN CRASHES

Vulnerable road users, which refers to bicyclists and pedestrians, are the most susceptible to a fatality or serious injury during a crash. This fact is supported by the crash history in Tahlequah. From 2017-2021, the City has experienced 16 pedestrian crashes and 4 bicyclist crashes, as shown in **Exhibit 9** on Page 32. Of the 16 crashes that involved pedestrians or bicyclists, 13 of them resulted in a fatality, serious injury, or minor injury.

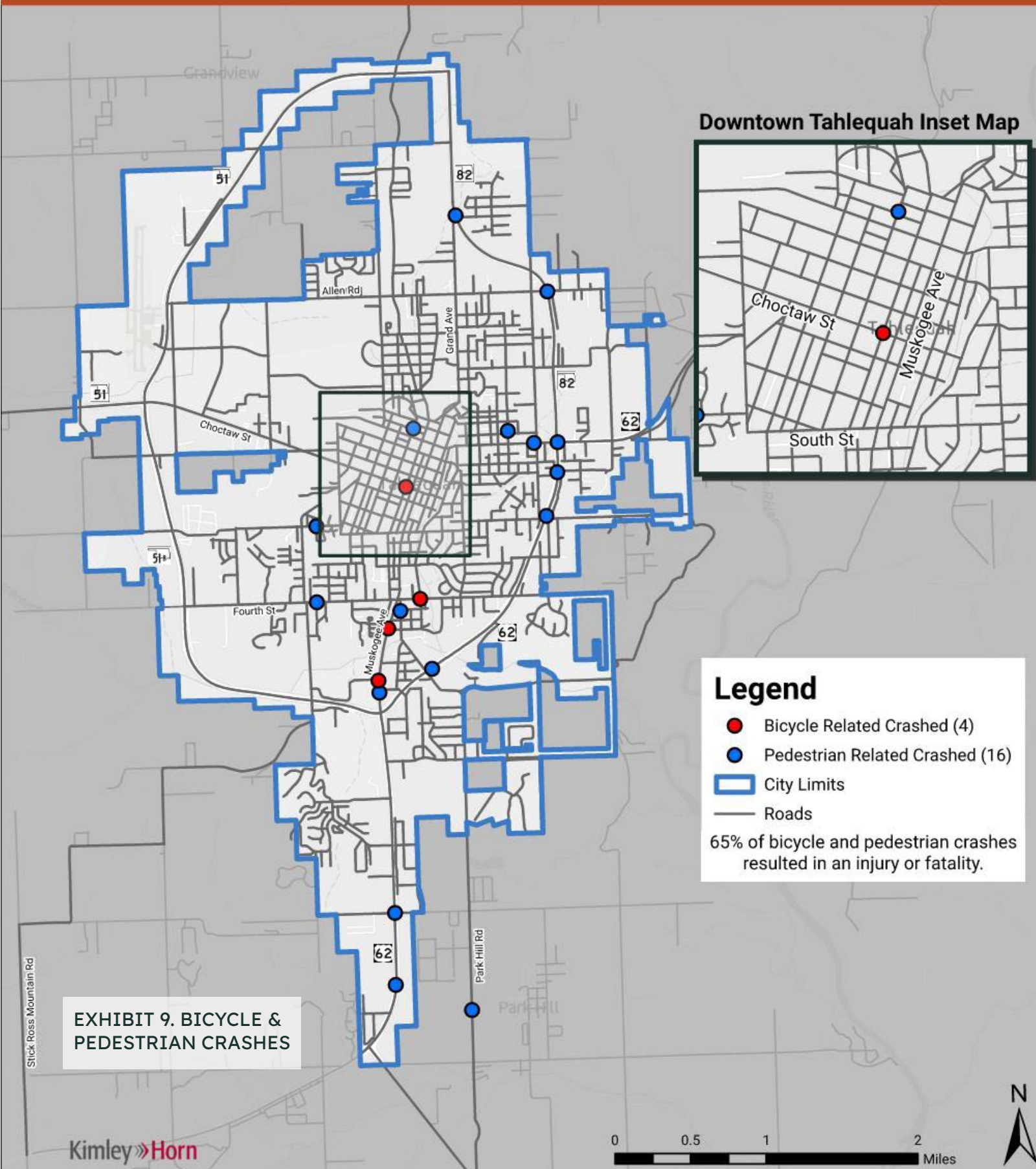
On average, pedestrian and bicycle crashes are more severe than vehicle-only crashes in the City. While only 0.2% of vehicle-only crashes resulted in a fatality, 15% of pedestrian and bicyclist crashes are a KAB crash; this comparison show that, if involved in a crash, a pedestrian or bicyclist is at a 75-time higher risk of experiencing a fatality or serious injury compared to drivers of a vehicle in Tahlequah. While this comparison may be skewed due to the small data set, this alarming discrepancy is a key factor to investigate further in relation to vulnerable road user safety.

A concentration of pedestrian and bicycle crashes occurs south of downtown Tahlequah along S Muskogee Avenue, near a variety of commercial businesses. The pedestrian infrastructure in this area of Tahlequah has long been either absent or insufficient; currently this corridor is under construction that will add sidewalks to address these issues. Otherwise, pedestrian crashes are dispersed throughout the City, often occurring at intersections or during low-light conditions.



Bicycle & Pedestrian Crashes

Source: OHSO Crash Data (2017-2021)



TAHLEQUAH

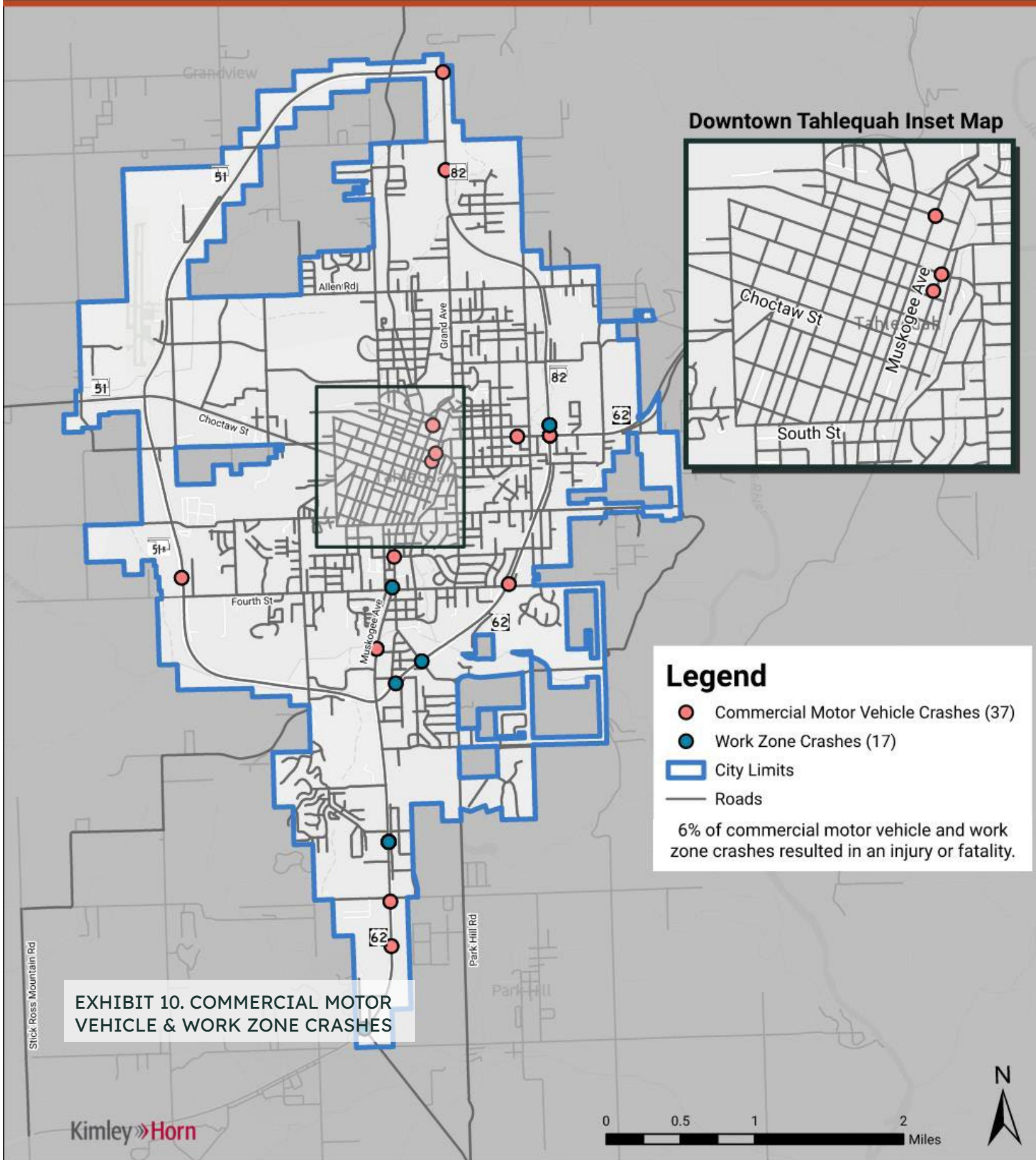
COMMERCIAL MOTOR VEHICLE & WORK ZONE CRASHES

Commercial motor vehicle and work zone related crashes are an important focus area due to their significant impact on road safety. These crashes often result in severe consequences, due to the heavy weight of commercial vehicles and the vulnerability of construction workers to traveling vehicles. In the available crash data, there were 37 commercial motor vehicle crashes and 17 work zone crashes; of these crashes, 6% resulted in an injury or fatality. **Exhibit 10** shows the location of these crashes in Tahlequah.



Commercial Motor Vehicle & Work Zone Crashes

Source: OHSO Crash Data (2017-2021)



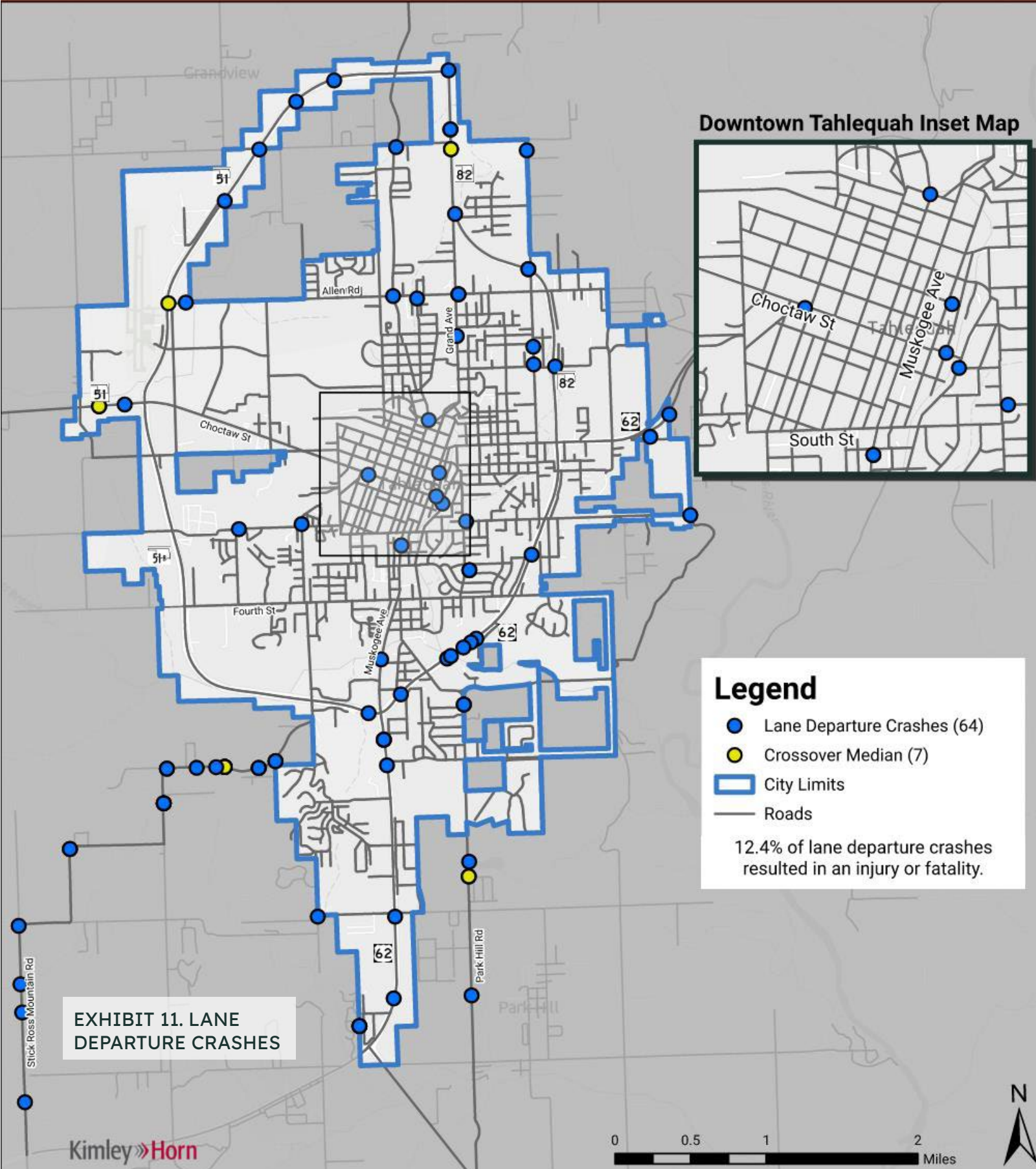
LANE DEPARTURE CRASHES

Lane departure crashes, which occurs when a vehicle unintentionally leaves the travel lane, often lead to head-on collisions, rollovers, or run-off-road incidents. These types of crashes are a major concern in Tahlequah due to the high likelihood of resulting in a severe injury or fatality. The City has experienced 64 lane departure crashes and 7 crossover median crashes, as seen in **Exhibit 11** From these crashes, 12.4% resulted in an injury or fatality. These types of crashes have primarily occurred along US-62, SH-51, Stick Ross Mountain Road, and Allen Road.



Lane Departure Crashes

Source: OHSO Crash Data (2017-2021)



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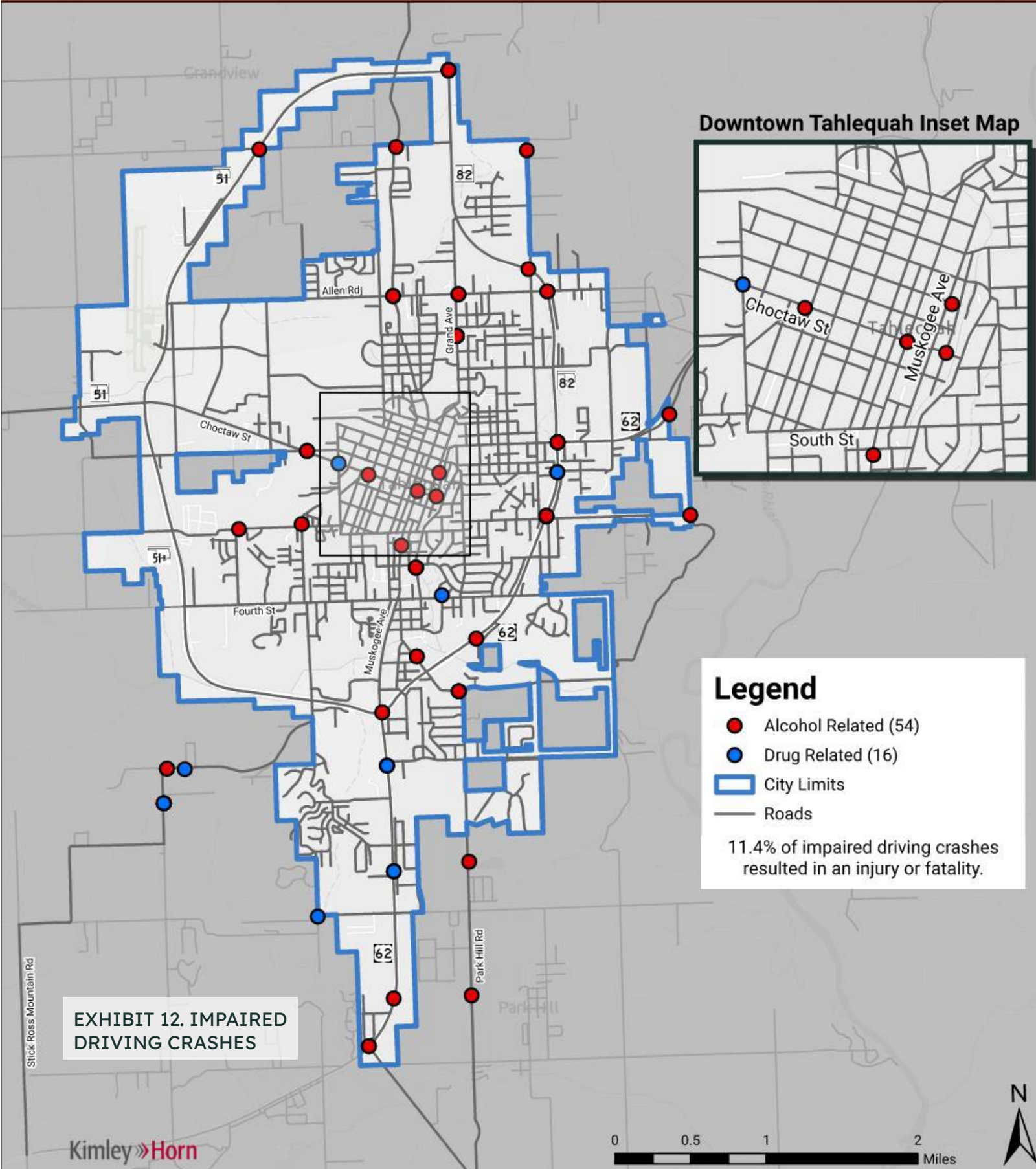
IMPAIRED DRIVING CRASHES

Impaired driving crashes represent a significant threat to road safety in Tahlequah. These crashes, which include impairment from both alcohol and drugs, lead to a disproportionate number of severe injuries and fatalities. In Tahlequah, there were 52 alcohol related and 16 drug related crashes, in which 11.4% resulted in an injury or fatality. As seen in **Exhibit 12**, a higher density of impaired driving crashes occurs in Downtown Tahlequah but are still seen dispersed throughout the city limits.



Impaired Driving Crashes

Source: OHSO Crash Data (2017-2021)



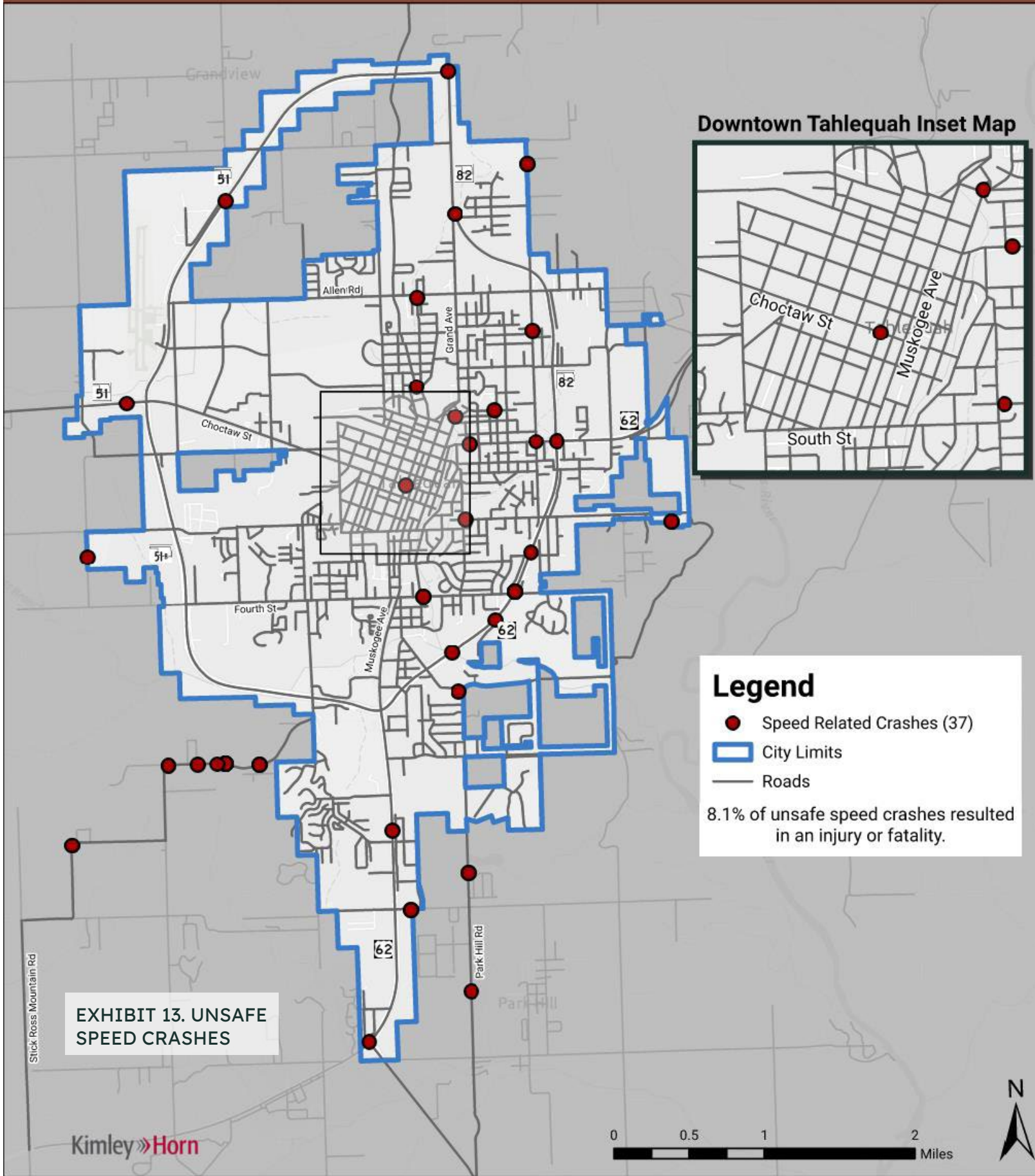
UNSAFE SPEED CHRSASHES

Speed related crashes are another important area of concern in Tahlequah, as excessive speed greatly increases the occurrence and severity of crashes. Tahlequah saw 37 unsafe speed crashes, which resulted 8.1% of the crashes resulted in an injury or fatality. **Exhibit 13** show the locations of these crashes; the Bypass and Stick Ross Mountain Road had the highest incidences for unsafe speed crashes.



Unsafe Speed Crashes

Source: OHSO Crash Data (2017-2021)



CRITICAL CRASH RATE (CCR) METHOD

The Federal Highway Administration (FHWA) outlines methods to calculate crash rates to prioritize locations where safety improvements are most needed. Outlined in the Highway Safety Manual, Section 4.4.4.5 on Page 4-41, the critical crash rate method identifies crash hotspots by comparing the observed crash rate at a roadway segment to the expected crash rate based on similar functional classification and traffic volumes. If the observed crash rate exceeds the expected crash rate, the roadway segment is considered to have a critical crash rate and is considered for the high injury network (HIN).

An ArcGIS Pro model was created to calculate the critical crash rate and supporting calculations for each roadway segment in the City. The model assigns crashes to an adjacent segment and performs the calculations in the order outlined by the FHWA. The following section outlines the process used in the calculation of the critical crash rate using fata, severe, and minor injury crashes from 2017-2021 in Tahlequah.

CRITICAL CRASH RATE (CCR) CALCULATION

The following three steps were followed to calculate the crucial crash rate for each road in Tahlequah:

- 1

Assigning Data to Road Segments
- 2

Calculate Variables of Critical Crash Rate
- 3

Calculate Critical Crash Rate Ratio

ASSIGNING DATA TO ROAD SEGMENTS

Calculating the critical crash rate requires three data inputs: roadway functional classification, daily traffic volumes, and crash counts. Since different factors, such as higher traffic volumes, more travel lanes, and higher speed limits, can impact crash rates, the normalization and comparison of these rates are crucial. The critical crash rate compares road segments that have similar roadway functional classification and normalizes daily traffic volumes to calculate crashes at a more even level based on their commonalities.

CALCULATE VARIABLES OF CRITICAL CRASH RATE

The critical crash rates were calculated using the equations outlined in the FHWA’s Highway Safety manual. The observed crash rate represents the existing KAB crashes on each road segment per 100 million vehicle-miles traveled. For the expected average crash rate per 100 million vehicles-miles traveled calculations, the daily volumes for each functional class were normalized. Furthermore, roadways were only compared to other roadways that were similar; for example, local roads were only compared to local roads.

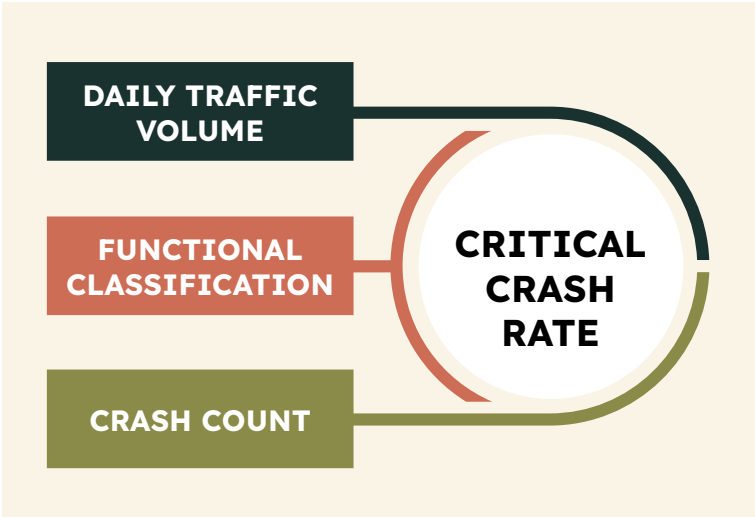
Figure 9 outlines the data inputs needed to calculate the critical crash rate.

CALCULATE CRITICAL CRASH RATE RATIO

A ratio is used to identify the magnitude of difference between the observed and expected crash rates. If the ratio is greater than 1.0 or the observed crash rate is higher than the expected crash rate, then that road segment’s crash history was greater than the other road segments that share the same functional classification. Any segments with a ratio of 1 or greater were flagged as potential HIN segments.

Exhibit 14 provides a visual summary of all the ratio results.

FIGURE 9. HIN DATA INPUTS



Tahlequah Critical Crash Rate Results

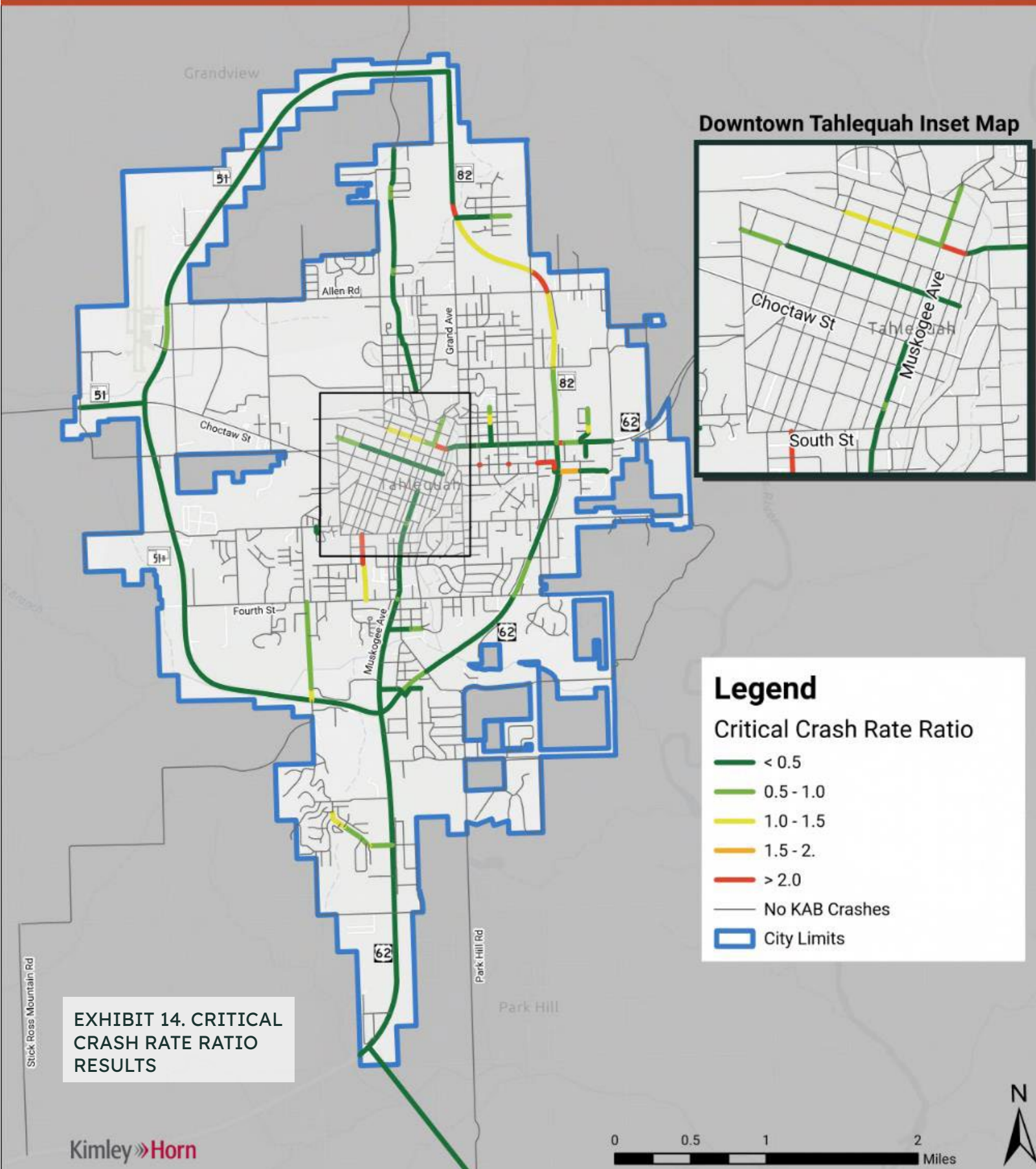


EXHIBIT 14. CRITICAL CRASH RATE RATIO RESULTS

HIGH INJURY NETWORK (HIN) DEVELOPMENT & RESULTS

The High Injury Network (HIN) was created through the selection of segments based on data-driven criteria combined with qualitative refinement of the model results. The goal of the HIN is to maximize the total vehicle-only KAB crashes and bicycle/pedestrian KAB crashes on the smallest percentage of City roads.

To refine and clean the model results, crash segments that only saw one crash but had a ratio of greater than 1.0 were removed from the model to prioritize segments with more severe crash histories. After this initial cleaning, the remaining segments were those with more than one KAB crash that occurred in the five-year crash history and had a higher-than-expected crash rate. While not all segments experienced a KAB crash, the influence area of the crash typically bleeds over to adjacent segments. To create a coherent and continuous HIN, the gaps between high crash segments were filled.

Following the refinement of the calculated critical crash rates, the HIN for the City of Tahlequah is determined. Tahlequah’s HIN consists of approximately 6.3 miles or 3.9% of the City’s roadways while capturing 53.1% of all KAB crashes and 57.1% of all fatal crashes.

A summary of all segments included in the HIN is shown in **Table 4**, and a map of the City’s High Injury Network is shown in **Exhibit 15** on the following page.

TABLE 4. HIGH-INJURY NETWORK SEGMENTS

HIN Segments	Limits		Length (miles)	Crashes			Total KABS	AADT
	From	To		K	A	B		
S Muskogee Ave	W Chickasaw St	Southridge St	2.30	0	5	35	40	9,500
S State St	W South St	W 4th St	0.44	0	1	0	1	200
US-62	S Park Hill Rd	E 7th St	0.56	1	2	4	7	3,500
W Choctaw St	W Keetoowah St	S Morris Ave	0.32	1	0	0	1	4,000
W Downing St	N Mission Ave	N Water Ave	0.41	0	0	4	4	3,000
E Downing St	N Maple Ave	N Ash Ave	0.16	0	0	4	4	7,600
E Shawnee St/E Boone St	N Cedar Ave	N Leena Ave	0.35	1	1	0	2	400
US-62	SH-82	Harris Ct	0.19	1	4	6	11	14,000
SH-82	Wheeler St	Crafton St	1.41	0	4	7	11	8,200



Tahlequah High Injury Network

