4. SAFETY ANALYSIS

4. SAFETY ANALYSIS

To identify the factors contributing to an increased likelihood of fatal and incapacitating injury crashes in the area, we conducted an analysis of crashes reported in the Indiana State Police Automated Reporting Information Exchange System (ARIES) spanning from the year 2019 to 2023. These factors included aspects such as road geometry, traffic flow, driver behavior, and environmental conditions.

Following the Safe System Approach, our methodology integrated safety analysis findings with proactive assessments to identify the roadway features linked to an elevated risk of severe crashes. By combining these analytical strategies, the Town has identified key areas where it can strategically prioritize its efforts in the forthcoming years to address the predominant types of severe crashes and employ evidence-based countermeasures.

4.1 HIGH-LEVEL TRENDS

The crash analysis focused on crashes specifically within the Town of Highland's police jurisdiction. Between 2019 and 2023, Highland averaged **856** reported crashes annually, 4.4% of which were reported as fatal or incapacitating injury crashes. The crash trends indicate a sharp decline in total crashes in 2020, largely attributed to the impacts of COVID-19. Since 2019, the number of reported fatal and severe injury crashes has steadily declined. However, potential changes in crash reporting practices over time may have contributed to this trend. The crash frequency and corresponding year-to-year percentage changes for the five-year period are summarized in ***Table 3***.

Table 3: Town of Highland Crash Frequency, 2019-2023

YEAR	TOTAL CRASHES	CHANGE (%)	INJURY AND FATALITY CRASHES	CHANGE (%)
2019	962	-	81	-
2020	705	-26.7	55	-32.1
2021	923	30.9	30	-45.5
2022	860	-6.8	12	-60.0
2023	830	-3.5	12	0.0
Subtotal 2019-2023	4280	-	190	-
5-year Average	**856**	-	**38**	-

The crash data was further analyzed to determine the crash frequency based on the following categories:

- Crash Type
- Light Conditions
- Roadway Surface Conditions
- Roadway Junction

CRASH TYPE

The crash data analysis indicates that rear-end collisions were the most common crash type in the Town of Highland, accounting for 43% of all reported crashes. This was followed by same-direction sideswipes, right-angle collisions, and left-turn crashes. Collectively, rear-end, right-angle, left/right-turn, and run-off-road crashes comprised 84% of all severe crashes reported between 2019 and 2023, as detailed in ***Table 4.***

The severity ratio is defined as the ratio of a crash type's share of severe crashes to its share of total crashes. For example, a crash type that represents 5% of severe crashes and 10% of all crashes would have a severity ratio of 0.5. A severity ratio greater than 1 indicates that a crash type was overrepresented among townwide severe crashes. Because the severity ratio is calculated with percentages, they are relative and are not comparable between different crash types.

In Highland, right-angle, left/right-turn, and run-off-road crashes have severity ratios greater than 1, indicating they are disproportionately represented in severe crashes. Although rear-end crashes account for the highest number of severe crashes, their severity ratio is 0.9, indicating they are slightly underrepresented relative to their overall frequency.

Table 4: Town of Highland, Crashes by Type, 2019-2023

MANNER OF COLLISION	PDO	SEVERE CRASHES	TOTAL CRASHES	PERCENT OF TOTAL CRASHES	PERCENT OF SEVERE CRASHES	SEVERITY RATIO
Backing	267	3	270	1.6%	6.3%	0.3
Right Angle	490	41	531	21.6%	12.4%	**1.7**
Left/Right Turn	476	28	504	14.7%	11.8%	**1.3**
Rear End	1757	70	1,827	36.8%	42.7%	0.9
Same Dir. Sideswipe	569	5	574	2.6%	13.4%	0.2
Opposite Dir. Sideswipe	72	0	72	0.0%	1,7%	0.0
Ran Off Road	150	20	170	10.5%	4.0%	**2.7**
Head On	61	8	69	4.2%	1.6%	**2.6**
Collision with Animal/Deer	65	0	65	0.0%	1.5%	0.0
Collision with Object	6	1	7	0.5%	0.2%	**3.2**
Other	177	14	191	7.4%	4.5%	**1.7**
Total	4,090	190	4,280	100.0%	100.0%	-

When implementing safety countermeasures to address specific crash types, it is essential to consider the locations where these crashes most frequently occur. In the Town of Highland, rear-end and right-angle collisions accounted for the highest frequency of severe crashes.

Analysis of crash patterns within the Town's jurisdiction indicates that the majority of severe rear-end crashes occurred along roadway segments without intersection involvement. In contrast, severe right-angle collisions predominantly took place at four-way intersections. ***Figure 5*** and ***Figure 6*** present crash trees that illustrate the distribution of severe rear-end and right-angle crashes by location type, highlighting the areas with the highest concentrations of these crash types.

Figure 5: Severe Rear End Crash Tree

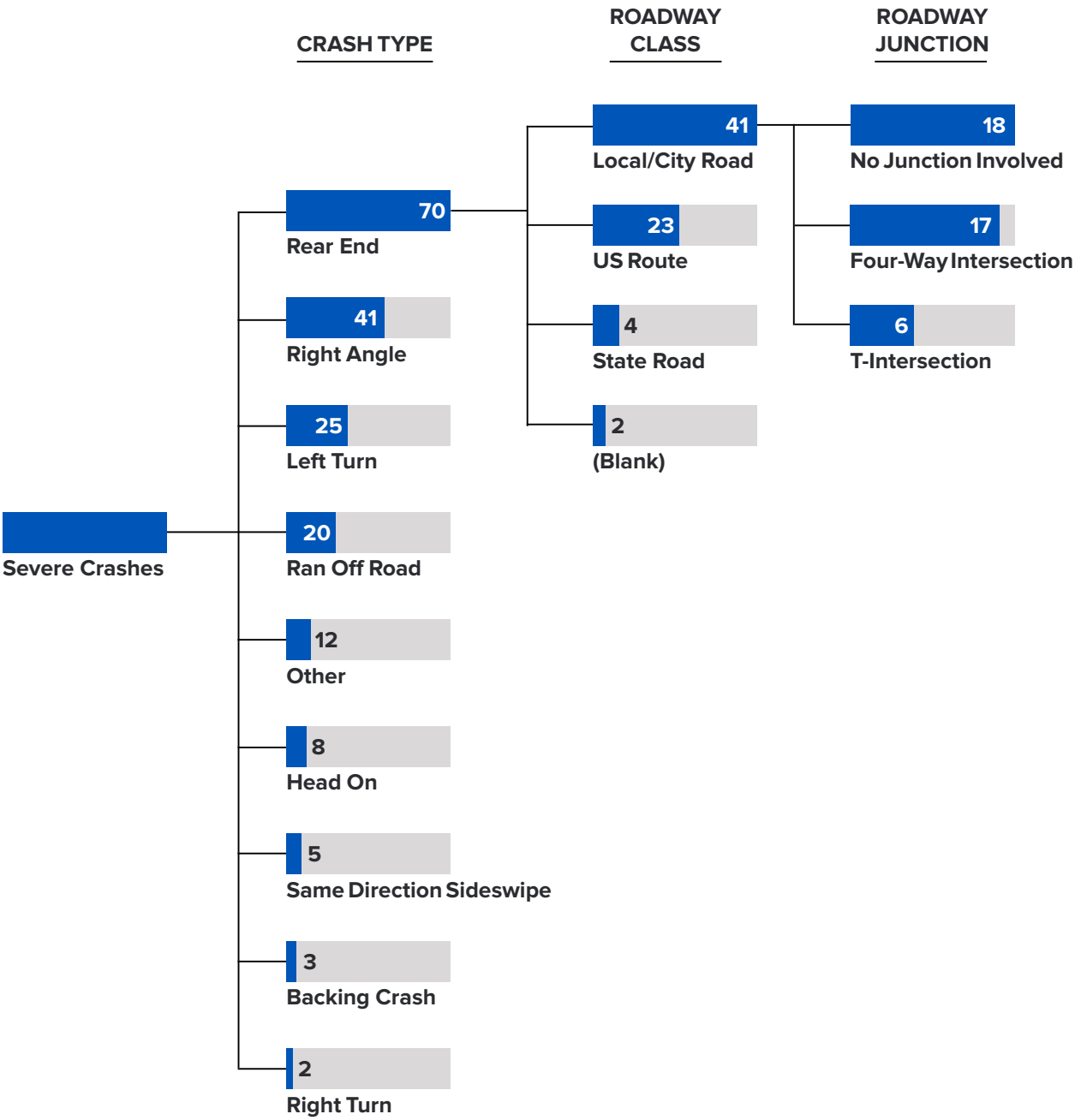
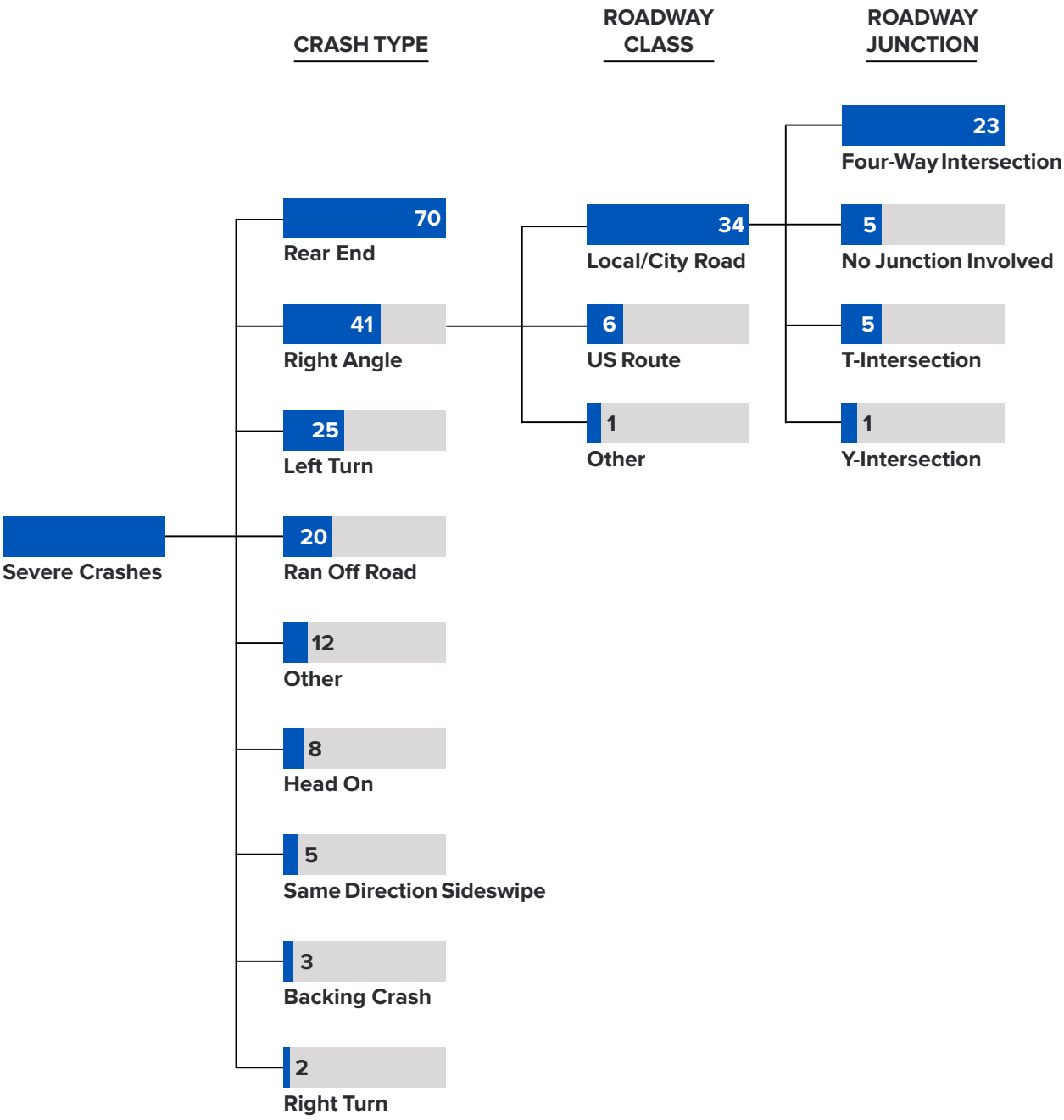


Figure 6: Severe Right Angle Crash Tree

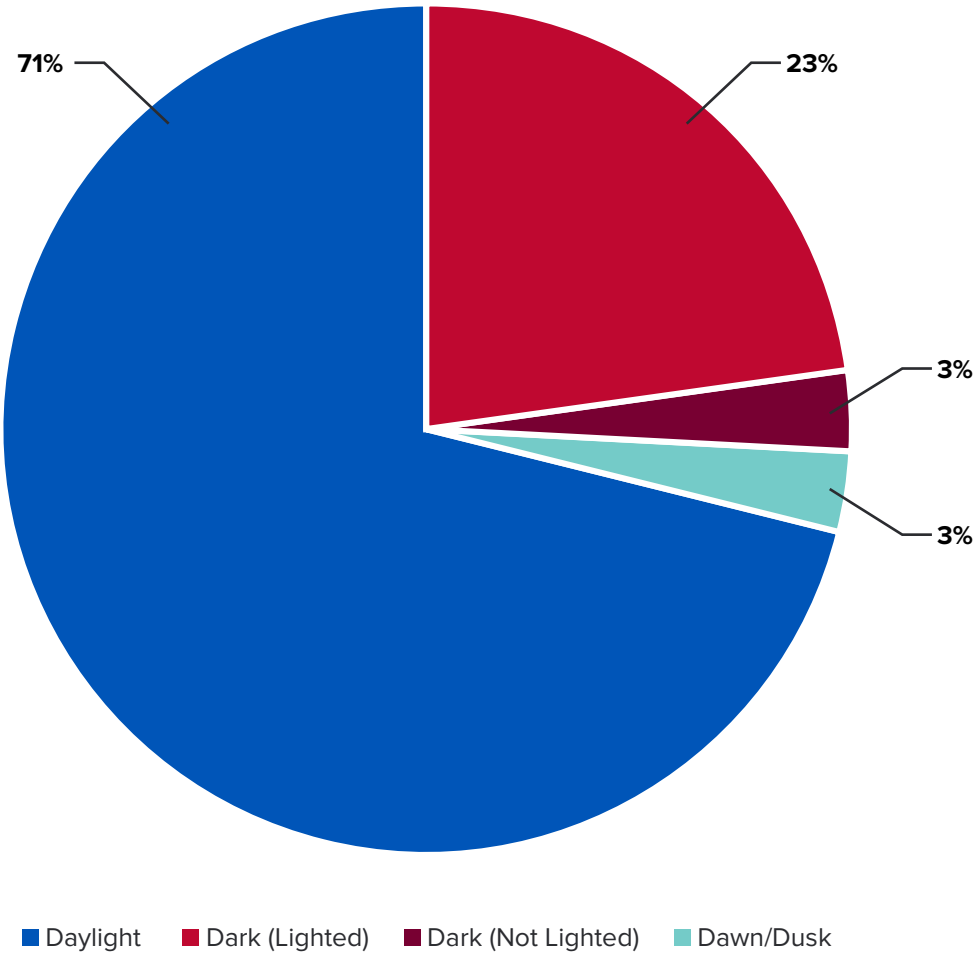


LIGHT CONDITIONS

The crash analysis results indicate that the largest proportion, 71% of the total, occurred during daylight conditions. Crashes in Dark (Lighted), Dark (Not Lighted), and Dawn/Dusk comprise the other 29% of the total.

Figure 7 summarizes the crash distribution by light conditions in Highland during the analysis period.

Figure 7: Town of Highland, Crash Distribution by Light Condition, 2019-2023

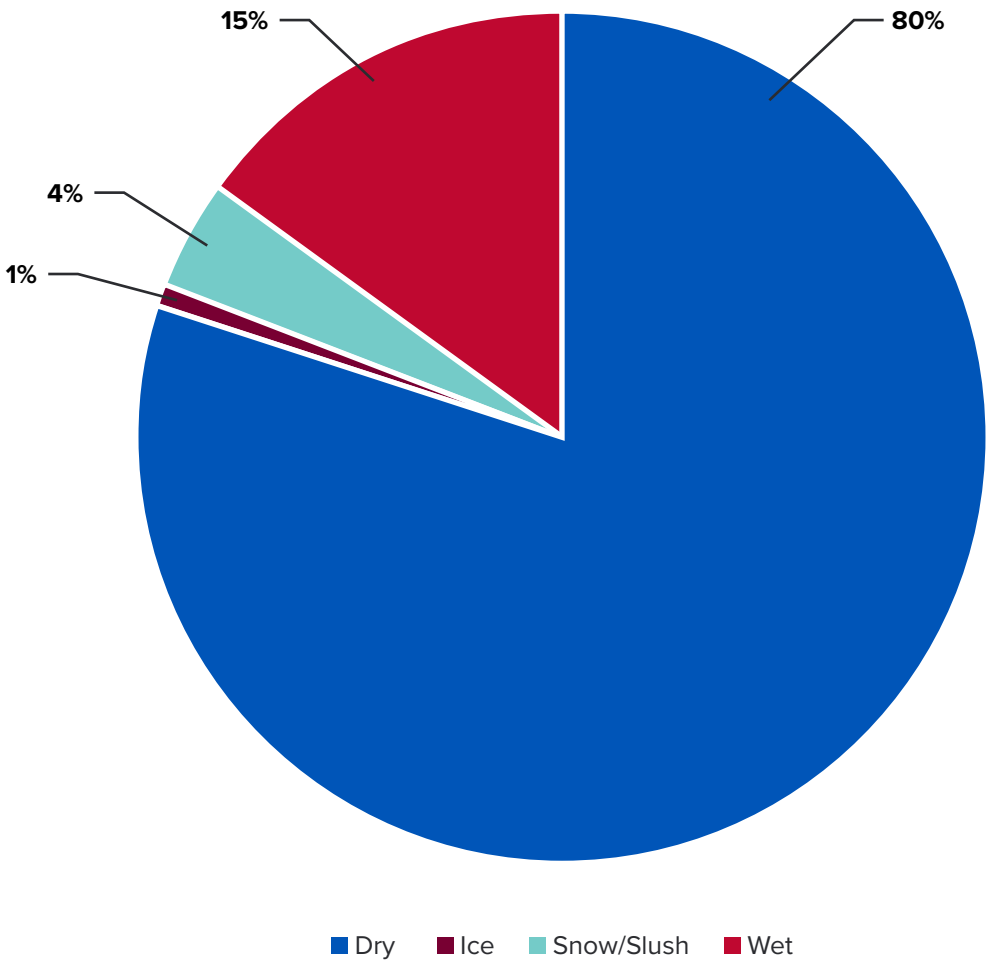


ROADWAY SURFACE CONDITIONS

The crash analysis results indicate that most crashes occurred on the roadway during dry conditions, comprising 80% of the total crashes. Conversely, crashes on wet, snow/slush, and ice surface conditions collectively accounted for 20% of the total crashes.

Figure 8 summarizes the crash distribution by roadway surface conditions in Highland during the analysis period.

Figure 8: Town of Highland, Crash Distribution by Roadway Surface Conditions, 2018-2022

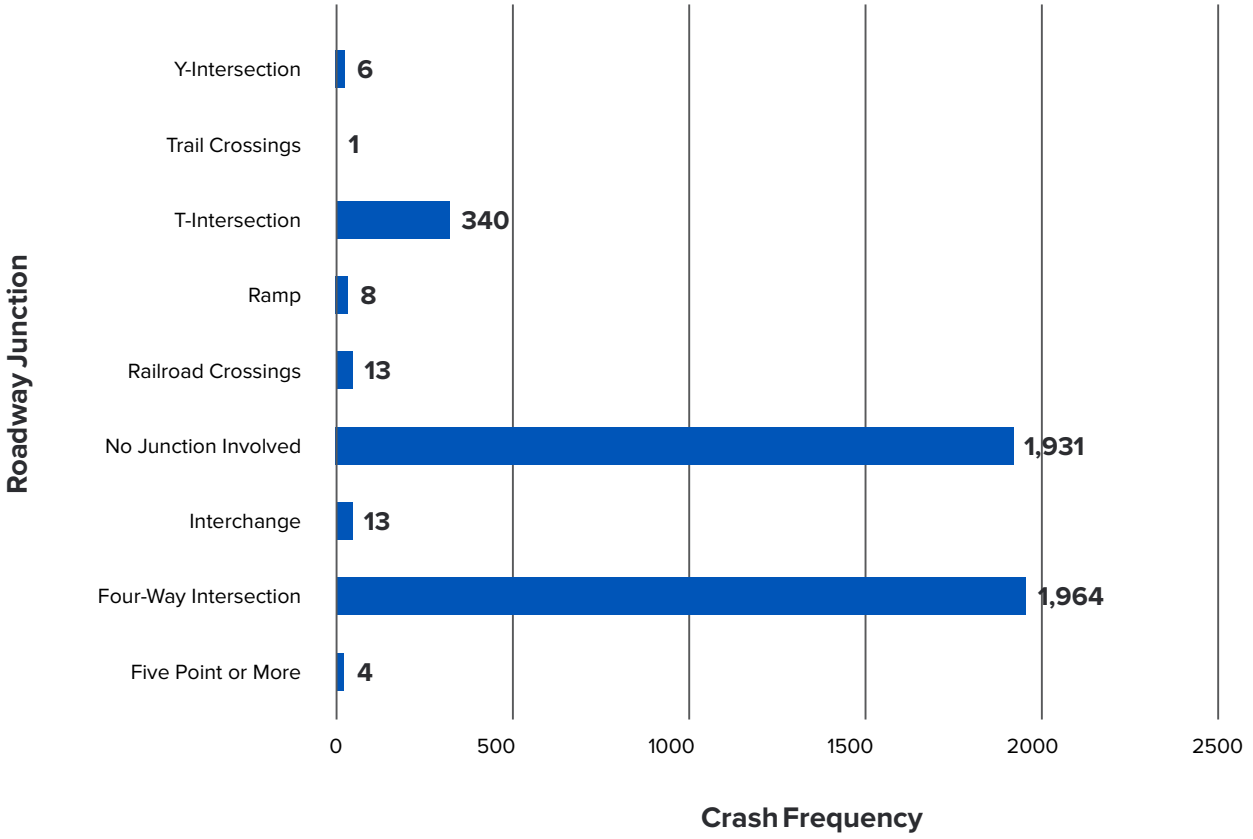


ROADWAY JUNCTION

The crash analysis results indicate that a slight majority of crashes occurred at intersections, either four-way or three-way (T-Intersection). A typical four-legged intersection has 32 vehicle-to-vehicle conflict points and 24 vehicle-to-pedestrian conflict points. These conflict points can include areas where vehicles are turning left, turning right, or proceeding straight through the intersection, as well as points where lanes merge or diverge. The prevalence of right angle and left/right turn severe crashes indicates that systemically reducing conflict points at intersections, such as by installing roundabout intersections or limiting turning movements through access management, would likely have a high impact on safety throughout Highland.

Figure 9 summarizes the crashes by roadway junction in Highland during the analysis period.

Figure 9: Town of Highland, Crashes by Roadway Junction, 2019-2023



4.2 SYSTEMIC SAFETY IMPROVEMENTS

Systemic safety improvements represent a proactive approach to addressing safety concerns on roadways by identifying and implementing measures that target common crash patterns and contributing factors. Unlike traditional spot safety improvements (discussed in Section 7), which focus on specific locations with a history of crashes, systemic safety improvements are applied across a broader network based on systemic risk factors. This approach helps proactively address safety issues comprehensively and efficiently, reducing the overall frequency and severity of crashes. Additionally, public and stakeholder input was considered to identify safety concerns that were not necessarily represented in the crash data, particularly raising concerns about pedestrian and trail crossings, sidewalk interconnectivity, and bicycle facilities.

Based on the crash data trends, three major crash categories were selected as ideal targets for systemic countermeasures:

- Right Angle/Left Turn/Right Turn (Failure to Yield)
- Pedestrian/Bicycle Crashes
- Rear Ends, High Speeds

Based on the review of national and international best practices, including *FHWA's Proven Safety Countermeasures*, and research collected through the *Crash Modification Factors Clearing House*, the following safety countermeasures were suggested as options to address these three severe crash types. Images have been sourced from the FHWA website.

ROUNDABOUTS

Modern roundabouts are a circular intersection configuration that safely and efficiently moves traffic around a central island. Compared to a traditional four-legged intersection, roundabouts have less conflict points, reducing opportunities for right angle or turning collisions to occur. The curved nature of roundabouts has the added benefit of reducing the speeds of vehicles entering the intersection, ensuring that when collisions do happen, they will likely be less severe. Converting a stop-controlled intersection to a roundabout can reduce fatal and injury crashes by up to **82%** (CMF ID: 211) and converting a signalized intersection to a roundabout can reduce fatal and injury crashes by up to **78%** (CMF ID: 226).

RAISED MEDIANS

A median in the center of the roadway separates opposite directions of travel, preventing vehicles from driving left of center and causing head-on collisions. They also control where vehicles are allowed to turn, which can help prevent right angle and turning crashes. As these crash types are associated with high levels of severity, reducing them will greatly impact safety. Installing a raised median on an urban street can reduce right angle crashes by up to **55.4%** (CMF ID: 2220).

RETROREFLECTIVE SIGNAL BACKPLATES

Adding retroreflective tape borders to signal head backplates reflects the headlights of vehicles, making them more visible to drivers, especially in dark conditions. This countermeasure is relatively low-cost and easy to implement, making it a very cost-effective improvement to implement in Highland. When implemented at a signalized intersection, retroreflective signal backplates can reduce all crashes by up to **15%** (CMF ID: 1410).

PEDESTRIAN HYBRID BEACONS (PHB)

Pedestrian Hybrid Beacons are a type of signal that is activated by pedestrians pressing a call button. They are sometimes referred to as HAWK signals. They are best implemented at midblock crossings and uncontrolled crossings or intersections, where vehicle speeds and a lack of gaps in traffic make crossing the road unsafe. These signals slow and stop vehicles when people wish to cross the road to give pedestrians the right of way to cross the road. When implemented, PHBs can reduce pedestrian crashes.

RECTANGULAR RAPID FLASHING BEACONS (RRFB)

These pedestrian actuated beacons are placed below pedestrian crossing signs on both sides of a marked crosswalk. They flash at high frequency to alert drivers to yield to crossing pedestrians. They are also applicable at trail crossings, school crossings, or at the entrance/exit of roundabouts. RRFBs can reduce pedestrian related crashes by up to **47%** (CMF ID: 9024).

SEPARATED BIKE LANES

Installing separated bicycle lanes is the best way to protect the growing number of bicyclists in Highland. Creating a safe network of bicycle facilities not only protects the lives of vulnerable road users, but promotes an alternative mode of transportation, which can alleviate vehicular traffic on busy roads. Barriers such as flexible posts, curbs, or tree lawns are effective means of separating bike traffic from motor vehicle traffic and reduce the chance for collisions. In places where the right of way limits the space available for bike lane separation, reallocation of the roadway lane space, such as through road diets, can make the bike lane installation more feasible.

SIDEWALK CONNECTIVITY AND ACCESSIBILITY

The public of Highland have identified a lack of sidewalk accessibility to be a major safety concern within the Town. By installing sidewalks or multi-use paths where they do not exist and improving them to comply with the Americans with Disabilities Act (ADA) standards where they already exist, Highland can protect pedestrians and promote transportation equity for those who do not travel via motor vehicles. Existing curb ramps that do not meet ADA standards should be redesigned as part of this process, and sidewalks should be maintained and repaired to keep them safe and accessible.

LEADING PEDESTRIAN INTERVALS

Leading pedestrian intervals (LPI) are a signal timing strategy that gives pedestrians extra time to begin crossing the road before vehicles receive a green light. These extra seconds allow pedestrians to establish their presence in the intersection to turning vehicles, making them less likely to be hit. When implemented, LPIs can reduce pedestrian crashes at signalized intersections by up to **13%** (CMF ID: 9918).

ENHANCED CROSSWALK VISIBILITY AND INTERSECTION LIGHTING

Roadway lighting improves visibility and safety for drivers and pedestrians alike. To ensure the safety of pedestrians attempting to cross Highland roads, it is crucial to make drivers aware of crosswalks and trail crossings. This can be achieved with enhanced signage, improved lighting, highly visible pavement markings, and PHBs or RRFBs where appropriate. Installing high-visibility crosswalks in an urban setting can reduce pedestrian crashes by up to 40% (CMF ID: 4123). Many intersections and corridors can benefit from installing or improving existing lighting, and it is one of the simplest ways to combat nighttime crashes. Adding lighting can reduce nighttime crashes at intersections by up to **38%** (CMF ID: 433).

LOW-COST SIGNING AND MARKING IMPROVEMENTS

According to the FHWA, this includes adding double-up signage, advanced warning signage, and enhanced striping at stop-controlled intersections. Because these countermeasures are relatively low-cost, applying them systematically where appropriate has a high benefit-to-cost ratio, and can prevent crashes such as rear ends from occurring at these intersections. The added visibility at these intersections also has the benefit of reducing crashes that occur in the dark.

Similar strategies can also be implemented at railroad crossings. There are several railroad crossings on Highland's roads, and improving the signage and pavement markings at these crossings will alert drivers to their presence. Flashing advance warning signs are also an effective strategy for reducing crashes at railroad crossings.

4.3 HOTSPOT INTERSECTIONS AND HIGH INJURY NETWORK (HIN)

Identifying hotspot intersections and high-injury networks plays a critical role in understanding and addressing areas with a high frequency of crashes and severe injuries, ultimately leading to the implementation of effective safety measures to reduce traffic-related fatalities and injuries.

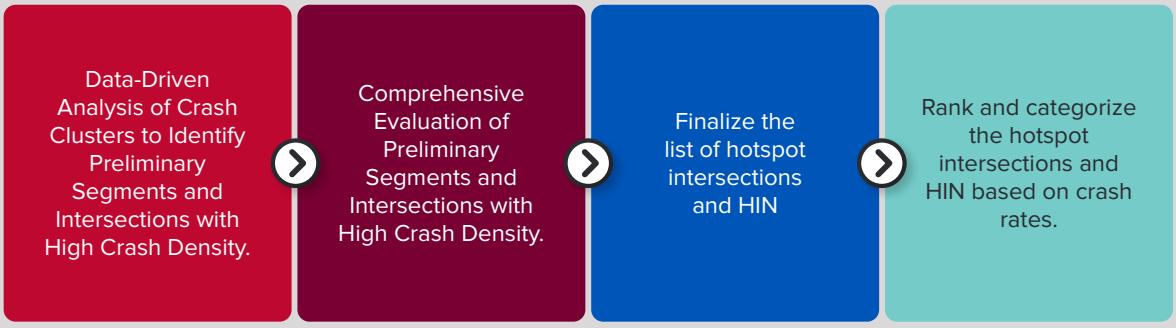
By utilizing crash data and statistical analyses, we can identify trends and contributing factors associated with crashes and injuries at specific locations. This evidence-based approach identifies underlying issues and solutions tailored to address the unique safety challenges of each intersection or corridor within the high-injury network.

METHODOLOGY

Identifying the hotspot intersections and HIN was a four-step process, as shown in ***Figure 10***. It involves a systematic approach that leverages data-driven analysis and comprehensive evaluation to prioritize safety improvements.

- **Data-Driven Analysis of Crash Clusters to Identify Preliminary Segments and Intersections:** This initial step involved analyzing crash data to identify clusters of crashes occurring at intersections and segments of roadways. By examining the spatial distribution of crashes, we identified areas with a high frequency of crashes, indicating potential hotspot intersections and segments within the road network.
- **Comprehensive Evaluation of Preliminary Segments and Intersections:** In this step, the comprehensive evaluation of the identified preliminary segments and intersections was performed to determine crash statistics, with a focus on the percentage of severe crashes.
- **Finalize the List of Hotspot Intersections and High-Injury Network Segments:** Building upon the comprehensive evaluation, the list of hotspot intersections and high-injury networks was finalized based on predefined criteria, ensuring that priority is given to intersections and segments with a significant concentration of severe crashes.
- **Rank the Hotspot Intersections and High-Injury Networks Based on Crash Rates:** Finally, the identified hotspot intersections and high-injury networks are ranked based on crash rates, which consider the frequency of crashes relative to the volume of traffic and/or roadway length. Ranking the locations allows the Town to prioritize safety improvements based on the level of risk posed to road users. Intersections and segments with higher crash rates are assigned a higher priority for safety interventions.

Figure 10: Methodology for Hotspot Intersections and HIN Identification



4.3.1 IDENTIFICATION OF PRELIMINARY SEGMENTS AND INTERSECTIONS

ArcGIS Pro software was utilized as the primary tool for spatial analysis and visualization of crash data. This GIS platform provided the capability to create a detailed heat map which served as an effective visualization tool for identifying clusters and patterns of crashes within the Town. The resulting heat map depicted areas with varying levels of crash density, with hotter colors indicating higher crashes and cooler colors representing lower densities. The roadway segments and intersections with high crash densities served as the initial focus for further evaluation and assessment to determine their suitability for inclusion in the final list of hotspot intersections and high-injury networks. ***Figure 11*** shows the injury and fatality crash data map that was utilized to identify preliminary segments and intersections.

The analysis of the heat maps revealed notable clusters of high crash density along specific roads within the Town boundaries, including Indianapolis Boulevard (US 41), Kennedy Avenue, 45th Street, Ridge Road, and Cline Avenue (SR 912). A significant concentration of intersections with high crash density was observed along these streets.

4.3.2 COMPREHENSIVE EVALUATION

Crash trends at each of the preliminary segments and intersections were assessed, with a summary provided in ***Table 5*** and ***Table 6***, respectively.

Table 5 : Town of Highland, Crash Trend for Preliminary HIN Segments, 2019-2023

SEGMENT NAME	TOTAL CRASHES	INJURY CRASHES	FATALITY CRASHES	PERCENTAGE OF INJURY/FATALITY CRASHES	INJURY CRASH TYPES
Grace St - Ridge Rd to LaPorte St	41	5	0	12%	Rear End; Right Angle; Left Turn
Highway Ave - 1st St to 5th St	72	3	0	4%	Backing Crash; Right Angle; Left Turn
41st St - Kennedy Ave to Ellen Dr	57	6	0	11%	Rear End; Right Angle; Left Turn
Kleinman Rd - Clough Ave to 41st Ln	75	5	0	7%	Rear End; Right Angle; Ran off Road
SR 912 - Ridge Rd to 179th St/ River Rd	312	15	0	5%	Left Turn; Rear End; Right Angle
Ridge Rd - 5th St to Grace St	84	8	0	10%	Rear End; Right Angle; Left Turn
US 41 - Ridge Rd to Hart Rd	595	27	0	5%	Rear End; Right Angle; Left Turn
US 41 - 81st St to City Limits	62	5	0	8%	Rear End; Right Angle; Same Direction Sideswipe; Left Turn
Kennedy Ave - 81st to Main St	816	41	0	5%	Rear End; Right Angle; Same Direction Sideswipe; Left Turn
Ridge Rd - Parkway Dr to Kennedy Ave	295	14	0	5%	Rear End; Right Angle; Same Direction Sideswipe
45th St - Wildwood Ct to SR 912	826	33	0	4%	Rear End; Right Angle; Same Direction Sideswipe; Left Turn
US 41 - Hart to S/O Industrial Dr	455	17	1	4%	Rear End; Right Angle; Same Direction Sideswipe
Main St - Kennedy Ave to W/O Prairie Ave	353	15	0	4%	Rear End; Right Angle; Same Direction Sideswipe; Left Turn

Figure 11: Highland, Injury and Fatality Crash Data Heat Map, 2019-2023

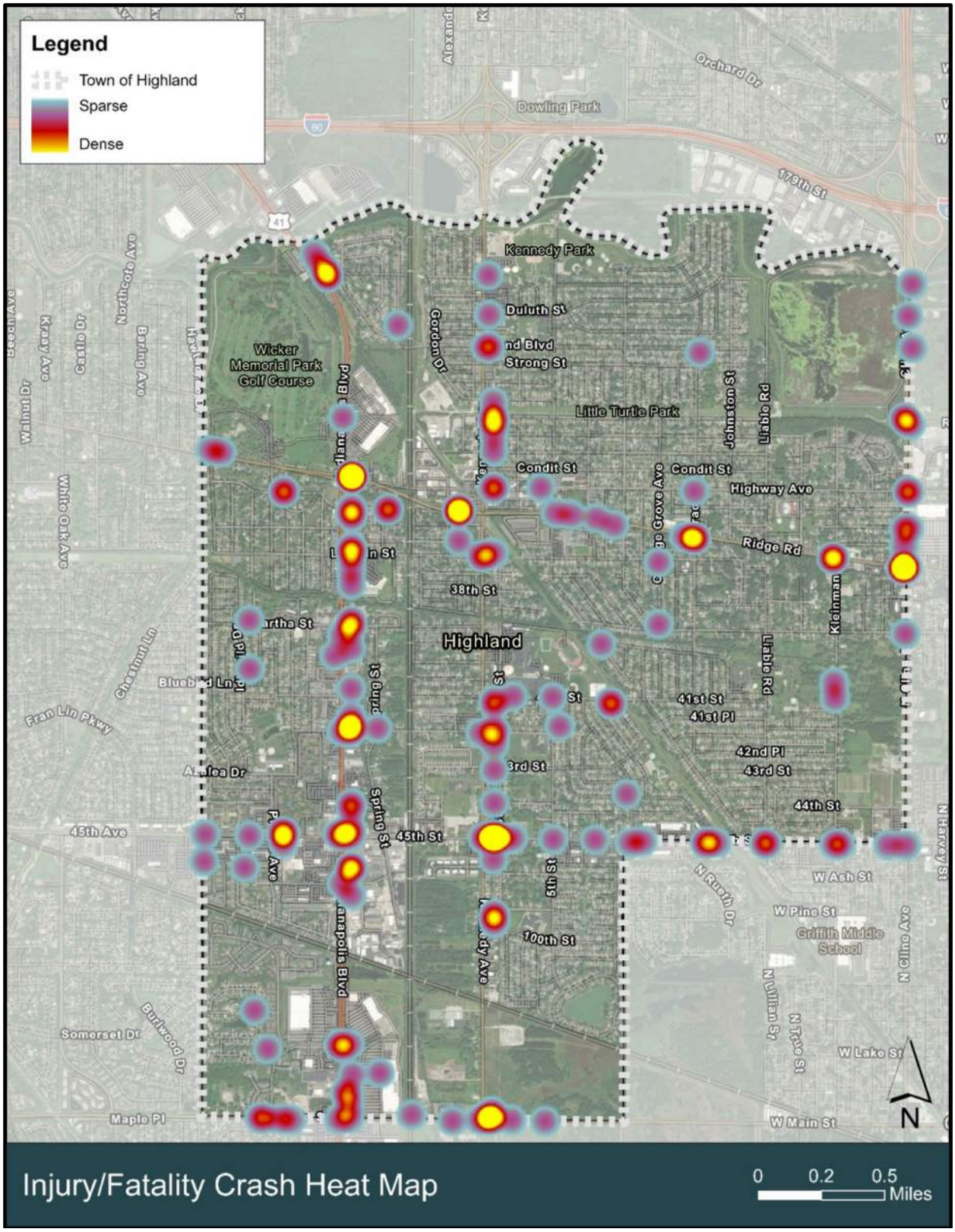


Table 6: Town of Highland, Crash Trend for Preliminary Hotspot Intersections, 2019-2023

INTERSECTION NAME	TOTAL CRASHES	INJURY CRASHES	FATALITY CRASHES	PERCENTAGE OF INJURY/FATALITY CRASHES	MAJOR CRASH TYPES
41st St & Ellen Dr	3	2	0	67%	Rear End
Kennedy Ave & 45th St	160	8	0	5%	Rear End; Right Angle; Same Direction Sideswipe; Left Turn
Ridge Rd & Grace St	31	4	0	13%	Rear End; Right Angle; Left Turn
SR 912 & Ridge Rd	150	7	0	5%	Rear End; Right Angle; Same Direction Sideswipe; Left Turn
Kennedy Ave & Main St	107	6	0	6%	Rear End; Right Angle; Same Direction Sideswipe; Left Turn
SR 912 & 179th St/River Rd	54	3	0	6%	Rear End; Same Direction Sideswipe
Kennedy Ave & Lincoln St	37	3	0	8%	Rear End; Left Turn
US 41 & Hart Rd	80	5	0	6%	Rear End; Right Angle; Same Direction Sideswipe
45th St & Farmer Dr	44	2	0	5%	Rear End; Right Angle
45th St & Lillian St/Liable Rd	15	2	0	13%	Rear End
US 41 & 45th St	225	5	0	2%	Rear End; Right Angle; Same Direction Sideswipe
45th St & Kleinman Rd	31	2	0	6%	Rear End; Left Turn; Right Angle
US 41 & Martha St	74	4	0	5%	Rear End; Left Turn
SR 912 & Wirth Rd	32	1	0	3%	Rear End; Same Direction Sideswipe; Left Turn

4.3.3 RANKING HIN AND HOTSPOT INTERSECTIONS

The frequency of crash occurrence (crash frequency) is the simplest technique for identifying high-hazard locations. Intersections or roadway segments of uniform lengths are simply ranked in order of the number of crashes that occurred during a given period. Although simple to perform, reliance on crash frequency tends to bias the identification process in favor of higher-volume roadway sections and intersections. As a result, it may ignore severe safety problems on low-volume roads or intersections. Crash rates are typically considered better risk indicators than crash frequencies alone because they account for differences in traffic volumes and exposure. Crash rates for roadway segments are normally expressed in terms of crashes per 100 million vehicle miles of travel, whereas for intersections, it is normally expressed in terms of crashes per million entering vehicles.

Table 7 summarizes the HIN ranking by injury and fatality crash rate. Segments with higher injury and fatality crash rates, such as Grace Street—from Ridge Road to Laporte Street or Highway Avenue—from 1st Street to 5th Street, indicate areas of significant safety concern. Notably, Kennedy Avenue—from 81st Street to Main Street, is one of the more heavily traveled roadways and consequently has the highest number of total crashes. Despite this, it has a lower severe crash rate than most of the segments listed. This further emphasizes the importance of utilizing crash rates to avoid bias towards heavily traveled roadways. Various factors, including traffic volume, road design, enforcement efforts, and driver behavior, can influence crash rates and severity, necessitating a comprehensive approach to road safety analysis.

Table 7: Town of Highland, HIN Ranking by Injury and Fatality Crash Rate, 2019-2023

SEGMENT NAME	TOTAL CRASHES	INJURY CRASHES	FATALITY CRASHES	VOLUME OF VEHICLES PER DAY	LENGTH OF ROADWAY SEGMENT (IN MILES)	TOTAL CRASH RATE	INJURY & FATALITY CRASH RATE	RANK
Grace St - Ridge Rd to LaPorte St	41	5	0	2621	0.42	2040.82	248.88	1
Highway Ave - 1st St to 5th St	72	3	0	1620	0.49	4970.02	207.08	2
41st St - Kennedy Ave to Ellen Dr	57	6	0	3563	0.46	1905.63	200.59	3
Kleinman Rd - Clough Ave to 41st Ln	75	5	0	4917	0.69	1211.29	80.75	4
SR 912 - Ridge Rd to 179th St/ River Rd	312	15	0	21650	0.51	1549.98	74.52	4
Ridge Rd - 5th St to Grace St	84	8	0	15191	0.40	761.81	72.55	6
US 41 - Ridge Rd to Hart Rd	595	27	0	33731	0.90	1073.72	48.72	7
US 41 - 81st St to City Limits	62	5	0	39016	0.16	544.21	43.89	8
Kennedy Ave - 81st St to Main St	816	41	0	17596	3.00	847.02	42.56	9
Ridge Rd - Parkway Dr to Kennedy Ave	295	14	0	18120	1.02	877.12	41.63	10
45th St - Wildwood Ct to SR 912	826	33	0	12815	4.52	781.38	31.22	11
US 41 - Hart Rd to S/O Industrial Drive	455	17	1	26910	1.22	758.07	29.99	12
Main St - Kennedy Ave to W/O Prairie Ave	353	15	0	20232	1.44	663.91	28.21	13

Table 8 summarizes the hotspot intersections ranking by injury and fatality crash rate. The total crash rate and injury and fatality crash rate provide insights into the overall safety performance of each intersection. Intersections with higher crash rates and ranks, such as 41st Street and Ellen Drive, shall require further investigation and targeted safety interventions to reduce the frequency of crashes.

As per the safety analysis results, the HIN and hotspot intersections in Highland are shown in ***Figure 12*** and ***Figure 13***, respectively.

Table 8: Town of Highland, Hotspot Intersections Ranking by Injury and Fatality Crash Rate, 2019-2023

INTERSECTION NAME	TOTAL CRASHES	INJURY CRASHES	FATALITY CRASHES	TOTAL ENTERING TRAFFIC	TOTAL CRASH RATE	INJURY & FATALITY CRASH RATE	RANK
41st St & Ellen Dr	3	2	0	4063	0.40	0.27	1
Kennedy Ave & 45th St	160	8	0	30411	2.88	0.14	2
Ridge Rd & Grace St	31	4	0	17812	0.95	0.12	3
SR 912 & Ridge Rd	150	7	0	37838	2.17	0.10	4
Kennedy Ave & Main St	107	6	0	33849	1.73	0.10	4
SR 912 & 179th St/River Rd	54	3	0	17575	1.68	0.09	6
Kennedy Ave & Lincoln St	37	3	0	19172	1.06	0.09	7
US 41 & Hart Rd	80	5	0	32035	1.37	0.09	8
45th St & Farmer Dr	44	2	0	13890	1.74	0.08	9
45th St & Lillian St/Liable Rd	15	2	0	14409	0.57	0.08	10
US 41 & 45th St	225	5	0	39725	3.10	0.07	11
45th St & Kleinman Rd	31	2	0	16977	1.00	0.06	12
US 41 & Martha St	74	4	0	35020	1.16	0.06	13
SR 912 & Wirth Rd	32	1	0	9061	1.94	0.06	14

Figure 12: Highland, High Injury Network, 2019-2023

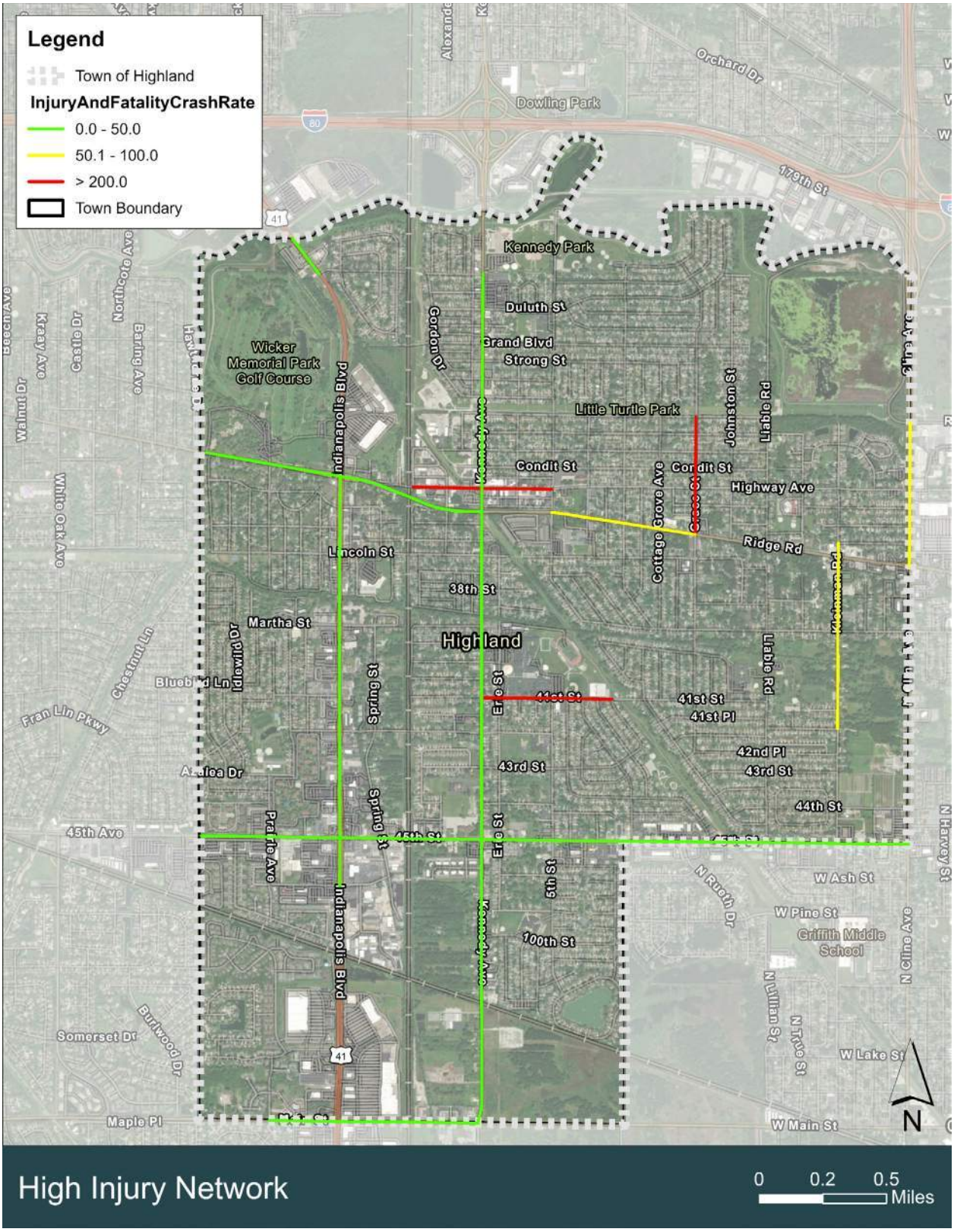


Figure 13: Highland, Hotspot Intersections, 2019-2023